ACRST-1993

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OFFICIAL TRANSCRIPT OF PROCEEDINGS

Agency: Nuclear Regulatory Commission
Advisory Committee on Reactor Safeguards

Title: Subcommittee on Materials and Metallurgy

Docket No.

LOCATION: Bethesda, Maryland

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UNITED STATES NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

DATE: December 16, 1993

The contents of this transcript of the proceedings of the United States Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards, (date) December 16, 1993, as Reported herein, are a record of the discussions recorded at the meeting held on the above date.

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UNITED STATES

NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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SUBCOMMITTEE ON MATERIALS AND METALLURGY

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Room P-110

7920 Norfolk Avenue

Bethesda, Maryland

Thursday, December 16, 1993

The Subcommittee met, pursuant to notice, before Robert Seale, Chairman, at 8:30 a.m.

ACRS MEMBERS PRESENT:

R. Seale, Acting Subcommittee Chairman

W. Shack, ACRS Member

W. Lindblad, ACRS Member

H. Lewis, ACRS Member

T. Kress, ACRS Member

P. Davis, ACRS Member

E. Igne, Cognizant ACRS Staff Member

PARTICIPANTS:

J. Strosnider, NRR

C. Welty, EPRI

E. Murphy, NRR

S. Long, NRR

J. Blomgren, Commonwealth Edison

K. Karwoski, NRR

T. Reed, NRR

P R O C E E D I N G S

[8:30 a.m.]

MR. SEALE: Good morning. This is a meeting of the ACRS Subcommittee on Materials and Metallurgy. I am Robert Seale, Acting Chairman of the Subcommittee.

The ACRS members in attendance are William Shack, Thomas Kress, William Lindblad and Pete Davis, and Dr. Hal Lewis has just joined us.

The purpose of this meeting is to discuss the steam generator operating experience and steam generator rulemaking activities. Elpidio Igne is the Cognizant ACRS Staff Member 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 30 November.

Dr. Shack has declared that a potential conflict of interest may exist due to the participation of Argonne National Laboratory staff colleagues in the preparation of the proposed steam generator NUREG. Accordingly, Dr. Shack may participate in our discussions and ask questions today, but he will not vote.

A transcript is being kept and will be made available as stated in the Federal Register notice. It is requested that each speaker first identify himself or herself and speak with sufficient clarity and volume so that he or she can be readily heard.

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

Today we're going to hear a status report from the staff on the steam generator NUREG and also some comments from the industry. We understand that the staff expects to have the SER available early next year and, undoubtedly, we'll hear more at that time.

We've also been made aware that the staff has been in contact with the French and perhaps others and we may get some word on those discussions later after the reports on these talks have been verified. There may be proprietary aspects of those discussions, as well. So we'll see at that time.

The agenda for today's meeting is relatively straightforward. In discussing with several of the participants, it may well be that we can move the industry comments immediately after the staff completes and perhaps finish before a perhaps later lunchtime of about 1:00 or so, maybe a little after that. I think that would be consistent with some aspects of reinventing government or something like that. Anyway, we can get you guys back to useful activities today.

We will hear from various people from the NRC staff this morning. Mr. Jack Strosnider is the Branch Chief involved and I will ask Mr. Strosnider to begin and to introduce his colleagues, if he will.

By the way, in view of the relatively small number of people involved, we've sort of rearranged the table so we can get eye-to-eye with these folks and perhaps break down some of the artificial barriers. See who blinks first.

MR. LINDBLAD: You are no longer an oligarchy?

MR. SEALE: No comment.

MR. LEWIS: Isn't it in the House of Lords where the distance between the two sides is greater than two swords' lengths, for obvious reasons? This is greater than two fists' lengths.

MR. SEALE: Yes. Go ahead. If you have something constructive to say, say it.

MR. STROSNIDER: Good morning. My name is Jack Strosnider. I'm Chief of the Materials and Chemical Engineering Branch in the Office of Nuclear Reactor Regulation.

I'd like to introduce today's subject of steam generators with a few observations regarding some changes in technology and changes in the modes of degradation that are effecting steam generators and the implications of those changes with regard to regulations.

I only have two viewgraphs, so this will be a fairly brief introduction. I don't plan on going into a great level of detail. But what I hope to do is provide a broader framework or perspective for the rest of today's discussions. We will get into more detail on some of these subjects as the staff makes their presentations.

Since the mid-1970s, there have been some significant changes with regard to technology and, in particular, I want to focus on nondestructive testing technology as applied to steam generators.

One of the first changes is the data collection and management systems. There is much greater capability today than there was back in the 1970s with regard to the speed at which data can be collected and the amount of data that can be managed. In that regard, I'm referring to analyzed and tracked from outage to outage.

As an example, if you look at what some licensees are doing today with regard to inspections for outside diameter stress corrosion cracking, which occurs at the tube-to-tube support plate intersections, if you consider roughly 4,000 tubes in a generator with eight support plates, that gets you up to 32,000 intersections on the hot leg, 64,000 on the hot and the cold, maybe four steam generators, so you're up to a quarter of a million data points.

Within today's technology, the ability exists to inspect all of those, to keep track of those from outage to outage, and, in some cases, not inspection with just one type of probe, but, in some cases, even with a couple different types of probes. It can be done quickly enough -- I'll say a little bit more about the economies here, but this is something that is a viable option today, which it certainly wasn't back in the mid and late 1970s.

At that point in time, these kind of inspections I don't think could have been done, at least not economically. They weren't feasible.

In addition, there is some greater sensitivity with regard to the NDE methods that are used today. Again, going back to the 1970s, the industry was relying primarily on bobbin coil eddy current probes. They were fine looking for wastage. With regard to denting, you probably weren't even as interested in the electrical signals, whether you could get the probe through the tube or not. People were doing gaging.

Today we have rotating pancake coil probes, multiple frequency probes. These things are becoming standards in the industry. They're being used on a very wide basis. They provide a much greater level of sensitivity.

There's been some improvements. This is good news in the area of NDE technology. I think another important change here is the fact that it's economical now for the utilities to apply these technologies. And, certainly, I'm not the expert on this. It's not the NRC's business to understand all the economics.

But from the submittals that we see coming in for the type of inspections and alternate repair criteria that the industry is interested in doing and from discussions, presentations they've made to us, this is -- the economies are such that there's a real driving force to use these technologies.

This becomes very significant with regard to the effective life of a steam generator and during, in some cases, the effective life of a power plant. It may be economical to inspect and extend the life of these steam generators. In some cases, replacement may be viable. In other cases, it may not.

So there's a strong driving force to apply these things and we see that based on some of the industry initiatives and the direction that they're headed.

There's also been some changes with regard to the degradation mechanisms that are being experienced. In fact, if you look at the next page in the handout, let me indicate that this viewgraph is courtesy of EPRI. They have done an excellent job of keeping these sort of statistics and there's a report that goes into detail on this.

I wanted to use it because it illustrates the point very well, I think, that, again, reflecting back to the mid-1970s, wastage was one of the early problems and then denting. The NDE technologies were adequate to deal with those.

We've seen some significant changes, though. If you come out here to the early 1990s now, you see that -- and there's some good news here -- wastage is pretty much eliminated. Denting is certainly not the kind of problem it was. There are some new forms of degradation occurring, perhaps due to changes in the way the generators are operated, perhaps just due to aging. But, nonetheless, you see that there's a large amount now of stress corrosion cracking, the inner granular stress corrosion cracking occurring at the tube support plate and tube intersections, which I mentioned.

So in particular, in today's environment, we're dealing with outside diameter stress corrosion cracking. We are seeing increased incidents of circumferential cracking and also we've seen some incidents of freespan stress corrosion cracking. We'll be discussing these in a little more detail, some of the operating experience, later.

They do create some new challenges. It's difficult for some of these mechanisms to get an accurate measure of depth. With regard to outside diameter stress corrosion cracking, it's because of the morphology and the fact that there may be a large number of cracks and some inner granular attack at the location, such that you can't really single out a specific crack and get its depths.

What has been proposed is that perhaps there are other NDE parameters that are more appropriate, in this case, of voltage amplitude.

Circumferential cracking is something that is difficult to detect if you don't use the right methods. The bobbin probe, for example, is not going to pick these up. The rotating pancake coil, however, can see those. It's the same thing with freespan cracking.

Nonetheless, for these types of cracks, it is difficult in some cases to get a reliable depth measurement until the cracks have some significant depth.

What happens then is these cracks are taken out of service when they're detected. So you end up in more or less a catch-22 where it's difficult to define some crack growth rates, because you'd like to have measurements from one outage or the next or at least that's what the practice has been in the past.

So these degradation mechanisms provide some new challenges. Fortunately, as I indicated, some of the NDE technology has improved and is better suited to deal with that today.

MR. SEALE: Mr. Strosnider, looking at those various causes, it almost seems like there's a virus that walks through the population of steam generators from one time to the other. Is there an EPRI report or something that would be available that could give us a little bit more detail on the time of service and other parameters that are involved in the appearance of these various problems that might help us understand that a little better?

MR. STROSNIDER: I think perhaps Chuck Welty from EPRI might --

MR. WELTY: I'm Chuck Welty. I'm from EPRI. I'm the Manager of the Steam Generator Strategic Management Program there. Yes. There is a report and I will provide a copy of it to Alex, an annual report from which the data is -- I'll be covering some of that material in my presentation.

MR. STROSNIDER: They have a more detailed breakdown and I think it's very interesting. You can take the time to look at it.

MR. SEALE: Very good. Thank you.

MR. STROSNIDER: This is an area in NDE technology. It's one example of where there's been changes. There's other technology changes which are influencing the way the industry is managing steam generator problems.

But just as an example, you can look at those. But it's interesting to say, well, what's the consequences or the impacts on the current regulatory requirements. Well, one of the first things -- consequences of this change is that the regul·tory criteria, the regulatory requirements are out of date.

If you look at the plugging criteria 40 percent limit, which is in most of the plant technical specifications, the basis for that and that criteria was developed back in the early to mid-1970s. The primary focus was on wastage type degradation and, as I pointed out earlier, it was easy to get a depth measurement on that sort of thing and it was very applicable or appropriate criteria for that form of degradation.

When you look at some of the modes of degradation occurring today, it's not necessarily true. ODSCC at the tube support plates is an example where it's difficult to get a depth measurement. So you've got a criteria which, in fact, is difficult to implement.

When you look at circumferential cracking, IGSCC and some of those other mechanisms, it may be that the 40 percent criteria is not the most appropriate thing to be looking at.

In addition, if you look at the scope of inspections, the tech specs typically requiring a three percent initial sampling size, the industry, on their own initiative, is doing considerab_y more than that. It's partly related to the technologies that are available. It's related to the reliability and economic aspects.

But, nonetheless, there are some problems in that our criteria and regulations date back to the 1970s and they don't reflect current technology or current experience.

The consequence of that is that, as a regulator, we've been having to deal with some of these issues on an ad hoc basis. I'd like to go back and count the number of tech spec amendments and plant-specific reviews that we've done in the last several years. I haven't had time to do that. We're too busy doing them. But there's a large number of them.

What's the result of that? If you go back and look at them, you will see that there are some inconsistencies. I'm not suggesting that there's any safety problem there, but what happens is, again, the technology is changing and as we look at plant-specific situations, some of the evaluation criteria turn out a little different from one plant to another.

But, clearly, they're not all the same, which provides some difficulty with stability in the regulatory environment. From the industry perspective, it's certain that it's as much difficulty as it is for us to review a large number of plant-specific submittals, it's also difficult for them to put together plant-specific submittals, breaking new ground each time and not being certain what the outcome in.

This results in a drain of resources, both at the NRC and in the industry. Finally, from the NRC perspective, we have issues regarding procedures for addressing generic issues. If we approve a plant-specific amendment with an alternate plugging criteria, there is -- if it makes good sense to the industry, there is undoubtedly going to be other plants standing in line to get the same sort of thing.

At what point does it become generic? Well, we believe we're at that point. We have a generic issue to deal with and we need to follow our procedures, for a large number of reasons.

So there is a need for a generic approach to this, to try to get the thing under control and to address all those issues.

What are the attributes that we'd like to see in this sort of approach? Well, we'd like to see something that's performance based. This is a general regulatory direction, I think, that the agency has been headed. It makes good sense. Less prescriptive regulation.

The easy example, again, is the 40 percent plugging limit. If we say everybody will plug at 40 percent, maybe that's right today, it was right in the 1970s, but will it be right tomorrow or further down the line. So it has to have some adaptability.

We want to put together a generic approach that will allow for changes in technology, changes in operating experience, and let those things be addressed. That's important also because it should provide some incentive.

The bes xample and thing that we're very interested in here is the incentive to continue to improve the NDE methodologies and techniques.

More appropriate plugging criteria will go hand in hand with being able to quantify the types and size of defects.

Finally, we believe that we have to have an integrated approach here. This is not just a materials issue. If you look at some of the recent safety evaluations that have been issued by the staff, and later when you see our integrated plan dealing with this, steam generators involve systems considerations, materials, and radiological. We want to make sure that we have the appropriate balance and that we have the appropriate levels of safety, looking at the whole system from beginning to end.

Finally, we believe it should address all PWRs. So if you look at the attributes that we feel are important in this generic approach, when we look at these, we conclude that that looks like a rule might be the appropriate direction to go and, in fact, that is what we're doing. We are proceeding down the path to a rulemaking.

We will be discussing our integrated plan a little later in the presentations. Rulemaking is a piece of that. There are some other aspects of it which are going on with regard to issuance of a generic letter to deal with the outside diameter stress corrosion cracking issue, which, if you look back at the slide, is just a major problem that's affecting steam generators today.

As I said, these are just a few examples which I wanted to present a few observations, hopefully to provide a framework for the rest of today's discussions.

I don't have a overhead of the agenda, but if you take a look, you'll see that Emmett Murphy is going to be talking about some of the recent experience and regulatory implications, a little more detail and expansion on some of these observations, I think, any current issues he'll be discussing.

Ken Karwoski is going to be talking about repair limit issues, the voltage-based criteria. We'll give a little bit of a status report on NUREG-1477, which was issued in the spring in draft form with regard to criteria for voltage-based repair of outside diameter stress corrosion cracking. Finally, we'll show you how we're trying to fit all this together in an integrated plan.

So that's what I prepared to say. Are there any questions?

MR. DAVIS: Yes. I have one, Mr. Strosnider. I'd like to get an indication of how pervasive this problem is. Can you tell us what percentage of tubes are plugged now and the current operating population and how that's changed in the last few years? This really doesn't tell me how many tubes have a problem.

MR. STROSNIDER: I think the report --

MR. DAVIS: Maybe this will come up later.

MR. STROSNIDER: The report -- and perhaps -- I'm not sure if Mr. Welty from EPRI will get into some more detail on that. I could make a few observations with regard to the outside diameter stress corrosion cracking.

It's a large percentage of the tubes that are being removed from service. If you look at the number of plants that are affected, there's clearly five plants which are affected. I'm aware of that because we've issued interim plugging criteria for those plants.

There are other plants that are detecting this same problem; perhaps not as pervasive in their plant, but the anticipation or at least we may have to anticipate that there will be more plants that are experiencing this. It depends on how good some of the corrective actions that the industry is able to come up with, how effective they are.

I'm not sure if that answers your question.

MR. DAVIS: Well, let me ask it a different way. A 100 percent would be how many tubes?

MR. STROSNIDER: It's 100 percent of what's in the industry, of all the PWRs out there.

MR. DAVIS: No, that's not true. A 100 percent is the number of tubes that have had a problem, that have been plugged. How many tubes is that?

MR. LINDBLAD: It differs per year.

MR. DAVIS: Is it going up or down?

MR. WELTY: This is Chuck Welty from EPRI. Some of the viewgraphs that I will have in my presentation show you the relative percent for each one of these for the tubes in service in this country and in the world. I don't have the number right off the top of my head. I believe it's around 6,000 tubes a year, total worldwide, that are getting plugged, but that's -- the report that I will send you has those numbers in numbers, both the total tubes in service, as well as the number being plugged. I've got them in a percent.

MR. STROSNIDER: But you're right. This is the number of tubes that have been removed from service.

MR. SEALE: Any other questions?

MR. SHACK: The OD stuff is the tube support plate. The ID stuff is basically the tube sheet. Is the problem split up that way?

MR. STROSNIDER: I think generally. There are always some specific cases, but, generally, the primary water stress corrosion cracking is occurring at the roll transitions, roll top of the tube sheet. If you go back and look at some of the early experience, and there may be still some occurring in the field today where you have some dent locations, there was some primary water stress corrosion cracking associated with those locations, too.

Emmett, do you want to add something to that?

MR. MURPHY: Yes. I'll have a viewgraph showing where these OD cracks and ID cracks are occurring.

MR. SEALE: Any other questions by members of the Committee?

[No response.]

MR. SEALE: I have one observation and perhaps we'll hear more about it later. But in the limited information that I have been able to glean on these kinds of problems, there does seem to be some vendor-related specificity. That is, certain vendors have problems, others don't, and perhaps that difference is evening out over time. I don't know.

One of the problems the ACRS has recently run into, at least in our minds, is the use of criteria on another issue, seal pump failure, which seems to have been drawn from a very limited sampling of the population of pumps; that is, the Westinghouse, in that particular case, experience has been the basis for the -- seems to be the basis for the criteria that have been involved.

Now, when you talk about adaptability in your list of attributes of the proposed plant, I would hope that that adaptability would include the ability to separate out what seems to be systematic differences between one design and another and so on, so that we don't get ourselves into the problem of prescribing the same medicine for all ills or whatever. It's just a comment based on some other problems we've seen.

MR. STROSNIDER: I understand the comment. I think it's a good comment. The other attribute that comes into play here is the performance-based aspect of what we do.

MR. SEALE: Yes.

MR. STROSNIDER: As opposed to being prescriptive. Rather, to have some performance demonstration of why a particular NDE method, for example, does what it's supposed to do in the particular application that it's being used in, which cuts across vendors and any other differences.

MR. SEALE: Mr. Lindblad?

MR. LINDBLAD: Thank you, Mr. Chair. Mr. Strosnider, you certainly have demonstrated an operational need to see what can be done here. I just want to tell you that I'm going to be interested in what you tell us today about the safety risks and the levels that are involved, rather than some of the techniques for testing.

Now, maybe they're intertwined, but I -- as you speak of consequences of change, I was looking to that of being a change in risk. I'd be interested in seeing how that develops.

MR. STROSNIDER: That's a fair observation. I didn't focus on that. I'd just make a general comment that when you look at these different types of degradation that occur, some of them are more risk-significant than others.

MR. LINDBLAD: Right.

MR. STROSNIDER: And that comes back to how easy are they to find; also, what would the mode of failure be under postulated accident conditions. If you look, for example, at the outside diameter stress corrosion cracking, where you've got a tube support plate that's surrounding the area of degradation, there may be less risk involved with that sort of condition than, for example, the freespan IGSCC crack, which is more difficult to detect.

Those are some of the issues we're going to have to deal with and if you see -- I believe when Emmett Murphy presents some of the plant-specific operating experience, you'll see how those different degradations are manifesting themselves. So we can get into those discussions.

MR. LEWIS: If I can just add something. We're all the products of our experience and backgrounds and whereas I'm also interested, along with Bill, in the risk significance of what we're talking about today, I'm also, as a physicist, very interested in why it will be proposed to be useful to back off from cracks to the voltage on an unspecified instrument as an indicator of first probability.

So just preparing for the day, at least some of us would be interested in the justification for the proposed new instrumentation.

MR. STROSNIDER: Okay.

MR. SEALE: We can proceed now.

MR. DAVIS: You don't like empiricism?

MR. LEWIS: I do believe in empiricism if you don't have anything better. In this case, it's cracks that cause it, not voltage.

MR. LINDBLAD: Instruments contain and if your criteria is based on an instrument, then you may have a problem down the road.

MR. MURPHY: Good morning. My name is Emmett Murphy and I'll be speaking about recent operating experience and some regulatory implications that we can draw from this recent experience.

I'd like to start off, though, by giving an overview. As Jack has noted and as everybody knows, steam generator tube degradation problems are widespread throughout the industry.

We've had seven steam generator tube rupture events in this country to date. There have been nine worldwide, including the U.S. These problems, steam generator degradation problems, have led to several forced outages per year. It's led to SG replacement at eleven plants to date. Twelve more are planned. Figure 170 million per job and you're talking big bucks.

Extensive tube repairs and outage extensions and the problems have also involved significant personnel exposure to the workers. I can recall presenting basically this same viewgraph, I think, going back to around 1988 to you fellows, only the numbers have changed a little bit.

The number of tube rupture events has gone up. The number of replacements has gone up. But now, as before, there's no end in sight to the problems that we're experiencing with steam generators.

MR. LINDBLAD: How is a tube rupture event defined? How big a leak do --

MR. MURPHY: There are various ways you can define tube rupture, of course. I think the way we have defined tube rupture for purposes of settling on this number is that where the tube failure results in leakage exceeding the normal makeup capacity of the primary coolant system, that's a tube rupture.

There have been other cases beyond those we've counted here in these seven that have involved what any mechanical engineer or materials engineer would call a rupture. Tubes have come apart. They fishmount, but the resulting leakage, for various reasons, was less than normal makeup capacity of the primary system and we have not included those events as ruptures here.

I can think of at least three such events in addition to these seven in this country.

This viewgraph provides an overview of many of the major types of degradation problems that we're experiencing here in the U.S. and also I think provides an answer to Mr. Shack's question about where we tend to see OD initiated cracking as opposed to primary initiated cracking.

I think the answer to the question is it's pretty complex. You can pretty much get the cracks anywhere. To make the point, we had a lot of early problems in this country with outer diameter initiated stress corrosion cracking and IGA that took place within the crevices of the tube sheet and the sludge pile. We also tended to get pitting there in the early 1980s.

As I say, this is OD initiated cracking. Jack has talked about the very widespread ODSCC occurring at the tube support plates. An interesting note to make here about this

ODSCC is at Catawba, during the current outage, they have found in excess of 8,000 indications of ODSCC. Clearly, this would be a devastating blow to a utility if he had to plug, if all these indications are we're going to require plugging of the tubes.

What saves the day for Catawba are voltage-based plugging limits. But more about that later.

We tend to get primary side cracking I think probably most frequently in the tube sheet area, such as in the expanded region of the tubing, we tend to get -- we get both axial cracking and we see circumferential cracking at the expansion transitions. We also tend to get OD cracking at the expansion transitions at some units.

Dented tube support plate intersections provide a pretty complex potential set of problems here. At North Anna where we had dented intersections, we had circumferential cracks induced by the dent that initiated on the OD and we had primary water stress corrosion cracks, same intersections, that were axially oriented.

We still run into stress corrosion cracks in the U-bend region, driven largely by the high stresses in the U-bend area. You will see up here in the corner the failure mechanism that was involved with the North Anna and Mchama Rupture events.

MR. LINDBLAD: Besides these degradation

mechanisms, it's my understanding that many tubes have been plugged because of fabrication concerns. Is that true on the first and second rows, let's say, of U-bends?

MR. MURPHY: That was a common practice at Westinghouse plants for a number of years. I think I heard a recent presentation from the industry that suggested that the current trend is more toward unplugging tubes that have been previously plugged in an attempt to recover these tubes. Sometimes they're doing stress relieves of the U-bends, inspect them and restore them to service.

I'd like to to spend a moment here talking about recent trends of concerns that we draw from recent experience. I think perhaps the most notable trend in recent years has been the emergency of stress corrosion cracking as the dominant degradation mechanism affecting steam generator tubing.

This may be ID initiated cracking or OD initiated cracking. There are two major reasons why we need to be concerned about stress corrosion cracking. The first is stress corrosion cracking -- the detection and sizing of these cracks poses a significant challenge to the current eddy current test capabilities in the field. This relates to the low signal amplitude of the indications and their low signal of noise.

The other implication of stress corrosion cracking is that the apparent crack growth rates that one deduces from the inspection results can be extremely high. For this reason, mid cycle inspections are sometimes necessary to ensure that cracks are detected before structural burst margins, as specified in Regulatory Guide 1.121 are exceeded.

In other words, you want to stay within these safety margins. You need to shut down at mid-cycle to avoid having cracks grow beyond the threshold of regulatory guide criteria.

Another important trend of note in recent years has been the emergency of freespan cracking. We're generally talking about here cracks that occur between support plates. Examples include McGuire 1 and 2, Palo Verde Unit 2, Farley Unit 1. So far the cracks down at Farley Unit 1 are shallow, but they are there, nonetheless, and I think we need to take note of that.

Recently there was a freespan axial crack, I believe it was OD initiated, in the U-bends at Braidwood. I think it was September, October, somewhere around there. October. This is something we may need to keep an eye on. It may be a lot of things. It may be perhaps a harbinger of McGuire type freespan cracking problems.

MR. SEALE: Excuse me. I understand you're keeping a close eye, along with the operator, on Palo Verde

Units 1 and 3. I was wondering has there been any evidence that anything is showing up there?

MR. MURPHY: No. Well, yes and no. Palo Verde Unit 1 came down in September of this year. They did not find any clear indications of free span cracking. What they did find was fairly extensive circumferential cracking at the expansion transitions, OD initiated, I believe.

Crack growth rates or the potential crack growth rates at Palo Verde Unit 1 are a potential concern. A comment that we had for the utility when we discussed this issue with them was that we wanted them to do a better job of trying to estimate the crack growth rates of Palo Verde Unit 1 in order to ascertain whether they need to have a mid-cycle inspection.

At Palo Verde Unit 3, which is presently shut down, they're in the midst of the inspection as of this moment. At the present time, they have not found anything of clear significance at Palo Verde Unit 3.

MR. SEALE: I understand the operating schedule is such that actually Unit 2 is the lead unit in terms of actual operating time or at least it was at the time the first problem showed up.

MR. MURPHY: Actually, I think as a first order of approximation, at the time each of these three units are shutting down, the operating years are almost the same among the three different units.

MR. SEALE: At the time they shut down.

MR. MURPHY: Yes.

MR. LINDBLAD: Mr. Murphy, I know you described this as recent trends, but over the long period, the 25 years that Mr. Strosnider showed us a graph on, there has been quite a change in the sensitivity of detection. When we're talking now about the recent trends, is that with a normalized, standardized detection method or is it with improving sensitivity as we go on?

MR. MURPHY: Well, both. Clearly, a lot of the indications being found today would have been much more difficult to find with the technology that was in use a decade ago. So we tend to find cracks sooner.

But there's another fact of life that one has to consider that complicates the issue. These cracks will either make themselves apparent sooner or they'll make themselves apparent later. You have to reckon with them sooner or later. The increased sensitivity, of course, provides the ability to --

MR. LINDBLAD: To get an early warning. But it also means that perhaps we've lived with many cracks for many years before they were detected.

MR. MURPHY: There's some element of truth in that and, of course, we'll be talking about that very point throughout the morning.

Just a couple of final points about freespan cracking. Freespan cracking was the mechanism behind the two most recent tube ruptures in this country, at McGuire Unit 1 in 1989 and, most recently, Palo Verde Unit 2 in the spring of this year.

Another aspect of freespan cracking is even though the cracks are occurring in the freespan, they're still difficult to find. Still, finding such flaws particularly early or before you've had a big leak or a rupture represents a significant challenge to the inspection personnel.

By the way, I think these two slides are intended to focus on issues that I think we need to be concerned about. Simply finding lots of indications isn't, of itself, something for concern from a regulatory standpoint, but certainly from an economic standpoint. But we think the concerns we're going through right now here are things we do need to be aware of and to be concerned with.

The third such trend I'd like to mention or allude to is the emergence of circumferential stress corrosion cracks. These have occurred both at Westinghouse type units and at Combustion Engineering type units, primarily at the expansion transition locations, at the top of the tube sheet at these units, but we also see these circumferential cracks elsewhere.

Such cracks, of course, have high tube integrity significance. These cracks have been up to 360 degrees around the tube circumference, with average through-wall penetrations in excess of 90 percent. So they are of tube integrity significance.

They can only be detected if licensees use RPC probes, non-standard type probes at susceptible locations. The types of eddy current probes that are used for routine inspection are not capable of detecting these kinds of cracks. One has to be looking for them to find them.

The next point I think is one that warrants special attention. Since the beginning of 1992, at least five plants have experienced periods during which one or more tubes have had insufficient margins for Regulatory Guide 1.121 sustained main steamline break pressure. As a matter of fact, in most of these instances, there was no margin. The burst pressures are down around the values 2,500 psi, which you may postulate an actual main steamline break delta P.

These instances have involved McGuire Units 1 and 2. We only have direct evidence of one tube being involved in each situation at McGuire 1 and 2. At ANO-2, three tubes pulled from the steam generators during the spring of 1992 exhibited 360 degree circumferential cracks, with average through-wall penetrations between 88 and 94 percent through-wall. So this plant was vulnerable to multiple failures for some period of time prior to that shutdown.

Palo Verde Unit 2, the direct evidence involves only two tubes as being vulnerable, but we can infer from the inspection results that the number may well have been higher than two tubes. Summer recently became aware of another tube there that, prior to its discovery by eddy current inspection, was potentially vulnerable to failure during a postulated steamline break.

MR. SEALE: Now, some of those cracks were circumferential and some were axial. Is that correct?

MR. MURPHY: That's correct. These were circumferential. The others are all axial.

If one looks at a risk analysis from steam generator tube rupture related events, such as risk analysis as described in NUREG-0844, one can lump the core melt risk from two different types of accident sequences, one involving steam generator tube ruptures as initiating events, that's one category. Another category would involve steam generator tube ruptures occurring as consequential events.

With respect to the first category, we build the frequency with some degree of confidence of ruptures occurring as initiating events. And so we have -- as frequency of tube rupture evolves over time, we can rather easily estimate the impact on core melt risk.

With respect to tube ruptures occurring as consequential events, that's a much more difficult problem. I think that we have to take note of this situation, be aware of it to ensure that if these incidents -- if we are, in fact, on a trend here toward increased instances of such events, then clearly that should be a cause for concern. Clearly, we want to turn that situation around.

MR. STROSNIDER: Emmett, if I could just interject something here. Jack Strosnider. One of the bullets that I have in my slides was with regard to an attribute of our generic approach going to all PWRs. I think if you look at this at least from an inspection perspective, one of the things that we recognize is that there's varying degrees of use of some of these advanced methods out in the field.

For example, if you look at circumferential cracks at the top of the tube sheet, it's important to do an RPC, a rotating pancake coil examination. The sort of thing that we're looking at is making sure, without necessarily saying this is how you do it, that people do some monitoring and inspection for that type of degradation, so that hopefully they catch it and take some corrective actions before it leads to tube leaks or tube ruptures.

The other comment with regard to this is that perhaps despite some of the best inspection work you might do, there is always some likelihood that you can miss some of these types of defects. That's why I mentioned earlier you need to look at this from an overall systems perspective, taking into consideration primary to secondary leakage monitoring, and even if you take the whole -- through the whole scenario, looking at operator training and response to events. So it's a very complex issue.

MR. MURPHY: In that vein, back, I think in three of the four cases here, with the benefit of hindsight, one can go back and critique the previous inspection work and say really they shouldn't have gotten into this situation, if they had done a more effective job with the existing technology previously.

Let me amend that statement. That's all four situations, not three of the four.

The final point we need to be aware of is there's no question that tubing, SG tubing typically exhibits leak before break behavior and that leak rate limits and leak rate monitoring are effective methods for minimizing the frequency of tube ruptures. But the point I would like to note, though, about recent experience is that we see that the occurrence of freespan cracking, axial cracking, and circumferential cracking may, in some instances, occur and lead to the tubes becoming vulnerable to rupture without significant precursor leakage.

In other words, we can't count on leak before break when it comes to freespan cracking or circumferential cracking.

MR. LINDBLAD: Let me see if I can understand that better before you remove it. The experience is service experience, correct?

MR. MURPHY: Yes.

MR. LINDBLAD: With generator tubes. And then it says "may become vulnerable." Are you saying that there have been ruptures without precursor leakage or is this still problematic?

MR. MURPHY: There have been ruptures without precursor leakage, absolutely. There have been ruptures with leakage amounts and ramp speeds that are well within the industry envelope of normal routine types of leakage occurrences and, at the time, were of no special note or concern to the utility.

MR. LINDBLAD: So I can replace "may" with "do" in that statement.

MR. MURPHY: You can, except that sometimes you will, in fact, with axial cracking or circumferential cracking, get a leak that gives you a timely warning that you have a problem, that shuts you down and you can make timely repairs. That will frequent happen. But the converse is also true. You may not get that precursor leakage.

We don't necessarily have leak before break in these instances.

MR. SHACK: Emmett, just to give me a calibrated feel here for what we're talking about, with the circumferential cracks, 360 degrees, 80 or 90 percent through-wall, what's your margin for failure on your normal pressure, your normal DP?

MR. MURPHY: I believe under accident conditions with a uniform circumferential crack, my best recollection is you need at least around 17 percent remaining wall, on average, to sustain steamline break pressure. So you would need, on average, something on the order of 92 percent or thereabouts to sustain a normal operating pressure differential.

MR. SHACK: So it's on that order.

MR. MURPHY: That's assuming you're not getting any help in restraining that tube from adjacent support structure and rust and corrosion product, so forth.

MR. WELTY: The converse is eight percent.

MR. MURPHY: Yes. Converse is eight percent remaining ligament. That's what you need there. I just want to briefly describe some of the implications of recent experience. These are not just implications of the recent concerns or the emerging concerns I was talking about, but experience in general.

One, there is a need for improved in-service inspections. There have been widespread deficiencies in inspection programs throughout the industry. We've described many of these deficiencies and information notices through the years. These problems are behind many of the circumstances that I did describe in the previous viewgraph, to be sure. So further discussion this morning on the need for improved inspections.

Not specifically related to the concerns I just described, but clearly an implication of recent experience is that there is a need for flaw-specific plugging criteria. The standard 40 percent plugging limit is over-conservative for some, but not all flaw types; for some, but not all cracks.

The 40 percent through-wall plugging limit, therefore, can lead to unnecessary plugging of tubes and we need to be cognizant of this, therefore.

Finally, it has become clear from our review of the instances of leaks during normal operation that there is clearly a need for both more restrictive limits and approved monitoring of primary to secondary leakage as an effective means for minimizing the frequency of tube ruptures.

MR. SEALE: Those two bullets are kind of counter to each other, aren't they?

MR. MURPHY: These improvements, I suspect, overall, would be in the direction of providing more restrictions, operational and inspection restrictions. The other, of course, would be, in some cases, a relaxation of existing requirements. Probably the most notable example has been the voltage-based plugging limit issue, the use of a one-volt criteria in lieu of a 40 percent plugging criteria.

The case for that is that the cracks that are subject to that criteria tend to be very short, tend to exhibit very high burst pressures, even though they may be greater than 40 percent through-wall. So the idea is to try to come up with a plugging limit that is more consistent with the actual burst of leakage integrity of the tube, the degraded tube.

MR. LINDBLAD: Let me be sure I understand your first remark there, Mr. Murphy. Mr. Strosnider showed us that we had 25 years of experience in tube degradations. Are the in-service inspection programs better or worse today than they were ten years ago?

MR. MURPHY: Five hundred percent better.

MR. LINDBLAD: Are they better or worse than they were five years ago?

MR. MURPHY: There's been a continuous and steady improvement.

MR. LINDBLAD: So the deficiencies we're talking about are really programs that may not achieve as much as state-of-the-art can do today. Is that --

MR. MURPHY: I'm sorry. I didn't understand.

MR. LINDBLAD: When you speak of widespread deficiencies in inspection programs --

MR. MURPHY: Let me give you a typical example.

MR. LINDBLAD: -- are you talking about a systematic deficiency --

MR. MURPHY: Yes.

MR. LINDBLAD: Or -- okay. I'll listen.

MR. MURPHY: Just to cite an example, I mentioned a plant which had experienced these large circumferential cracks. This situation only developed because the appropriate inspection technique had not been applied at this unit in previous inspections. Even though the location where these cracks occurred was known, generally known throughout the industry, the industry to be highly susceptible to circumferential cracks which require a special inspection technique.

That's kind of an extreme example of what I'm talking about, but the problems are pervasive throughout the industry.

MR. LEWIS: But that's not systematic.

MR. LINDBLAD: They're PWR plants and you're saying that a vast majority of them don't do it right. Widespread is what I'm --

MR. MURPHY: The inspection practices throughout the industry -- I'm going to get into this shortly anyway in a different context. But the inspection practices vary widely among utilities. The inspection practices improve radically once a utility becomes aware of a significant problem. We generally do see significant upgrades in the inspection programs in those circumstances.

Incidentally, those plants I cited in the previous viewgraph, the ones that had those periods of vulnerability, each one of those plants has substantially upgraded its inspection program following discovery of those problems.

MR. LEWIS: Let me ask the same question in a different way. Each of those bullets begins with the word "need" and the need is -- am I correct in saying that in each case, the need is a judgment call that the previous part of your talk was devoted to making these needs plausible, but there's nothing more than plausible, the judgment call behind the word "need." Am I correct? Am I overstating the case?

I'm particularly asking the question, let me say why, because if there's any great thrust in nuclear regulation over the last few years anyway, it's been toward what is called risk-based regulation; that is, any assertion of a need ought to be related to a reduction of the public risk or to improved assurance that the public risk is as low as we all think it is or something related to risk.

But that's not been demonstrated for any of those three bullets, is that correct?

MR. MURPHY: We will be going through -- I am, with the word "need," setting up -- Tim Reed will be here -- for his later presentation.

MR. LEWIS: You're saying I should beat on him and not you.

MR. MURPHY: No, I'm not.

MR. LEWIS: I'll do that, if you want.

MR. MURPHY: It's these needs that lead to -- that have led to the development of the SG integrated action plan rulemaking activities and all that kind of stuff. This is why we need to do that.

Now, with regard to risk, part of the exercise that we'll be going through as part of this rulemaking activity will be deal with the safety goals on --

MR. LEWIS: I didn't mention safety goals, you did. But you're saying that the need is a programmatic need, not a public safety need.

MR. MURPHY: The risk considerations are -- they are issues of regulatory compliance. I didn't really intend to get into all this right now, but I would only point out that we -- that the tubes constitute the bulk of the surface area of the reactor coolant system boundary. We're developing large cracks in this boundary. We're getting occasional ruptures.

MR. LEWIS: That doesn't help, because --

MR. MURPHY: And risk from tube ruptures that are consequential events -- those kinds of estimates are difficult to achieve with great accuracy. I think one must also, just using a common sense approach, just ask himself the question, when he's given these big cracks that degrade pressure integrity to less than 2,500 psi, with such frequency over a two-year period, I think one needs to seriously confront the adequacy of the regulatory basis.

MR. LEWIS: That's your set of arguments. Thank you.

MR. MURPHY: Yes, you're right. It is judgmental.

MR. LEWIS: Of course. I knew that. As far as the argument about the surface area, I've got to respond by saying that the surface area of my body is predominantly skin, but it's not the major threat to my health, although it's the major source of my bleeding when I bleed. Surface area is an irrelevancy, I think.

MR. STROSNIDER: This is Jack Strosnider. I'd like to see if I could address that question a little.

MR. LEWIS: You don't want to let me wait and beat on --

MR. STROSNIDER: No. The comment I wanted to make is that, first of all, with regard to the generic initiative we're taking to develop a generic approach to this issue, we will be and we have in the plan the sort of risk evaluations and looking at this and I mentioned looking at the whole system in terms of thermal hydraulic response, materials integrity, radiological consequences, operators, etcetera.

So we're going to be looking at that very closely as we go through developing criteria. But I think the driving force for the word "need" in these slides are some specific examples and Emmett just gave four of them where here were plants that were susceptible to multiple ruptures under postulated accident conditions.

If you go back to some of the earlier risk assessments on 0844, what we see is they didn't -- this points to a possible increase, at least in that factor in the risk assessment.

If you want to keep it where we think it was, if you want to assure yourself that it's not going to get any worse than you had in those prior evaluations, then you need to do some things here.

MR. LEWIS: Let me just interrupt and say the word "possible" should never appear in an argument that is associated with risk-based regulation and the argument that you've got to make things better as a driving force should never appear.

The argument for risk-based regulation is that you want to maintain the level of safety that is appropriate to the adequate protection of public health and safety. At some point, somebody's got to make that decision. And unless you start way down at the bottom, which is what we're doing here, it never gets to the top.

MR. STROSNIDER: And the point that I'm making is if you look at the generic issues A3, 4 and 5 and 0844 in the resolution of those issues, they determine that the risk is acceptable. You now look at some of these situations that occur in the plant, you say, well, if I want to maintain the assumptions that went into those risk assessments, it appears that I need to do some things, like enhanced inspections.

If you look at the last bullet that was on there, which was with regard to primary to secondary leakage monitoring, if you go back and look at some of these tube rupture events, you see that if people had been using the best technology and the operators had responded a certain way, you might have avoided some of those ruptures.

That goes to maintaining the current frequency of initiating events at the level that it has been, which has been deemed to be acceptable.

MR. LEWIS: Only a few show that not using the most modern and best techniques will degrade the safety if applied below acceptable limits. That's what you have to show in the end. So I have a mixed feeling.

I'm concerned about the relevance of all this to risk, wearing one of my hats, but wearing my physicist hat, I'm very interested in eddy currents. I'll beat on everybody as we go along, until I get tired.

MR. STROSNIDER: Why don't we let the risk fellow talk about it, Steve Long.

MR. LONG: I'm Steve Long. I'm in the Risk Assessment Branch in NRR. I generally agree with what you're saying, but remember that we're talking about changing the basis for regulating the inspection and the maintenance of tube integrity.

The criteria we have now for tube integrity are there shouldn't be anything going more than 40 percent through the wall of the tubes and a lot of the previous risk assessments are based on that assumption.

We're finding now that we really can't tell when something has gone more than that distance in the tubes; in some cases, 100 percent through the tube wall. So we're really trying to use risk and other approaches to define a more appropriate way of regulating tube integrity.

The current regulation doesn't necessarily guarantee the safety level that we would like. We're not sure what safety level it's providing now. We're not sure what it might provide in the future as the degradation gets more widespread.

But the type of regulation we have now provides a disincentive to find out how bad your tubes are becoming until something makes it apparent, like a tube rupture. The tube rupture -- one tube spontaneously rupturing is something we wouldn't like to see happen very often. It looks like from the IPE that there's about a one-times-ten-to-the-minus-four or somewhat better probability of mitigating each one of them.

So we wouldn't like them to be happening several times a year, that it would challenge the safety goals. The other part of it, though, is we're not sure right now what the response would be to a major secondary side depressurization, how many tubes we may pop under those circumstances or during an ATWS event.

In addition, we're concerned about the response of the tubes under high temperature/high pressure conditions where the core may be melting from some entirely different cause besides the tube integrity, what that may mean in terms of essentially the containment integrity, where the tube wall is really serving as the containment.

So we're going to be looking at a lot of these things from, I'd say, a fairly fresh perspective, trying to see what types of assurances we could get with inspection techniques and then we would be setting essentially new standards on voltage or rotating pancake coil or whatever type of tests that we feel would give us a reasonable assurance of safety, but it would be different than the 40 percent through-wall.

MR. LEWIS: I have no problem with what you've said, except every now and then you said things like "We would like to be sure," that's not good enough and so forth. In general, I'm in favor of better diagnostics. There's no question about that. And, in fact, just to look a little bit ahead, I'm going to start out needing to be convinced that a voltage-based criterion for a specific measuring instrument is a better way to go than a crack depth, because cracks cause leaks and volts don't cause leaks.

So you're backing off from the approximate cause of leaks. You can get into a pickle in which, in the end, as technology improves, you can be making serious mistakes. I'll give you an example. We still talk in earthquakes about Richter magnitudes. The Richter magnitude is the actual amplitude of the first oscillation in a particular sizemometer that was built by poor Richter at Cal. Tech., and we're still calibrating the damned earthquakes --

forgive me -- the darned earthquakes in terms of that particular instrument.

It inhibits progress in understanding earthquakes, because everything has got to be referred back to that particular instrument, which takes a particular cutout of the spectrum. You don't want to get to the point at which you're too dependent on a particular measuring instrument. I can give you lots of other examples. You want to get as close to the root cause as you can.

MR. MURPHY: Let me make just one final point before we --

MR. LEWIS: I'm digressing.

MR. MURPHY: I'm sorry. Am I interrupting?

MR. LEWIS: Go right ahead.

MR. MURPHY: One final point to note here. Each of these tubes I've mentioned here was either a ruptured tube or a pulled tube. These are tubes that slapped us in the face. There may well be a number of other occurrences out there in the industry for which we don't have definitive information regarding its residual integrity.

NUREG-0844, which included that steam generator tube rupture events were not a dominant core melt contributor, was based on the premise -- on the assumption that the conditional probability of tube rupture given steamline break was one in 20. I think we need to -- when we see -- when we get direct evidence of situations like this, I think we need to be mindful of the potential significance of these kinds of events and what we can do to minimize the occurrence of these kinds of events.

MR. SEALE: Excuse me. Bill, you had some comment.

MR. LINDBLAD: I found Mr. Long's comments very helpful, but I don't see him on the program. Is he going to make a presentation, Mr. Strosnider?

MR. STROSNIDER: It is not on the agenda.

MR. LONG: It wasn't intended because at this point I don't have the information necessary to do very many calculations.

MR. LINDBLAD: Mr. Strosnider, did I understand that you said that the statement of safety or what the NRC believes still has to be determined in the course of rulemaking or have you reached some conclusion at this point about relative risk and how a change in criteria would effect risk? Because that's what I find necessary for us to conclude something here.

MR. STROSNIDER: We are not prepared today to discuss the full scope of risk assessment. What you're really getting from today's agenda is the materials engineering perspective and you're getting our perspective on these various types of degradation, where we think they might be significant contributors to risk.

With regard to the overall criteria or generic effort that we're pursuing, you'll see, when we put up the plan for it, that it involves not just materials engineering, but the Risk Assessment Branch, the Systems Branch, the Radiological Branch, and there are activities -- work that's going to be done to assess these risks and assess whatever performance-based and alternate criteria we come up with in terms of risk, as well as the other general design criteria.

MR. LINDBLAD: But that has yet to be done.

MR. STROSNIDER: It's yet to be done.

MR. SEALE: I hope we're not falling too far behind. I hope we're helping ourselves with some of the later issues.

MR. LEWIS: Well, Bob, we may be able to pick up some time, because if I understand this last conversation, we really shouldn't be talking about risk. We should be talking about the difference between these two methods for assessing the integrity of steam tubes. In this case, we should skip all this other stuff and get down to that.

MR. SEALE: We'll see.

MR. LEWIS: I have no problem dealing with a part of the problem.

MR. MURPHY: The NRR response to what's been going on in the way of operating experience has been fourfold. One, of course, we monitor SG experience. We issue information notices and bulletins, what have you, in response to events of concern that we see.

Very importantly, we also communicate various issues and concerns with the regions for their consideration and for when they're performing their activities at the sites. We recently, over the past couple of days, on Tuesday, we had a counterpart meeting with each of the regions, representatives from each of the regions who are involved in steam generator issues within their regions. So this is an important area of activity for NRR.

Secondly, for plants that are experiencing significant SG degradation problems, we interact with the regions and with the licensees to ensure that licensee programs provide adequate assurance of tube integrity and public health and safety.

We've gone through some very manpower-intensive efforts recently on Palo Verde, McGuire, ANO, to be sure that these plants have taken all the necessary precautions and actions to provide adequate assurance of public health and safety.

Thirdly, we're spending a lot of resources within NRR to evaluate plant-specific proposals for alternate plugging limits. Right at the present time, for example, there is a proposal in-house for a so-called W-star type plugging limit. It is similar to other type F-star, P-start criteria which involve actual cracks within the -- axial or circumferential cracks within the tube sheets, where there is some embedment distance between the occurrence, the cracks and the top of the tube sheet.

We're also involved in reviewing interim voltage-based plugging criteria. Ken Karwoski will be discussing the voltage-based criteria in more detail in a moment.

Finally, we are implementing the NRR integrated SG action plan that Tim Reed will be talking about in a moment -- in an hour.

For plants that have experienced significant degradation and which draw the attention of NRC staff, there are a number of potential issues, issues that come up again and again from plant to plant.

These issues -- some are fairly obvious. We're invariably discussing the scope of the inspections. The inspection equipment procedure is being employed. The training of the analysts. We discuss very closely with the licensee his operational limits and monitoring procedures from primary to secondary leakage.

We take a close look at -- well, actually, in this case, we're also interested, but we don't as aggressively pursue actions being taken by utilities to mitigate further degradation, such as improving their secondary water chemistry programs, implementing T-hot reductions. The licensees tend to have a very strong economic incentive to do what's necessary to mitigate further degradation.

A very important area that we do focus on, though, and aggressively pursue is the tube integrity assessment at the severely degraded plants. An important issue is the protected crack growth rates, because an important question is how -- once the plant restarts, how quickly will cracks below the detection threshold grow and begin to challenge the structural margins implicit in the Reg Guide 1.121 and will there be a need for a mid-cycle inspection to ensure that those criteria are satisfied for the duration of the cycle.

So this is a very important issue to be addressed in the cases of these plants experiencing significant degradation.

Additionally, we frequently have a need, especially of late, to consider risk and safety considerations involved with plant restart. As an example, at Palo Verde Unit 2, as they completed their outage, recovering from the steam generator tube rupture event, we concluded that there was great uncertainty in the projected crack growth rates for Palo Verde Unit 2.

Even though the licensee was proposing to operate for six months only prior to performing a mid-cycle inspection, given the uncertainties of crack growth rates, we did not fully ensure that the reg guide limits on structural margins would be maintained for the duration of that six months.

For this reason, as part of the SER to support plant restart, the risk assessment people within NRR took a look at potential safety and risk implications of the uncertain crack growth rates and that then became an integral part of the staff's rationale to support operation for six months and the authorization to operate for six months.

As part of this exercise, we frequently discuss with the licensee their emergency operating procedures, how well they've been updated to keep abreast of developments in that area and owner's group activities in this area, and how well and intensely the operators have been trained on these procedures for responding to tube rupture events or other steamline break events involving tube ruptures.

I want to get on to a different topic now, the next topic of the agenda, which deals with steam generator in-service inspection issues.

As we've already discussed, there have been extensive difficulties in the past, right up to this present day, in detecting flaws reliably and accurately sizing flaws. These difficulties have stemmed from a number of --

MR. LINDBLAD: Mr. Murphy, frequently when we're talking about inspection in this room, we're talking about NRC inspection. These are licensee inspections, are they?

MR. MURPHY: These are in-service inspections conducted by the utilities on the condition of their steam generators, eddy current inspection.

MR. LINDBLAD: Does the NRC have their own inspection team that audits these inspections with their own measures?

MR. MURPHY: We don't have anything like the Region I mobile NDE van with an eddy current capability. We have nothing analogous to that situation for steam generators. The regions do follow and send inspectors out to review inspection programs at individual utilities. So, yes, they do have activities in this area.

MR. LINDBLAD: But, in general, you're talking about the difficulties licensees have in doing the inspections.

MR. MURPHY: That's correct.

MR. STROSNIDER: Emmett, I would like to point out -- this is Jack Strosnider -- that we have on occasion, where we feel necessary, we have some technical assistance contract with Oak Ridge National Laboratory, where we have some eddy current experts on-call. They have gone out with people from NRR and regional inspectors to review some of these inspections. These are people who are qualified to review eddy current data and verify the sort of calls being made.

So on a case-specific basis, we have done that when we felt it's appropriate.

MR. MURPHY: The difficulties with the effectiveness of the NDE inspections stem from a variety of different reasons. One is small initial sample sizes that are sometimes employed at individual utilities.

MR. LINDBLAD: Not en ugh cracks, are you saying?

MR. MURPHY: Not enough inspections. Not pushing the probe through enough tubes. They also relate to reasons associated with the eddy current technique itself; equipment limitations, probe limitations, limitations in the test and evaluation procedures at the site, and personnel limitations. Primarily, those are the data analysts.

MR. SEALE: When you say personnel limitations, do you mean the problem of just supporting the time required to do it in terms of radiation exposure or do you mean competent people to interpret the results?

MR. MURPHY: I'm talking primarily about the people that interpret the results. The inspection difficulties, as we've noted earlier, are the most acute for cracks due to their low amplitude and low signal on noise.

At the present time, it's the staff's opinion that 40 percent through-wall cracks cannot be reliably detected or sized with NDE technologies and practices currently being applied in the field.

However, cracks can be reliably detected before tube integrity is impaired, but this is provided that utilities are using the appropriate test equipment, including probes, test procedures and data analysis procedures, and if the analysts have been adequately trained and tested on these procedures.

As I noted earlier, there have been deficiencies in this regard throughout the industry.

MR. LINDBLAD: Let me understand what that says. You say your current criteria calls for tech specs which require plugging 40 percent or greater through-wall cracks.

MR. MURPHY: That's right.

MR. LINDBLAD: So you're saying that 40 percent or less through-wall cracks cannot be reliably detected.

MR. MURPHY: They sometimes get up to --

MR. LINDBLAD: But we don't need to if we only want to plug the ones that are greater than 40 percent.

MR. MURPHY: That's true if you're talking about ODSCC at the tube support plates, but we're not always talking about ODSCC at the tube support plates. We're sometimes talking about 17-inch long cracks in the freespan.

MR. LINDBLAD: And the tech spec doesn't cover that currently.

MR. MURPHY: The tech spec -- this is the appropriate plugging limit, 40 percent, and we need to be able to find these. Right now we can't do it reliably.

MR. LEWIS: What does the word "reliably" mean?

MR. MURPHY: Reliably, I think, in a regulatory sense, means that you can -- that your confidence of finding a given indication is consistent with the goal of providing for adequate tube integrity and adequate protection of public health and safety.

MR. LEWIS: Is that what reliably means?

MR. MURPHY: It's 95 times out of a 100.

MR. LEWIS: I thought reliably meant 95 percent or 92 percent or 37 percent of the time.

MR. MURPHY: It's somewhat of a function. The answer to that question is somewhat of a function of the kind of flaw you're dealing with.

MR. LEWIS: But if you say it cannot be reliably detected, it would be nice to know what the word really means. Have I missed the point?

MR. LINDBLAD: They're quantitative.

MR. LEWIS: Twenty-two?

MR. MURPHY: What I'm talking about are the -- eddy current reliability is often expressed in terms of probability of detection.

MR. LEWIS: Sure. That's fine.

MR. LINDBLAD: What is that?

MR. LEWIS: What is it?

MR. MURPHY: What is probability of detection?

MR. LEWIS: Yes, that you regard as unreliable. When you say it's not reliable, you must mean that there is some probability of error, non-detection.

MR. MURPHY: For example, I think as a first order of approximation, if you have a 50 percent through-wall crack, typically, the probability of detection is on the order of -- let me say 40 percent through-wall crack, the probability of detection is on the order of 50 percent.

MR. LEWIS: Fifty percent.

MR. MURPHY: Yes.

MR. LEWIS: So you think it can only be detected about half the time at 40 percent.

MR. MURPHY: At 40 percent through-wall.

MR. LEWIS: At 40 percent, okay. I'm just trying to get at the number. So at 40 percent through-wall, just so I haven't misunderstood you, you think that you only have about half a chance of detecting them.

MR. MURPHY: Right.

MR. KRESS: The other part of that question is if that number were 90 percent, would you be happier, or 95 percent?

MR. MURPHY: Sure.

MR. KRESS: What level would you be willing to quit at?

MR. MURPHY: I think you have to look at the end result. The end result, as far as I'm concerned, is we're getting a awful lot of -- we're getting tube ruptures at some frequency. We're getting other situations where tubes are vulnerable to failure if they're challenged by a postulated event.

I think we need to look at what's been happening, ask ourselves the question does this pose any safety concern or create any other regulatory issue that we need to deal with and to correct, and that's what we're doing as part of the integrated program.

MR. KRESS: You're saying 50 percent probability and lower you know is not reliable, but you're not sure what would be.

MR. MURPHY: You can't judge the issue in a vacuum. Is 50 percent the right number or 95 percent of confidence the right number? We have to look at what the end result is in terms of how well we're maintaining tube integrity and what the risk implications -- safety implications of that --

MR. STROSNIDER: Jack Strosnider. I'd like to say something on both these questions, because I think they're excellent questions. They're questions that we've asked ourselves. In pursuing this plan that we're putting together, we have some data, which Emmett just referred to, which may be somewhat dated, but I'm not sure about that, about what the reliability is.

Part of the thing that we feel is important here when you start looking at performance-based regulation is if you don't at least set the performance criteria, you should certainly at least understand what the performance is. There probably needs to be additional work in understanding exactly what these probabilities in detection are.

We've had discussions with the industry on this. The second part about what's acceptable fits into the overall risk picture. Certainly, it has to be factored in, as I said earlier, from beginning to end. But both of those questions are questions that we've asked and that we plan to address in the work that we're pursuing now.

MR. LEWIS: Sure. No. I agree completely with you. In fact, I thought that the 50 percent that I just heard was based on data which show that people miss 50 percent of the through-wall cracks 40 percent of the way through the wall. Is that not based on data, what you said?

MR. MURPHY: It's based on work done by Research. It's based upon a large number of tubes that have been pulled from the field and you compare the --

MR. LEWIS: So it's based on data.

MR. MURPHY: Yes. It's based on data.

MR. LEWIS: Then the question of whether it's acceptable would depend on what the overall risk is, because if missing half of them was unsatisfactory and missing 25 percent of them would be satisfactory, I'm just inventing a number, that would be a determination that you would make by deciding that you don't mind -- that you want to cut the risk due to this contributor in half and you would only want to do that if it's a substantial contributor.

So the extent to which you're willing to be loose about anything depends on how important it is. So in the end, you've got to -- and we are going toward risk-based regulations. So you're going to have to do that.

MR. MURPHY: In the case of ODSCC at the tube support plates, which is a major contributor to tube plugging around the country, we've already made the conclusion that the occurrence of short cracks above 40 percent through-wall are not of significant tube integrity concern and we've resorted to -- and we've proved for a number of units the voltage-based rate, which, in effect, will allow 100 percent through-wall cracks, if they're short enough, is a small enough signal to remain in service because they don't represent a significant threat to tube integrity.

MR. LINDBLAD: Was that a generic conclusion or was it only applied to individual licensees?

MR. MURPHY: So far -- Ken is going to talk about this in a moment. It's been a plant-specific decision up to now. We're working on the generic finding right now as part of NUREG-1477, but that discussion is to follow.

As has been noted by Jack earlier this morning, inspection capabilities through the years have been significantly improved. Back when I first came here, everybody was routinely using single frequency analog techniques in the field. Today everybody is involved. It's pretty much standard practice throughout the industry to utilize digital multi-frequency eddy current systems.

There's been considerable developments in the area of probe technology. We now have alternatives to the industry standard bobbin probe, which is the one that's routinely used for inspection. Of particular note is the motorized rotating pancake coil probe, which has the capability to detect circumferentially-oriented cracks.

It also gives us the capability -- the utilities the capability to detect cracks at locations, such as dents, expansion transitions, U-bends. So the development of these other probe types has been another significant development in eddy current technology.

There have been improvements to the updates of the code to accommodate these technology improvements. Furthermore, I think of particular note is the development by EPRI and the industry, in general, a set of SG examination guidelines. These guidelines date back to the early to mid-1980s, but have been substantially upgraded year by year. I think they're now into Rev. 3 of these guidelines.

If all the utilities were implementing these guidelines, the tube integrity performance would be superior in the field to what it is, in fact. The degree of adherence to these guidelines does vary widely among different utilities.

In spite of these improvements, much does remain to be done. Even with the best technology and the best analysts, the utilities are still challenged to find, with a high degree of likelihood, deep cracks at their facilities.

Part of the problem relates not just to limitations of current eddy current techniques and practice, but relates to what Jack referred to as out-of-date requirements that we presently have in place in the tech specs.

Much of what industry does to find these very small amplitude indications involves the use of -- it involves industry initiative, going beyond minimum requirements, as specified in the code and the tech specs. Clearly, we need to update our regulatory basis to be consistent with the technology used today and to be consistent with the kinds of problems that are actually being experienced in the field.

This is being pursued as part of the integrated steam generator action plan. I think it's worthy of note that an important element of this integrated plan is to include consideration of the industry-developed guidelines for SG inspection. As we pursue this plan and we work toward improved regulatory framework governing tube integrity issues, we will be giving close consideration to the EPRI guidelines.

I'm not going to spend much time talking about this. I know that Mr. Blomgren and Mr. Welty are here to talk about the various EPRI programs, industry programs. But I think it's worthwhile just to note briefly what's contained in these guidelines in terms of general subject matter.

Rev. 3 of the guidelines include enhanced criteria for the qualification of NDE personnel. These qualification criteria are both generic and plant-specific. The generic program, I think, is generally referred to as the so-called QDA program, for qualified data analyst. It involves trending modules, testing, and testing of the analysts, but each of a number of degradation mechanisms to ensure that they're all of some good minimum threshold capability.

The guidelines also include performance demonstration criteria for eddy current test techniques. That's equipment and the procedures. They contain detailed guidelines on data acquisition. They also address detailed guidelines for data analysis. Finally, the guidelines contain a number of recommendations with respect to recommended sample sizes. These recommendations, again, go beyond minimum regulatory requirements.

The guidelines recommend an initial section sample of 20 percent of the steam generator tubes. The current minimum regulatory requirement is three percent.

Finally, on the subject of eddy current test issues, we met with the regions two days ago to discuss and have some give-and-take on steam generator tube integrity problems being experienced around the country. One of the areas we focused on was where the regions need to concentrate attention and to discuss what with licensees -- focus their discussions with the licensees.

The items here on this viewgraph are areas where we discussed -- these are areas which we concluded warranted detailed consideration by the regions as they pursue their activities. Locations in the generator subject to circumferential cracking should be inspected by MRPC probe or equivalent. Circumferential cracks are not generally detected by bobbin probes, as I've indicated.

We know that certain areas of the generators are subject to these circumferential cracks and we need to pursue with utilities what actions utilities are taking to inspect these areas with the appropriate probes. These include the tube sheet expansion transitions and combustion units, the Wextex and full depth roll expanded transitions in the Westinghouse plants, the tube support plates at heavily dented intersections.

Another area warranting attention at steam generators was a number of large dents. Large dents can obscure a small amplitude crack signal. When confronted with this kind of problem, the only way that one can have reasonable confidence of finding a small amplitude crack signal is to use the appropriate technique, which is something on the order of an MRPC probe.

A number of utilities are not sensitized to this issue and discussions with the utilities I think are warranted on these kinds of issues when they're encountered.

MR. SEALE: Is that "affected by" on that chart?

MR. MURPHY: I'm sorry.

MR. SEALE: The note under the second bullet, "The bobbin dent signal."

MR. MURPHY: The bobbin dent signal can mask a flaw signal.

MR. SEALE: Read the next line.

MR. MURPHY: The next line, "RPC is not affected by the dent."

MR. SEALE: "Affected by." Okay.

MR. LINDBLAD: It's a typo on your viewgraph.

MR. MURPHY: Okay.

MR. LEWIS: You ought to run the whole bunch of slides through a spell check because there have been lots of things like that.

MR. MURPHY: I did this one last night. I was tired.

MR. SEALE: I gathered that, with the timing on this.

MR. MURPHY: The RPC coil rides the surface of the tube. It, therefore, rides the dent and the dent does not produce a response then. Small radius U-bends produce a lot of noise or a lot of interference signal on the bobbin channels. RPC is really the only way to effectively inspect small radius U-bends for small volume cracks.

A very important issue that frequently comes up is the need for all eddy current indications to be reported and dispositioned as pluggable or not pluggable, irrespective of signal amplitude or signal noise ratio.

It was common practice for a number of years throughout the industry for the analysts not to record low amplitude signals, indications on the order of a volt or even a volt-and-a-half might not be reportable. According to the plant guidelines, plant procedures, even though there is considerable pulled tube evidence to show that cracks can be up to 100 percent through-wall by the time you're talking about one volt signals.

In fact, this kind of practice represented a de facto interim plugging -- de facto voltage-based plugging limit. In some cases, it may well have been appropriate, even though it wasn't formally reviewed. On the other hand, as we talked about, there are areas like the freespan locations where that kind of approach is not appropriate.

MR. LINDBLAD: Do these measuring systems have processing to enrich the signal-to-noise ratio or are these raw signal-to-noise ratios that you're talking about?

MR. MURPHY: There is considerable signal processing and they have filters to avoid --

MR. LINDBLAD: So yes, they do.

MR. MURPHY: And they should have criteria -- they should have criteria that called for retesting when --

MR. LINDBLAD: So when you're talking about the signal-to-noise ratio, it's the processed signal-to-noise ratio.

MR. MURPHY: Yes.

MR. KRESS: If one is supposed to make a dispositioning judgment, how does one do that irrespective of single amplitude and signal-to-noise ratios? Is there another way to look at the data and say that this has to be plugged or doesn't have to be, other than using those?

MR. MURPHY: When faced with a low amplitude distorted signal, for example, it's difficult to interpret on a bobbin channel. One might be very reluctant to plug such a tube purely on that basis alone. It could be a flaw. It might not be a flaw.

What is most normally done by utilities in these sort of situations is to do an MRPC examination. The MRPC examination can generally be expected to resolve the question of whether you're dealing with a real crack.

MR. KRESS: You're not calling an MRPC an eddy current indication then. You're restricting that simply to bobbins.

MR. MURPHY: Current practice is to use bobbin for your routine inspection work.

MR. KRESS: I see.

MR. MURPHY: And where bobbin indicates that you have a potential flaw or distorted flaw or something you can't quantify, at that point, you bring in MRPC. You use MRPC to resolve that indication.

MR. KRESS: Now I understand.

MR. SEALE: So this is really just a screening criterion, isn't it?

MR. MURPHY: Bobbin is, for practical matters, used as a screening method.

MR. SEALE: Then the MRPC settles that, hopefully.

MR. MURPHY: Yes.

MR. LINDBLAD: Let me go back to a discussion we had earlier. When you spoke of 40 percent through-wall cracks cannot be reliably detected, did you mean bobbin tests or rotating pancake coil tests?

MR. MURPHY: I meant both, although there's conflicting evidence and I think it depends on the situation. There have been times when RPC is performed better, like at Palo Verde and the discovery of freespan cracks.

MR. LEWIS: When you say both, do you mean either or do you mean both? What do you mean?

MR. MURPHY: Typically speaking, both MRPC and bobbin probes are not going to detect shallow cracks.

MR. LEWIS: True.

MR. MURPHY: Bobbins will never detect circumferential cracks until they become --

MR. LEWIS: They're not designed to.

MR. MURPHY: Right. They're not designed to. RPC will.

MR. LEWIS: That's why they don't.

MR. MURPHY: Furthermore, bobbins have great difficulty in detecting cracks at dents, at expansion transitions, at U-bends. RPC does have the capability to resolve cracks at those locations.

MR. LEWIS: I'm still trying to understand the answer to Bill's question, though. When you say the 50 percent on the 40 percent through-wall cracks, you mean neither one can detect it in 50 percent of the cases. Is that what you mean?

MR. MURPHY: At 40 percent through-wall, yes.

MR. LEWIS: That's all I ask, if you meant either or both.

MR. MURPHY: This is the last half of that viewgraph.

MR. LEWIS: That's an interesting one. That will cut down the questions.

MR. MURPHY: Let me go through here quickly. Utilities should have a basis for dispositioning undefined, non-quantifiable, distorted bobbin indications as non-pluggable. Utilities shouldn't be arbitrarily dismissing low amplitude, distorted or non-quantifiable signals.

MR. LEWIS: Is that strange combination of letters "dispositioning standard in the trade?"

MR. MURPHY: I believe so.

MR. LEWIS: Does everyone say dispositioning?

MR. MURPHY: I believe so.

MR. LEWIS: Even though it's not a word. That's interesting.

MR. MURPHY: A basis should be developed before relying on eddy current depth measurements for dispositioning stress corrosion cracks as pluggable or non-pluggable. There is considerable evidence developed as part of the NRC research program and also developed by the industry themselves that shows that bobbin or eddy current probes in general exhibit poor performance, extremely poor performance for purposes of quantifying the depth of the crack.

And given that situation, one shouldn't rely on a depth measurement from eddy current to make -- as a basis for the decision as to whether to plug the tube or not plug the tube. In fact, most utilities don't rely on the eddy current depth measurements to make that decision. If eddy current finds a possible crack indication, MRPC confirms the indication as being a crack indication, the general practice is not to worry about the depth of the indication, just plug the indication or plug the tube with the indication. It's not universal, that practice is not universal.

We also discussed with the regions the need to focus on electrical noise being picked up during the test and, where necessary, to discuss that issue with the licensees.

Finally, for some of the newer plants where the tubes were manufactured by a pilgering process, we know from the Palo Verde experience that as these types of tubes begin to develop cracks, the pilgering process has introduced a pattern of stresses on the ID of the tubing that produces a large interference signal and greatly complicates the analysis of the data.

So we're going to need to focus attention on being sure that the plant data analysis procedures adequately address the pilgering noise issue and provide for getting around it.

Thank you very much. I think the next -- I'm not sure what's next on the agenda.

MR. STROSNIDER: I guess there's a break.

MR. SEALE: Yes. I guess there's a break. Are there any questions at this point, before we break?

MR. LINDBLAD: Yes, but I'll save it.

MR. SEALE: Okay. We'll reconvene at a quarter of eleven.

[Recess.]

MR. KARWOSKI: Good morning. My name is Ken Karwoski and I'm going to be talking about tube repair criteria. Specifically, I'm going to give a little background on how the tube plugging limits have historically been calculated and then go into some of the alternate repair criteria that the industry has proposed.

Regulatory Guide 1.121 contains the methodology for determining tube plugging limits. In this regulatory guide, there are several structural criteria which must be met in order to show acceptable tube integrity margins.

The most limiting of these criteria, there are two of them. They're either the one that requires a margin of safety of three under normal operating pressure differentials and a margin of safety of 1.4 under postulated accident conditions, such as a steamline break.

These structural criteria are used in the calculation of a minimum wall thickness requirement. So when you determine your plugging criteria, you use this minimum wall thickness requirement. You add a margin for eddy current uncertainty and a margin for degradation growth between inspections. You sum these three factors together, you subtract them from 100 percent of the wall thickness, and you end up with the tube plugging limit.

When this methodology was implemented in the 1970s, this has typically resulted in a tube plugging limit of 40 percent, and that's what's in most technical specifications. Some have a 50 percent plugging limit, but the majority are 40 percent of the tube wall thickness.

MR. LINDBLAD: Mr. Karwoski, I know that you're talking about tech specs and regulatory guides which aren't necessarily regulation. What general design criteria are they based on and where is the rule that covers all of this?

MR. KARWOSKI: Well, the general design criteria is 14, 15, 30, 31 and 32 all deal with steam generator tube integrity. Fourteen says --

MR. LINDBLAD: Is there any quantified number there?

MR. KARWOSKI: No. It's extremely low probability of abnormal leakage, rapidly propagating failure of growth structure. So the general design criteria does not say you shall calculate your plugging criteria by this methodology.

MR. LINDBLAD: Thank you.

MR. KARWOSKI: As I was saying, typical technical specifications have a 40 percent tube plugging limit in them, and that's applicable to all degradation mechanisms, as was alluded to earlier. It's applicable to stress corrosion cracking at the support plates, at the roll transition and the freespan. It's applicable to wear and actually to all degradation mechanisms.

Now, the minimum wall thickness calculation requires that you assume a certain crack geometry. Since wastage was the dominant degradation mechanism in the early 1970s, a uniform thinning model was used. This uniform thinning model led to the 40 percent depth base limit. However, for very tight stress corrosion cracks, as Emmett talked about earlier, this limit tends to be conservative and it's conservative for other flaw types.

As a result, the industry has submitted various other alternatives to this 40 percent depth base repair limit, some of which have been approved in the past and some of which we're revealing now.

There is a criteria that's been approved in the past for degradation within the tube sheet, referred to as F-star and P-star. This criteria essentially allows any tubes with degradation below a certain distance below either the top of the tube sheet or the roll transition, whichever is lower, to remain in service, regardless of the depth of degradation.

Structural integrity is ensured with this criteria because the tube is constrained from bursting by the tube sheet and also the distance that you set prevents axial pull-out of the tube from occurring.

Leakage integrity is ensured because the tube is essentially rolled into the tube sheet and it's a very tight crevice there and of all the tests done, there's been no significant leakage from there.

Another alternate plugging criteria which has been approved already is an alternate plugging criteria for pitting. This was approved, I believe, for one cycle at Indian Point Unit 2, where the 40 percent plugging criteria was changed for pits and they adopted a plugging limit on the order of 63-64 percent.

Of more concern now is other forms of degradation, such as the axial ODSCC at the support plates and the axial primary water stress corrosion cracking at the roll transitions. These two approaches differ from the depth based 40 percent plugging criteria in the sense that for the axial ODSCC at the support plates, it's a voltage-based approach, and for the primary water stress corrosion cracking at the roll transition, it's a length based approach.

I plan on briefly discussing both the voltage-based and the length-based approaches. The voltage-based approach, as I said, is applicable only to axial ODSCC at the support plate elevations. Under this approach, bobbin voltage -- bobbin indications less than a certain voltage are allowed to remain in service, regardless of the depth of degradation.

To demonstrate acceptable structural criteria, the industry has developed a first pressure bobbin-voltage correlation. On the Y axis you will see the first pressure and on the X axis the bobbin voltage. This is just an artist's interpretation of the correlation.

The data used to support this correlation comes both from pulled tube and laboratory-produced specimens of axial ODSCC at the support plates. What the industry has done is they've performed a -- they did a linear line to the data. It's a linear regression fit to the burst pressure and to the log of the bobbin voltage.

To determine the plugging criteria under this voltage-based approach, what was done was if you look at the lower 95 percent lower tolerance limit curve, you find the intersection curve of where it intersects the limiting structural criteria from Regulatory Guide 1.121 and that will define a voltage. That voltage is typically on the order of like four to five volts.

Now, to be consistent with Reg Guide 1.121, a margin for eddy current error and also for flaw growth between inspections must be accounted for. This typically results in the voltage being much less, on the order of two to three volts.

MR. LINDBLAD: Mr. Karwoski, I think this is about the first time we've really started to relate voltage to measurements. I think you heard at the introduction that there's some concern about that. Do we have standardized instruments or somehow are all these voltages identical and when we recognize that European practice gets different voltages, is there a French volt and a U.S. volt?

MR. KARWOSKI: There certainly is. Actually, that's the next point I was going to talk about.

MR. LINDBLAD: All right.

MR. KARWOSKI: To ensure that this voltage is consistent with what's measured in the field, specific calibration procedures are used. Calibration at a certain frequency, calibration with a certain size probe, calibration on a certain standard.

MR. LINDBLAD: Who maintains those standards?

MR. KARWOSKI: The utilities maintain their own individual standards. But to ensure consistency between the standards, there is what's called a laboratory standard, which was primarily used in the development of this, and then you do cross-calibration between the laboratory standard and the standards that are used in the field.

MR. LINDBLAD: Is that NIFT? I understand the utilities have replicas, but who maintains the standard? Is it an NRC standard or does the QDE lab have the standard?

MR. KARWOSKI: The standards are maintained by the individual utilities and the standard is both according to -- ASME code has certain requirements on the standard. The Regulatory Guide 1.83 also has certain -- makes certain observations on what that standard should include.

MR. LEWIS: I just need to be educated. These are not standards for the definition of voltage, of course. I assume my friend was kidding. These are standards against specific depth cracks, against specific materials, and done in a specific way. Is that what they are?

MR. KARWOSKI: The standard would contain such things as a 20 percent through-wall flaw, a 40 percent, 60, 80, 100 percent.

MR. LEWIS: In a particular material.

MR. KARWOSKI: Yes.

MR. LEWIS: So the machines have controls that calibrate them to give the right results against those specific standards which are defined. I'm just seeking education. How many such materials and crack depths are involved in calibration of an instrument, roughly? Ten, a hundred, two?

MR. KARWOSKI: For the purposes of this criteria, there's essentially one. You calibrate off of a specific hole. The industry has proposed to calibrate off of a 20 percent through-wall hole.

MR. LEWIS: A specific gadget.

MR. KARWOSKI: That's their calibration.

MR. LINDBLAD: So is the process tailored for whether you're looking for pits or general wastage or cracks?

MR. KARWOSKI: Under this approach, it's specific to axial ODSCC that's confined within the support plate thickness. So the voltage-based approach I'm talking is one specific mechanism.

MR. LEWIS: And the calibration involves one specific knob, namely sensitivity, or there are several? Presumably, in a thing like this, you would null out under some normal condition and then look for the difference. How many knobs do you adjust when you calibrate?

MR. KARWOSKI: I don't know if I could answer how many knobs you adjust, but essentially --

MR. LEWIS: It's important, because if there are many ways to meet the calibration standard, you could get many different results in the real world.

MR. KARWOSKI: The code has certain requirements on how you do the --

MR. LEWIS: It's all in the code?

MR. KARWOSKI: No, not all of it. But the code has certain requirements on where the flaw will appear in the flaw plane, at what angles. There are certain requirements in there. With respect to the voltage, you set the peak-to-peak voltage on the 20 percent -- under the industry approach, at 20 percent through-wall hole up to a certain voltage value.

MR. LEWIS: Is the only way I can really find out how this is done to go visit a plant, visit their lab and ask them how they do it? Which they bring in the calibrated instruments from some -- I'm really looking for information. I just don't know how this is done.

MR. BLOMGREN: Let me try to answer that. My name is John Blomgren from Commonwealth Edison. When you actually do an inspection at a site, you may, on every piece of equipment, every piece of eddy current test equipment that you've got gathering data, you may have a string of six to eight different calibration standards for different modes of degradation or for different kinds of flaws that you're going to measure, because there are lots of different things that with these multi-frequency eddy current instruments, but the data collection is pretty straightforward.

You can then do a tremendous amount in terms of mixing data to try to null out to remove noise, some of the things that were asked about this morning. So what they do is they have a lot of different geometries to allow you to get the right calibration for the right geometry.

For example, at an anti-vibration bar, if you've got wear, it's important to have the bar behind the wear, because the eddy current can -- doesn't just see the tubing or the tube wall. It also sees -- it can see a little bit beyond it. So you've got to have the right combination.

So there can be lots of different standards. What happens in this situation that Ken is talking about is every mode of degradation may actually end up with a somewhat different calibration standard.

Then what you do is kind of set the gain scale to the right voltage level so that you're able to see whatever it is you're looking for.

MR. LEWIS: So the operator adjusts the gain scale according to the situation he's looking for or looking at.

MR. BLOMGREN: That's correct.

MR. LEWIS: And there's a set of specific ways he's supposed to set it. I'm trying to find out whether it's a science or an art form.

MR. BLOMGREN: Yes.

MR. LEWIS: I deserved that. Congratulations. Which is it, a science or an art form?

MR. BLOMGREN: The answer is indeed.

MR. LEWIS: It's still yes.

MR. BLOMGREN: It's still yes.

MR. LEWIS: Very good. I know some stories that go with that, too. What I'm trying to really grope for, and it's just out of my own ignorance, is that if we're talking about having a new set of standards, they have to be objective. So I guess I just have to learn more and I shouldn't do that on Committee time.

MR. LINDBLAD: I think you should. I think it is an important issue that Dr. Lewis had.

MR. LEWIS: It is.

MR. LINDBLAD: Do you do round-robbin tests to see if everyone is calibrating the same way?

MR. BLOMGREN: And that's the next part of the answer. Yes. We do do some of those, but we do it in a somewhat different way and it goes back to -- I think it was Emmett's presentation where he was talking about the qualified data analysts and the program as part of the NDE guidelines to qualify techniques and equipment for very specific kinds of inspections.

That's really the way the round-robbin testing and the comparison of results and the standardization of specific calibration devices are, I guess, catalogued and then controlled.

MR. LINDBLAD: So when you do it this way, is a French volt equal to a U.S. volt?

MR. BLOMGREN: No, because the French -- we are cross-calibrated with the French volts, but, again, they have, in some cases, somewhat different modes of degradation. So they have developed somewhat different methodologies to calibrate or essentially set the gain control for voltage.

MR. KARWOSKI: In addition to that, they use different frequencies. They use different standards, different size holes and whatnot. So you would have to do another -- you cannot say two volts in France is the same as two volts in the United States. You can't say that, because they use different probes, different frequencies, different standards.

MR. BLOMGREN: But we are able to cross-calibrate the answers. I'm not trying to give the impression, but they have some different methodologies, as Ken has pointed out, that they have developed. In some cases, they've got some differences in equipment. It's not a better or worse issue. It's a different issue.

MR. LEWIS: There must be some nulling procedure. Everyone who ever measures anything looking for defect has a nulling procedure.

MR. BLOMGREN: Yes.

MR. LEWIS: So the nulling procedure must be specific to the location, the specific location. For example, I have a stud detecting machine I use at home. It's a gadget. You buy it from Sears Roebuck or wherever you like. And you hold it against the wall and it calibrates itself against you regular wall and then you move along and it detects the stud There must be something like that involved.

MR. BLOMGREN: Yes, there would be.

MR. LEWIS: That would be site-specific.

MR. BLOMGREN: Well, it's not so much site-specific, but it's technique --

MR. LEWIS: Vendor-specific.

MR. BLOMGREN: Technique-specific, depending upon the specific application of the equipment, and that could depend upon the specific kind of flaws that you're looking for. So it becomes a relatively complex issue.

I think Ken is trying to make the point that he's looking just at this one situation where you happen to have a correlation or we believe we have a correlation with something called bobbin coil voltage. It could be correlated maybe with something else that would not be bobbin coil voltage.

MR. LINDBLAD: But granting that it's complex, I guess, in U.S. practice, do you feel all the complexities have been recognized and that measurement standards are unambiguous?

MR. BLOMGREN: Yes, we do.

MR. SEALE: At the risk of opening Pandora's box even further, is it true that whoever's voltage correlation you may use, U.S. or French or whatever, and whatever flaw you're looking for in the test, that basically you're taking voltage and using a combination of burst pressure and code strength or something like that to make the judgment as to where the appropriate voltage is?

MR. KARWOSKI: That's the essential approach. You take the linear regression and you take the lower 95 percent prediction and lower tolerance limit and you take the intersection point of where it intersects your pressure criteria within Regulatory Guide 1.121 and that's where you get the voltage.

MR. SEALE: And then you step off from that by whatever conservatism you choose to invoke.

MR. KARWOSKI: Growth and error. And then getting back to the voltage measurement, there are limitations with respect to analyst variability. One analyst might call something one volt and another analyst might call it 1.1 volt. There are criteria within these guidelines that have been developed by the industry in order to minimize that variability between analysts. It's explicitly accounted for in the overall methodology that's used.

In addition, they have criteria on the amounts that a probe can wear, because probe wear can degrade the voltage that you get from a given crack. That's also explicitly accounted for in the methodology.

Now, under this approach, since bobbin coil voltage isn't correlatable to through-wall depth, you can potentially leave 100 percent through-wall cracks in service. As a result, you need to take a look at the expected leakage under postulated accident conditions.

So as a result, the industry has developed a correlation between leak rate and bobbin voltage. Once again, this is just an artist's interpretation of the data. But essentially what the industry has done is they've taken the leak rate or the log of the leak rate and the log of the bobbin voltage and developed a linear regression fit to that data.

Now, as you can see, there's a considerable amount of scatter in the data. So what the staff has concluded with respect to this is that predicting leakage under accident conditions is extremely difficult. We're still evaluating that issue. Without going into a lot of detail, we're still evaluating that issue.

MR. LEWIS: Leaving aside the question of whether all those points are the same, which is still fuzzy, in my mind, was that straight line drawn by using a computerized regression program that finds the best fit or was it drawn by somebody who thought it ought to go through the lower lefthand corner?

MR. KARWOSKI: Actually, it's a combination. Like I said, this is just an artist's representation. But this line is pretty close to the actual.

MR. STROSNIDER: I think the answer is in the industry submittal, it's a rigorous statistical evaluation using computer.

MR. LEWIS: That really is a regression.

MR. KARWOSKI: Yes.

MR. STROSNIDER: They really perform --

MR. KARWOSKI: They perform a regression analysis.

MR. LEWIS: And that is the line that came out of the regression?

MR. KARWOSKI: T~~is is just an artist's interpretation. It's pro etary information.

MR. LEWIS: I'm getting different signals from the two ends of the table. He says it was more or less and you say it was a regression.

MR. STROSNIDER: It is a regression, but since it's proprietary data, they could only show you an artist's representation of the regression in this particular graph.

MR. LEWIS: You mean there is a regression, but I don't have the need to know.

MR. KARWOSKI: It's proprietary.

MR. LINDBLAD: You'd have to close the meeting.

MR. SEALE: It's called a modified choke.

MR. LEWIS: I know how to do a recreation.

MR. KRESS: The regression coefficient is probably the .5. Why do you care?

MR. KARWOSKI: In the utility submittal, they do a statistical analysis and develop a linear correlation.

MR. LEWIS: Actually, very few people appreciate the fact that drawing a straight line through scatter points like this is not a trivial statistical problem. It's trivial if you assume there are no errors on the horizontal axis or no errors on the vertical axis, but there are errors on both. It's not a simple problem.

MR. KARWOSKI: We appreciate that.

MR. STROSNIDER: Jack Strosnider. The NRC staff and the industry have been discussing this regression for at least a year.

MR. LEWIS: Was it a two-way regression? Because the computer programs you get do not do two-way regressions, because it is a hard problem.

MR. KARWOSKI: As I mentioned before, the full voltage-based limit is on the order of two to three volts, depending on the size of the tubing and the individual plant. We have not approved that and we're still reviewing that and Tim Reed will be discussing the overall action plan with respect to that issue.

But we have approved more restrictive versions of this voltage-based approach for five plants. We had approved it for Trojan and for Cook Unit 1, Catawba-1, and Farley Units 1 and 2.

MR. LINDBLAD: More restrictive than what?

MR. KARWOSKI: By restrictive, I mean we've -- it's a much lower voltage limit. We've typically approved one volt for those five plants. It's on a cycle-by-cycle basis. The way they predict postulated accident leakage is much more conservative than what the industry proposed.

So more restrictive in the sense of what voltage level you would be allowed to leave indications in service.

MR. KRESS: Let me ask you a question. One of your curves showed a correlation between burst pressure and voltage.

MR. KARWOSKI: Yes.

MR. KRESS: Apparently, based on that correlation, you have come up with an interim criteria for voltage that you can use as to whether or not you plug or not. That strikes me as being a little bit upside down. Why isn't the interim criteria a burst pressure, that you can use whatever means you want to to measure?

It may be certain types of devices are calibrated so that you can use that device to measure the burst pressure by taking into account its uncertainties and so forth.

Why is the criteria a voltage and not a burst pressure is the question.

MR. KARWOSKI: I think during a normal in-service inspection, they inspect tubes using eddy current techniques and as a result, the only -- since, as Emmett pointed out earlier, you cannot reliably measure the depth of some of these indications, you need to rely on another non-destructive examination parameter such as bobbin voltage.

So that's what the industry proposed.

MR. KRESS: It turns out to be the same thing if you're always using the same instrument and the same thing. Backing off to the more fundamental things, like Hal and people speak of, a more fundamental parameter here is the burst pressure, which is related to cracks --

MR. MURPHY: But you are, in fact -- the answer to your question is yes. We're basically using burst pressure as your criterion. With this correlation, you've assumed a relationship between voltage and burst pressure. So whether you're using burst pressure or voltage, you're really talking about the same thing.

MR. KRESS: It matters in principal, though, as to how you write the regulations.

MR. LEWIS: We're not talking about the same thing, are we, really? Because the burst pressure is correlated with the voltage with the scatter plot and the scatter plot is not a direct relationship.

Leaving aside the question of whether a change in the regulation will be good or bad for whoever, if you're really interested in providing assurance against steam generator tube rupture, you would be -- if you were arguing that this improves that, then you would be arguing that the voltage indication is picking up something that the crack depth is not picking up that's related to burst pressure.

I haven't heard anybody make that argument.

MR. STROSNIDER: This is Jack Strosnider. Let me see if I can address this. If you start off with the regulations, which are our highest tier document, there's some general design criteria that Ken mentioned earlier about low likelihood of leakage, that sort of thing. It's not real specific.

If you go then to the Regulatory Guide 1.121, a lower tier document, it specifies some margin on pressure, a factor of safety that has to be applied on pressure. From that, you determine what flaw size could be tolerable in the tube.

But the critical point here is that you're going to do a non-destructive evaluation of the tube in the field. You have to pick the most appropriate parameter to relate to the burst pressure to compare it to the required margin of safety that's in the reg guide.

So the key word here is picking the appropriate NDE parameter. If you don't like the scatter involved with this voltage measurement for ODSCC, you should take a look at the attempt to measure phase angles based on this kind of degradation, because it's one NDE parameter or another. You look at voltage, you look at phase angle. The phase angle is more difficult to measure for this type of degradation than the voltage is.

I submit that you would see larger statistical variations if you were trying to do it on phase angle, which is a parameter that is typically used for wastage, for example. On a wastage indication, the phase angle, you get a cleaner pattern that you can read, you can measure the phase angle. That's not the case with this type of degradation. So the key is to pick the appropriate NDE parameter that you can relate to the burst pressure and demonstrate that you have the factors of safety required in the reg guide.

MR. LEWIS: One can object to that. First of all, let me just say I never said I didn't like the scatter. That's a very important distinction. This is not a matter of taste. The question is whether the scatter is statistical, which is the word you used, or whether the scatter is substantive and due to parameters that you have not looked at.

So everyone, I think, would agree with you that the problem is -- maybe not, but I certainly would -- that the problem is defined that measurable object which gives you the best indication of burst pressure without actually bursting the tube. That's what NDE means.

The question that comes to my mind is that tubes presumably, if the fracture mechanics people are any good, the tubes don't burst unless they've cracked. In events, you stay under the pressure. Therefore, the crack seems to be a splendid parameter if you could measure it.

Then the next question is can you measure it, but in order to measure it with a voltage, whatever the hell the voltage is, you have to either relate the voltage to the crack depth or else relate the voltage to something else that's important to the burst pressure of the tube, which is perhaps not picked up by other possible tests.

That's the lack I've seen. I've seen an empirical alleged correlation, but I do not know yet whether all those points are comparable with each other or whether each one is optimized in a particular way and then they have to be put on the same piece of paper, because I didn't get any clarity from that discussion about individual calibration.

But what we're all interested in -- I don't care what the regulations or the reg guides say. We're all interested in finding an indicator that one can use of the safety of the tubes. That's a technical question. That's not a regulatory question. I would love to be straightened out on that.

MR. STROSNIDER: Generally speaking, if you look at the voltage amplitude from the eddy current signal, you can relate that to the volume of material that's lost. If you look at this particular type of degradation, the ODSCC at the tube support plates, it's characterized by many short cracks occurring around the circumference and within the span and, in fact, even some inner granular attack, in some cases, which is a very general attack.

So when you go in and you measure a voltage, you're getting some measurement of the general condition with regard to the amount of material that's lost. Now, the difficulty -- if you had a single crack, which you'd be using standard eddy current methods, what you'd want to do is measure a phase angle coming from that single crack.

You can imagine if you've got a dozen cracks around the tube, you don't get one phase angle. You get all these things interacting. What you're left with is a more difficult signal to evaluate.

MR. LEWIS: You still get one phase angle.

MR. STROSNIDER: That's the point I was making. If you give that signal to a number of eddy current analysts and say measure the phase angle, they'll all take a best guess at it and you'll get a wide statistical variation.

MR. LEWIS: You get one for each one, but each one measures a phase angle.

MR. STROSNIDER: They try.

MR. LEWIS: Because that's what you can measure.

MR. STROSNIDER: They try, but it's difficult. But you can also measure the voltage. It's related to the general amount of material that's lost. When you look at the statistical scatter there, you would expect --

MR. LEWIS: This better be maybe statistical, NDE real.

MR. STROSNIDER: There's a lot of contributions to it, undoubtedly. Part of it, I would say, comes from the morphology of the cracks, which differ.

MR. LEWIS: Sure.

MR. STROSNIDER: So you're going to see some scatter depending upon the number of cracks, the depth of the cracks, the amount of IGA that's in there. You also have the human measurement errors. There's also some measurement errors in equipment. There are some explicit considerations for those things in the way you calibrate the equipment.

When you look at the scatter band there, I think in our evaluations, we've concluded that represents what those various contributions from the human factor, from the machine factor, also from the actual physical phenomena that's happening in the field.

So if you believe that you have a statistical representation of those things and what's going on, then you can, with some confidence, establish the lower bound and establish some criteria.

It would be as difficult or more difficult an effort using, for example, the phase angle, which is the more standard thing that's used.

MR. KRESS: But my point was that suppose next week you suddenly find out a guy can come in and take a hammer and peen on the tube and measure the vibrations of the noise and that that correlates much better to burst pressure than this thing does, but your regulation is written in terms of a voltage.

MR. KARWOSKI: The regulations specify the margins that the tube has to withstand. It does not say use voltage. The regulations don't -- they say --

MR. KRESS: So it wouldn't exclude him using this new technique as long as he can show the burst pressure, which is a measure of degradation, is still within the margins you need.

MR. STROSNIDER: Right. And that's the criteria --

MR. KRESS: I want to see the regulations written to allow that.

MR. STROSNIDER: On the plant-specific assessments that we've done, it's the margin on burst pressure that we've used as the criteria for assessing this. As I mentioned earlier this morning, the rule -- we do not want to be prescriptive. We want to be performance-based.

MR. KRESS: You're talking about a reg guide on how to use a bobbin or some other probe to allow it.

MR. STROSNIDER: Sure. And what statistical confidence levels do you want? From a regulatory perspective, what confidence do you want that this is the right NDE parameter? Those sort of performance-oriented characteristics are the things that we feel should be in a regulation, not a use this voltage or even to use voltage. It's to use the appropriate parameter as determined.

MR. LEWIS: Let me address this question of margin, because there's a fundamental issue here. Let me take an extreme position and say that all the scatter is due to the morphology of the cracks and that none of it is due to human aberrations or anything like that. That's an extreme position.

But what you've said is who the heck knows. It's a mixture of all those things. But let me take an extreme position, it's all due to the morphology in the cracks. In that case, we're not talking about a statistical confidence at all when we draw that line. We're talking about what fraction of the morphologies out there in the field are we going to let slip through this regulation, with an absolute certainly, and we're going to let 40 percent of the cracks go through that are going to burst tubes if we draw the line somewhere there, or 50 percent or whatever it turns out to be.

That's not what you want. What you want is some kind of -- I think that's not what you want, but if that's what you want, say it out loud. The point is that we have to know something once we back off to a criteria that is so far from the actual cause of bursting, which is cracks. We have to know something about the reason for the fluctuations before we're going to depend on that as a regulatory thing.

That's independent of the question of whether regulation is good for people or bad for people or whether there's risk or isn't risk in this. It's just the question of the technology of regulation.

So I think it's important to separate statistics that are real statistics from statistics which are really a distribution in physical things that you find out, the physical characteristics of the tubes. That's not statistics.

MR. WELTY: This is Chuck Welty from EPRI. My only thought would be that you're really talking flaw, not crack morphology. So you're talking a very complex flaw morphology. Subjectively, I think I would give you that most of the scatter is due to the flaw morphology, not due to the other statistics in there.

But it seems like the way we're handling the correlation is not letting the ones slip through. In fact, it's our intent to not let the ones slip through that impact tube integrity.

MR. LEWIS: But then you should draw the line below or above.

MR. WELTY: They did. That's what he did. That's the bottom line.

MR. LEWIS: I see. That's the bottom line.

MR. STROSNIDER: Ken, show them -- if you take the intersection of that lower tolerance limit and you have a vertical line, that would give you some bobbin voltage that gives you confidence that the data should be above that point. But, in addition what's been approved today is to go to a lower voltage to account for continued degradation between inspections, to account for uncertainties in the voltage measurements.

In fact, I think the number you gave, Ken, was that intersection may typically occur, what, three --

MR. KARWOSKI: Four to five -- 4.2 volts in the case of three-quarter-inch tubing.

MR. STROSNIDER: What's been approved to date is one volt.

MR. LINDBLAD: So you're way back.

MR. KARWOSKI: So you're over here.

MR. STROSNIDER: But you have to recognize that by the end of cycle, those voltages will increase.

MR. LINDBLAD: But when we're talking about the difficulties in detecting -- and I guess we didn't ask. If a flaw is detectable, is the morphology of the flaw interpretable at that point? So when you get a signal, you can't tell whether it's an axial signal or a circumferential?

MR. KARWOSKI: You can make some distinguished -- typically, you can discern whether or not it's axial or circumferential, to an extent. If the cracks are really closely spaced, a bobbin coil may not tell you. It may look like a circumferential indication, in which case you might want to do supplemental inspection with a rotating pancake coil probe to get further resolution.

MR. LINDBLAD: I know that's not your data and it's not your presentation, but, nonetheless, you must understand something about the data. Could the data have been segregated into various modes of failure?

MR. KARWOSKI: I'm not so sure what you mean by that question.

MR. WELTY: Again, that data is all for the -- this whole scheme, which John will talk about in a minute and I believe Tim is also going to talk about, is predicated on being able to discriminate among the defect types.

Currently, the way we do it is based on industry-wide tube pulls and knowing where you're inspecting for the damage form in the generator, as well as knowing that in that generator, you have that phenomena going on in that location.

For instance, the eddy current analyst looking at that data would know that he's looking -- or would know with a high degree of probability that he's looking at OD initiated SCC at tube support plates, a phenomena which we've got a fair number of pulled tubes and there's a lot of morphology or a lot of data to support that he has very good reason to suspect that that's what he's looking at at that location.

Now, he has a very high probability of detection when we're talking about voltages for that flaw form in that location.

MR. LINDBLAD: Is that an inference that he draws from how far the probe is inside the tube?

MR. WELTY: That's correct.

MR. LINDBLAD: Or is it a conclusion he draws from looking at the data?

MR. WELTY: He has to draw that from knowing where he's looking at on the tube. That's part of the site-specific -- the guidelines in the site-specific examination and the things that we tell him to look for in his inspection for that tube in that plant.

MR. KARWOSKI: This is going to be discussed a little bit later on, but with respect to the voltage-based limits, we have approved it on an interim basis. Tentative conclusions regarding interim voltage-based limits were documented in draft NUREG-1477. As I alluded to earlier, some of the conclusions were with respect to leakage under main steamline break differential pressure conditions. It's difficult to predict.

Another conclusion was that tube pulls were necessary, and this gets back to your concern that you do tube pulls to confirm the degradation mechanism at that location and that gives you added confidence of the voltage you're measuring is from that degradation.

MR. LINDBLAD: Tube pull is a destructive examination.

MR. KARWOSKI: Yes. You remove the tube from the steam generator and then you destructively examine it.

MR. LINDBLAD: So there's a limited number that's worthwhile to do.

MR. KARWOSKI: Right. And the correlation --

MR. LINDBLAD: And survival is what we're trying to have.

MR. KARWOSKI: And the correlation I showed you is from that database. Other conclusions were that certain enhancements in the ISI program will be required and that the probability of detecting cracks be assessed.

As Emmett Murphy said this morning, your probability of detection of stress corrosion cracking with respect to depth is on the order of 50 percent for around 40 percent through-wall.

So some assessment on the probability of detecting cracks with respect to voltage needs to be made. Once again, this whole voltage-based approach is plant-specific. It depends on the structural criteria that that plant would need to meet. It would also depend on -- there are certain radiological consequences that would be plant-specific, also.

MR. LINDBLAD: Ken, in the previous presentation, I think Emmett made a very strong point that we couldn't rely on bobbin results and that rotating pancake coil was the way to go for many of these. I think you're talking about -- when you're talking about these voltage limits, it's with the bobbin coil. Is that right?

MR. KARWOSKI: This is with the bobbin. Both the bobbin and the RPC probe have their own capabilities, their own limitations.

MR. LINDBLAD: But is the same voltage criteria applied to both bobbin and RPC?

MR. KARWOSKI: No. There are different calibration procedures. So in that case, you cannot compare an RPC voltage to a bobbin voltage.

MR. LINDBLAD: But in this presentation, you're only talking about bobbin.

MR. KARWOSKI: Specifically bobbin voltage calibrated with specific procedures, right.

MR. LINDBLAD: Thank you.

MR. KARWOSKI: Now, I'd like to talk about the length-based limits. The staff has just started reviewing this, but I'd just like to say this is applicable to one degradation mechanism. Also, it's only applicable to axial primary water stress corrosion cracking at the roll transition.

Similar to the voltage-based approach, you develop the length-based limit from taking a look at the crack length versus burst pressure correlation, subtracting off NDE uncertainty and also growth to determine your plugging limit, and the plugging limit is around an order of a half-an-inch for this degradation mechanism.

Just real quick, in summary, it's similar to the voltage-based approach in that it's programmatic. It involves commitments to specific inspection scopes, specific inspection methods, and reduced primary to secondary leakage rate limits. Also, under this approach, because you have the potential for leaving through-wall cracks in service, you also must address the issue of leakage under postulated accident conditions.

That's all I have on that, if there's no more questions.

MR. SEALE: Questions?

[No response.]

MR. SEALE: Let's move on, then.

MR. MURPHY: As Ken has mentioned, the staff has approved interim voltage-based plugging limits, the one-volt limit, on an case-by-case basis for five units to date. However, we expect that in the next very few years, that the number of utilities desiring such a limit for their plants will grow by quite a bit. Perhaps a couple of dozen plants may desire to have these kinds of limits.

So it's time for us, then, to move beyond establishing plant-specific positions on IPC and move on to a generic staff position on interim voltage-based plugging limits that have gone through the regulatory process, public comments, review by the CRGR, and discussions with you, so forth and so on, the regulatory process.

The technical basis for developing our generic position on interim-based plugging limits is going to be given in NUREG-1477. When finalized, the ultimate plan is to then issue that NUREG with a generic letter which would announce the fact that we have a staff position, an approved staff position, generic, with respect to voltage-based interim plugging limits. The NUREG is the technical justification for that generic letter.

The status of this effort, this generic effort is what I want to discuss right now. A draft position or a draft technical justification in the form of draft NUREG-1477 was issued in June 1993. The Federal Register notice announcing the availability of this document was issued on July 2, requesting public comments. Public comments were received toward mid to late-August. Those comments have been under review by the staff and its consultants.

We are expecting to have a draft report evaluating these public comments by December 17, tomorrow, 1993. At this point, the draft resolution of public comments will be circulated among staff members throughout the agency, Research, NRR, for their review and comment.

I think we've had past meetings with you where we've just described some of the controversy, if you will, on this issue. A number of different staff members have a number of different opinions and there is a lot to work out. It's not going to be a simple process to establish a staff consensus. So we anticipate that we will not be finalizing this report resolving public comments until the end of January of 1994.

We will complete the revisions to NUREG-1477 by March of 1994. As we are finalizing NUREG-1477, we'll also be putting together the generic letter. The generic letter will be going through the regulatory review process, CRGR. I would imagine we'll be meeting with you again. It will also be issued for public comment.

We expect that the letter will go out for public comment in April of 1994, with issuance, final issuance of the generic letter and NUREG-1477 in June of 1994.

MR. LINDBLAD: But none of this establishes a rule, is that right?

MR. MURPHY: No, it does not. The role of NUREG-1477 and the generic letter in the global scheme of things is going to be discussed by Tim Reed. This effort we consider to be an element of the total SG integrated plan.

Public comments came exclusively from utilities and various industry groups and vendors, such as Westinghouse, EPRI, and, as I said, a number of utilities. The issues raised by these comments, the major issues raised by these comments are summarized here.

I think one of the more difficult issues we're wrestling with right now as a result of these public comments is a recommendation contained in the draft NUREG regarding the need for additional tube pulls. The draft NUREG contained a recommendation that to implement IPC, a number of tube pulls would be required and that we would need to continue to pull additional tubes with each succeeding outage.

A second very major issue to be resolved here before finalizing NUREG-1477 is the methodology for estimating steamline break leak rate. Ken Karwoski talked about or presented an artist's rendition of the leak rate data that we have for tubing, cracked tubing, and the fact that -- he described the issues that exist with respect to how well one can establish a statistical model for that data.

The conclusion of the draft NUREG was that based upon information available at that time, one cannot conclude that there was a statistical relationship relating leak rate as a function of voltage with any confidence. Additional data, of course, has become available since the spring of 1993.

In addition, we have picked up a number of industry comments on this particular issue and this is one of the more difficult issues we're wrestling with right now.

MR. LINDBLAD: SLB stands for steamline break?

MR. MURPHY: Yes.

MR. LINDBLAD: How can we have had any experience to compare steamline break leak rate? You're postulating what the leak rate would be rather than determining. We haven't had any steamline break.

MR. MURPHY: There is a database that has been established on the basis of two types of test specimens. Tubes have been pulled from the field and two laboratory tube specimens in which they've done cracks and voltage rates.

These specimens have been leak tested in the laboratory under simulate steamline breaks.

MR. LINDBLAD: Excuse me. To me, a leak is something that happens before or when you're operating and a rupture is what happens as a result of an accident. Do we agree on that?

MR. MURPHY: Actually, I think we better clarify this. What I'm talking about here in the way of leakage is not leakage during normal operation. Rather, it is leakage through the cracks that may occur during a postulated steamline break accident, short of tube rupture.

As Ken said, by leaving tubes in service with less than one-volt indication, we are, in effect, leaving 100 percent through-wall cracks in service. These cracks may not leak during normal operation. The concern is they may leak under steamline break conditions. So we need to quantify how much leakage may be expected and then to compare -- assess the radiological consequences of that leakage, compare them to the regulations, Part 100.

A number of other issues also exist. The staff has requested in the draft NUREG that the utilities adjust their leak rate estimates to reflect the fact that POD or probability of detection of ODSCC flaws is less than one.

We had also recommended in the draft NUREG that certain indications exceeding one volt, but which were not confirmed by RPC, which were left in service, that those indications be considered in the leakage calculation based on the argument that this data had not been segregated out from the database when establishing the leak rate models.

A very important issue is the treatment of outliers. Right now it is the staff's judgment that there is no consistent treatment of outlier data which, in some cases, are being deleted from the database, from the correlations. The leakage correlation, in particular, is highly sensitive to how you treat these outliers, whether you consider these to be valid data points and worthy of inclusion in the correlation has a major impact on what your leakage model is going to predict in the way of leakage.

So the treatment of outliers is a major issue to be resolved and we picked up a number of comments on that issue.

Let me skip over Summer. There were a number of eddy current test issues that came up. Ken described the standardized procedures that have been set up to require that all people implementing interim one-volt plugging limits, they all use consistent procedures to characterize the voltage response of the indications to ensure that these voltages are consistent with how the burst pressure and the leakage correlations were developed.

There are some rather esoteric issues that need to be resolved with respect to these standardized procedures.

Ken referred to the -- described the basic methodology for arriving at a voltage-based plugging limit. He described using the lower 95 percent confidence bounds in the pressure correlation. He also talked about making corrections for voltage growth and for eddy current measurement error to arrive at a final plugging limit.

As we have a distribution of possible burst pressures as a function of voltage, we also tend to have a distribution of potential voltage measurement error. We also tend to have a distribution of crack growth rates in terms of voltage from indication to indication. One indication may grow a half-volt in the course of the cycle. The next indication may grow by a volt-and-a-half. So there's a frequency distribution of potential growth rates.

The industry recommendation for setting the voltage-based limit is based on the use of a lower 95 percent confidence interval prediction of the burst pressure correlation, average growth rates for the entire population of degraded tubing as observed between successive inspections, and the upper 95 percent probability value of voltage measurement error as determined based on a survey of performance among a number of different analysts on the same tubing.

The staff had recommended in the draft NUREG that all the parameters that plug into all the variables that affect the definition of the plugging limit, that a consistent set of 95 percent confidence interval values be used for each of those variables.

NUREG-1477 had a lot of discussion about methodologies to estimate off-site dose, given a certain leakage rate for purposes of assessing your compliance with Part 100 under the accident conditions. It was noted in the draft NUREG that a lot of these assumptions, the standard review plan assumptions which are routinely employed for doing these radiological assessments, are quite conservative. There is concern expressed in the NUREG and by the industry, for that matter, about heaping conservatism upon conservatism, but we've tried to be conservative in the estimation of leak rate and we add additional conservatisms in terms if iodine spiking assumptions, 500X iodine spike, a preexisting spike, 60 microcuries per gram.

There's another assumption where you assume worst case meteorology. You assume that the initial coolant iodine activity level is right up against the tech spec limit. So we're coming out, therefore, with a pretty conservative estimate of radiological consequence.

So there is discussion of propagation of uncertainty and how one might go about performing a more realistic assessment of radiological consequences from a given leak rate.

This is one of the issues, the desire in the -- the desire to do a more realistic dose assessment is one of the issues being taken up as part of the overall integrated plan and rulemaking activity. Nonetheless, and this is discussed in the NUREG and it's something we received comments on, we're looking at those.

Finally, the NUREG concluded that we need not consider the issue of severe accidents for purposes of establishing a generic position on interim voltage-based plugging limits, but that we would have to consider this issue ultimately as part of -- before we complete our review of higher voltage-based limits, the actual values of limits being proposed by the industry.

So this issue of severe accidents and to what extent we need to consider this issue at various stages along the integrated action plan was an item of -- the subject of industry comment.

MR. LINDBLAD: How did you draw that conclusion that one volt didn't involve severe accidents, 1.1 volt does? Is that what I heard you say? Something greater than one volt you do have to consider severe accidents, but one volt or less you don't.

MR. MURPHY: On that question, I will try to defer that to Steve.

MR. LINDBLAD: Maybe I've over-characterized it, but that's what I heard.

MR. LONG: First of all, I was not the author of that. I think I can support it in the following way, though. The current practice, as they have discussed before, has been to have some sort of eddy current testing that is very unspecified. A lot of the licensees have chosen to leave their noise levels high and, frankly, they don't look at anything that's much below a couple or three volts, in some cases that we're aware of.

What we felt we were doing here was not really relaxing things compared to what the licensees are already allowed to do. So the agency position was not intended to be a relaxation, but more of an opportunity for the licensees to look at little harder and not get penalized in the process by having to plug anything that they could see, not knowing if anything that they could see was or was not more than 40 percent through-wall.

I don't know how to say it any more than that. It just did not look like it was, in reality, a relaxation to go to one volt. We did not have the capability to go through all the risk assessments in time to make the decision here. So we tried to keep it at a level that we thought was clearly not a relaxation.

MR. STROSNIDER: This is Jack Strosnider. Just to follow on to that, I think the simple response is we felt there's enough conservatism in the one-volt limit, but when you start looking at some of the higher proposed limits, we feel we'd have to go through the more detailed evaluation of severe accidents.

In addition, in establishing a long -- from a regulatory perspective, in establishing a long-term generic position, these are considerations that we typically go through to make sure that there's no additional contribution to risk from severe accidents and that sort of thing.

So looking at this in the short term and feeling that we had an acceptably conservative criteria, we didn't feel it was necessary to do it at this point. But we do recognize that it's something that will have to be done in the longer term. There's some judgment involved there, obviously.

MR. LINDBLAD: We're talking about a generic one volt, is that right, applied to a number of plants.

MR. STROSNIDER: Yes. The generic letter --

MR. LINDBLAD: Could it be that if an individual plant came in, one could consider different standards on a case-by-case, without expanding the scope greatly?

MR. STROSNIDER: As I indicated this morning, it's always -- well, I didn't actually say it this specifically, but it's always the option of a licensee to propose some alternate criteria. The difficulty that we have and one of the driving forces behind establishing a generic position is to try to achieve some consistency and, also, from a resource point of view, it's very, very difficult for the NRC staff to review plant-specific submittals.

Right now we've got five of these plants which are operating on the interim criteria. We've asked the industry in some earlier meetings could we get an estimate of how many plant-specific submittals to expect. That's difficult for them to answer because it's hard to predict exactly what people are going to find when they do their inspections, but sort of a qualitative, well, you know, it wouldn't be surprising if it was 20 or 20 to 30 over the next couple of years.

That's a lot more staff time, frankly, than we have available. In addition, when you look at these databases that are being used in these evaluations, it's the same database. So aside from looking at some plant-specific considerations with regard to siting and maybe some systems aspects, you'd expect to see some consistency come out of it.

MR. LINDBLAD: Thank you.

MR. DAVIS: A couple of comments, Mr. Chairman, if I may, and a question. First the question. Have you looked at the IPE results and determined what the significance is of steam generator tube rupture accidents?

MR. STROSNIDER: I think Steve Long showed that briefly this morning.

MR. DAVIS: I'm sorry if I missed it.

MR. STROSNIDER: Well, he didn't talk a lot about it. He's probably the best person to respond.

MR. LONG: The IPE results have a very broad range, but most of the PRAs I'm familiar with show the consequences to the public, largely deriving from the highest LOCA or steam generator tube rupture sequences in PWRs. There are individual plants with vulnerabilities that come in here and there.

But I think from the standpoint of the consequences to the public of steam generator tube related accidents are a good fraction, in the tens of a percent, of the cause of consequences to the public. So in that sense, we consider them very important.

MR. DAVIS: Well, I looked at 1477 and there's a lot of useful information in that document, but I join my colleagues in being concerned that there's not enough yet in the area of risk assessment and I guess we're going to hear about some additional work you plan to do in that area.

Let me just indicate to you one thing. On Page 4-40, there is a reference to the safety goal criterion of ten-to-the-minus-six per reactor year for a large release probability, and that's disturbing to me because that -- and there is no criteria for a large release in the NRC safety goals.

In fact, recently, both the Director of Regulation, as well as least one of the Commissioners have backed off of that criteria as being a useful guideline for evaluating risk. You may want to consider using something else and I'd like to see public risk used myself, but I realize that adds substantially to the complication of the calculation. Just a note. I agree with you.

MR. LONG: Every place that I've seen a reference to ten-to-the-minus-six as a safety goal, I have at least tried to make it -- state it as a surrogate safety goal.

There are many authors of that report and at this point, I think we're trying to clean up things like that for the final version. The problem with the consequences is just as you said. There's an awful lot of additional calculation and uncertainty that goes into getting from the core damage to the consequences to the public.

Joe, I think we have some of that in the contract for the follow-on work, don't we, to try to get to the consequence side of it.

MR. DAVIS: Thank you.

MR. SEALE: Okay. Are we ready to go on no

MR. MURPHY: I guess so.

MR. SEALE: Proceed.

MR. REED: I'm Tim Reed. I'm the Project Manager in NRR chasing these steam generator effort. What I plan to tell you is what we're doing and why we're doing it and what we hope to accomplish.

Jack started the meeting off this morning by telling you that we have what we view to be outdated regulations from the 1970s, the 40 percent through-wall criteria, that really don't work too well for the kinds of degradations that we're seeing today, primarily outside diameter stress corrosion cracking and primary water stress corrosion cracking.

With these new mechanisms, we need to look at more appropriate repair criteria and I think we're also seeing, as mentioned by people before me today, pretty large inconsistencies in the way people do NDE out there.

Given these problems and our leakage events that have occurred and ruptures that have occurred, we've had to deal with these on ad hoc basis and it's eaten up our resources here, both on our side and I'm sure on the industry side, also.

So this is an effort, hopefully, to cure all those ills. Whether it will work or not remains to be seen.

The steam generator plan, we really have three major tasks involved. The first one is a short-term effort, which was just talked about a little bit, and that's the voltage-based criteria for the outside diameter stress corrosion cracking at the tube support plate, the tube intersections.

This is really finalizing that NUREG, putting a generic letter together, getting it out there roughly in June. That's to solve most of the problems that are going on in the United States right now.

These two right here are longer term efforts. The industry, EPRI, through NUMARC, has submitted four topical reports and we're looking at those really principally in that effort to support our efforts to come up with a steam generator rule and a reg guide.

We feel as though -- and I have slides on each one of these and we'll get into more detail. But we feel as though that's the best approach to solve all these problems. Generic letters and rules obviously are very generic and it requires a lot of people from several different tasks or disciplines, from classically the tube integrity people, who we have heard a lot from today, but also from the people who are looking at the systems type of issues, risk, and radiological consequences, which is the bottom line of why we do this whole thing in the first place.

MR. LINDBLAD: Before you leave that. Is there a tube repair process that goes on or are we talking about tube plugging?

MR. REED: We're talking about tube plugging criteria.

MR. STROSNIDER: Jack Strosnider. The industry has a number of alternatives now. Most widely used are tube plugging and sleeving and there are various types of sleeving operations. So there are cases where the utilities will decide to sleeve rather than plug a tube.

There's also some work going on in other repair methods that might be implemented in the future, but that's developed now at this time.

MR. DAVIS: But your definition of repair includes plugging, is that right? On this slide, for example.

MR. STROSNIDER: Yes. For this slide, it could be plugging, it could be sleeving. Yes.

MR. SEALE: It's really steam generator repair, not tube repair in that sense.

MR. REED: Yes. Steam generator tube repair criteria. Actually, the decision point to decide what you're going to do, sleeve, plug. Like Jack said, there are even new technologies that are being developed today for direct tube repair, but they're still in the early stages.

For the short-term effort here, I'm sure these guys will probably talk about it a little bit this afternoon. In the United States, the principal degradation of most concern is outside diameter stress corrosion cracking at the tube support plate, the tube intersections.

I think that's the one that we're having the most problem managing right now. So this effort of coming up with a NUREG, that provides a technical basis for a generic letter and that generic letter then doing this -- what you've heard, the one-volt criteria or some voltage criteria -- is really to kind of solve that, put that fire out in the short term and allow us to do a longer term rule effort, which will apply the same basic principals to any kind of degradation.

So what we're doing then is hopefully we'll be finalizing these comments and I think Emmett went through these specific dates, but looking at finalizing these comments this month, getting to the task team early in January, and getting a final NUREG roughly around February, and issuing a generic letter actually in June, not spring.

I'm sure you're aware of how long it takes generic letters to get cranked out. That's a very, very ambitious and aggressive schedule. The reason we're doing it, of course, is to provide some interim relief while we go and do a longer term effort to address all forms of degradation.

So that's the first task. The second piece here recall kind of fits into the longer term effort and what we're trying to do here as far as resolving it permanently. The industry -- EPRI and NUMARC have submitted four topicals to the staff, these topicals right here.

Initially, EPRI intended to submit these for tech spec changes. The staff now, as I'll tell you in the next slide, is really heading down the tracks towards a rule and a reg guide. So we're looking at these in terms of supporting our efforts and coming up with a rule and associated reg guide.

But Chuck and Mr. Blomgren can discuss these in a lot better detail than I can, but this is -- the first topical is basically just discussing the steam generator degradation specific management, the overall, sort of like a motherhood document, how you implement this approach.

These inspection guidelines, you've heard something about these today, the EPRI inspection guidelines. This is how you go about doing an NDE and doing it properly given the kinds of degradation you have.

These are two topicals that really now involve two different kinds of degradation. One is the ODSCC type of degradation and the other is BWSCC. You've heard a little bit about that today.

We're actually looking at this topical in support of our NUREG and generic letter, also, since it really bears on the same technical area. But we're looking at all these now and hopefully helping us put together a rule.

These two things will probably be more in a rule and a reg guide -- helping us address a rule and a reg guide. These two would probably be more examples of how you do it properly. How these topicals actually end up, though, as we work with EPRI and NUMARC, they could dramatically change.

So where we'll come out and what the bottom line is, these things will probably change and eventually we'll generate some sort of evaluation reports which will then feed into our overall rule and reg guide effort.

As I said before, today we've been -- Jack's branch, in particular, has been almost turned around in circles in responding to problems with cracking in generators on an ad hoc basis. We're going to hopefully try to defer any kind of thing on a plant-specific basis as much as possible, because we simply just don't have the resources to do all this rule, reg guide, generic letter, NUREG, and then also do plant-specific reviews. There simply isn't enough people.

MR. LINDBLAD: What do you expect the licensee to do, shut down and wait for you to be ready?

MR. REED: We expect that most of the degradation in the United States will be addressed by the generic letter. In other words, most of the people out there who are having problems are having problems with ODSCC at the tube support plates.

The generic letter and the associated NUREG and the finalized 1477 should provide relief to those individuals while we go for a longer term effort.

MR. LINDBLAD: And for those that are not, what do you expect them to do?

MR. REED: For people who have, for instance, PWSCC, it's a good question. I'll have to defer to Jack on that.

MR. STROSNIDER: Jack Strosnider. To be realistic, I assume we will see some plant-specific submittals.

MR. LINDBLAD: And you will reveal them.

MR. STROSNIDER: The message we're trying to get across is that we have to minimize that to the extent possible. I do believe, in the feedback we've gotten from the industry in addressing the ODSCC issue, at least with the current status of the industry, that will address the vast majority of the problems.

Any other sort of difficulties -- we've had one plant express interest with regard to the primary water stress corrosion cracking at the top of the tube sheet. They found some alternative ways to address their problem. We've only had that one case.

I think part of what you see here in the industry submittal is trying to get -- trying to anticipate what could possibly happen and to have some things in place to deal with those in time. We feel that that's a good idea, but that the rule which would be more broad in scope could address not just that issue, but provide a framework for addressing whatever else might come up in the future.

So I think we're going to address the main issue with the generic letter that we want to get out next spring or as soon as possible and the rest of it, at least the current indications are that we should have time to deal with it on a generic basis.

As I say, realistically, there's always the possibility that somebody comes in with a plant-specific submittal.

MR. LINDBLAD: And you're not going to excuse him from his license fee if you don't review it.

MR. STROSNIDER: No. Depending on the situation, we'll have to review it.

MR. REED: We just are hoping that -- you know, we have had one plant that has had it and they've addressed it in another manner, and with some luck, we won't have anybody else --

MR. STROSNIDER: Let me add one more thing, which is aside from the resource issue, which is very real, there's also an issue of -- and I had a bullet on one of my slides this morning with regard to the NRC's procedures for dealing with generic issues. One of the things we're very interested in is answering the type of questions that you've been asking today with regard to risk in the overall picture with regard to steam generator safety. And we'd like to do that before we set precedents on a plant-specific basis, because if you start looking from a regulatory perspective, when you set those precedents, sometimes they're difficult to undo.

It would be much, much better off for everybody if we had gone through the sort of questions in the process that we've been discussing and have a good understanding of that before we make those decisions.

MR. LINDBLAD: But it sounds to me, as we've been discussing this, that your branch and your task force has a very good understanding of what the circumstances are and the like and what needs to be done is that the risk for the safety-related work be developed. That's really not in your branch, as I understand it. That's in some other part of the agency.

And you've said that severe accidents need to be addressed and you wouldn't do that, but some other part of the agency would.

MR. STROSNIDER: Yes.

MR. LINDBLAD: So you really need to task other people to get up to speed so that they'll be ready for --

MR. STROSNIDER: That's correct. The Materials and Chemical Engineering Branch will support those evaluations as necessary. I don't know. Tim doesn't have the task force. I think the industry presentation has it.

MR. REED: Yes. Actually, these guys have it. But I was just going to mention we do have all the different disciplines on this task force.

MR. STROSNIDER: And I believe the other branches and disciplines are up to speed. We have people here today from Reactor Systems, from the Risk Branch. It is truly an integrated effort not only within NRR, but we also have members of the Research office participating in this activity.

So we're at a point of we understand, I believe, what needs to be done and we're at the point of implementation.

MR. LONG: Steve Long with the Risk Assessment Branch. Part of the difficulty we're having right now is trying to turn the standards we're thinking about for in-service inspection into probabilities of failure under certain circumstances. It's getting to the statistics of the inspection process or to the probabilities of the failure of that process to detect things we worry about.

It's really underway right now.

When we think we have that pretty well in hand, we then begin the logic of the risk assessment.

MR. REED: This isn't in your pack. The industry and NRC have roughly similar organizations as far as this steam generator rulemaking effort and both have a management oversight level, high level management oversight level. We both have technical steering committees, Jack being on it, and then also three other individuals from NRR and then Research. I'm the Project Manager and then the task group is made up of people who I think cover all the disciplines from start to finish, from the tube integrity side, the materials, then the system side, mitigation procedures, training, instrumentation, the risk assessment, looking at what's the risk significance of this whole thing, the bottom line radiological consequences, what's it mean for the health and safety of the public, and severe accidents, leaving through-wall cracks in service, what that means as far as severe accidents.

So I think we have all the right kinds of people involved to address the issues. That's basically the way the organization looks. It is a multi-discipline effort. I think I'm done with that one.

In fact, I was going to get a little bit more onto that here when we get to -- as I mentioned in the beginning, Jack has mentioned, several other people mentioned, with all the problems that we have as far as outdated regulations and degradations that are in generators today, if you apply 40 percent through-wall, you'd plug the generators out pretty quickly.

It's questionable whether that's even a good repair criteria for the kinds of degradations that we have. Given that situation, we feel as though a rule is probably the most expedient way to resolve the problem. It's something that will apply to everybody who has got a steam generator out there. We hope to do it in a manner that the next slide will cover, which is the kind of stuff I'm sure you're used to hearing these days on performance-based regulation and flexibility and that kind of thing.

This gives a little more detail of the same ideas here. Steam generator rule. Obviously, motherhood up here on providing adequate assurance of steam generator tube integrity. I think Ken mentioned a little earlier today some of the GDCs involved.

I think if you go to 10 CFR Part 50, I think GDC-14 talks about an extremely low probability of rapidly propagating fracture and normal leakage. That applies to the reactor coolant pressure boundary. The steam generators make up about roughly 50 percent of it.

The tubes there also are the containment. So the two of the three principal boundaries of fission product release makes it pretty significant. So we need to understand what that tube integrity means, what that GDC-14 and 15 and several others mean for steam generators.

When we come up with a rule, we hopefully will have the kinds of attributes that are here. We want to establish ends and not be prescriptive in the means in how you meet the ends. So that's what I call performance-based.

That hopefully then allows you flexibility and how you're going to meet these ends. Then if you do that correctly, you allow incentive to the industry to develop technology, a better means of NDE. That means you can go in in a simplistic way.

You want to allow these guys to go in and see the cracks, but when they see the cracks, you want to have a repair criteria that's rational. Today, if they go in with the best NDE methods now, they'll see a lot of cracks and they only have one criteria, a 40 percent through-wall depth criteria. I think we need to have the appropriate repair criteria given the kinds of degradation.

So we'll specify ends. We'll leave hopefully the means up to the individuals on how to meet that and then allow technology to evolve and to advance and fit into the whole approach.

Now, any time you do a rule, you've got to look at everything from start to finish. So we're going to be looking at safety and risk considerations, and that's been brought up several times. We're in the early stages here, so we don't have the kinds of answers to the very good questions on what this means as far as risk.

But, again, in simple terms, we're changing the baseline from a 40 percent through-wall criteria to something else and you've got to ask yourself what does that mean in terms of risk. It's not the same anymore, what is it. It is better, worse or what, and we just don't have those answers today.

Then when you do this integrated approach, you want to have a balance that considers everything from start to finish so that you're not being overly conservative or not conservative enough. But these are just the desired attributes of any rule, I guess, that would be put out today.

Now, we're obviously almost at the very beginning of this effort. So somebody had to take a reasonable guess at what kind of elements would be in a rule or a reg guide, for that matter. This would be the best guess we have today and it's almost certain to change.

Most rules -- I think virtually all of them have these kinds of things, applicability definitions and implementation. The real stuff is right here, the kinds of elements we feel are going to be in the rule.

The steam generator rule needs to address the situation when you have brand new steam generators or non-degraded steam generators and degraded steam generators and how you go from one to the next. Obviously you don't want to have guys going in with a brand new steam generator doing 100 percent inspections, but you want to do something for new steam generators and as you see degradation, you want to crank up your inspections appropriately.

So there will be something as far as that and what you need to do as far as ISI for different kinds of degradation, what have you.

Now, at a rule level, all this stuff is going to be pretty general. At a reg guide level, it's going to be more detailed. But at both levels, as I understand it, we're going to try to keep out the kinds of things that will lock you into a technology, like a bobbin coil, an RPC, a UT or anything else.

We're trying to leave it such that if somebody comes up with some new device, we're not in the mode of doing a new rule or new reg guide or what have you. We can hopefully do a rule that's general, a reg guide that's a good way of meeting the rule, and then perhaps the reg guide will reference acceptable means of topicals and what have you and how you meet the reg guides to meet the rule.

MR. SEALE: Did the same person who did this slide do the previous slide that talked about performance-based?

MR. REED: Yes.

MR. SEALE: There doesn't seem to be any leak between the headings there in performance-based.

MR. REED: That's true. It's pretty schizophrenic. We know we want to address certain elements in a rule, but we don't want to nail people down in how you do these things. That's a good point.

We know you need to address tube integrity. I think everybody will agree with that. And what does it mean for steam generators. In broad terms, in a rule, you need to discuss these things to some extent. I think one thing I'd like to point out here is that today's generator -- mostly in today's industry in the United States, there are those who have had steam generator problems who have enhanced their monitoring.

But to a large extent, the kinds of instrumentation involved out there, we're going to see something probably to enhance that instrumentation, both for leakage detection and for enabling an operator to mitigate an event.

If you look at steam generators, and some of these guys in this room can discuss this a lot better than I can, you've got basically a certain probability of initiating frequency of a rupture. So I'll throw a number out like ten-to-the-minus-two. If you want to get to a number like ten-to-the-minus-six, another number out of the air, you're relying on the operator for the next ten-to-the-minus-four. It's one of those events where you really rely on human beings.

So you want to make his life as easy as possible. You want to give him the information, give it to him quickly so that he has the best chance of mitigating the event and hopefully never getting into any kind of problems with core damage.

So the idea with instrumentation is, first, to see if you've got any kind of leak. It's kind of a defense-in-depth approach and it hopefully precludes -- so you can shut down the reactor before you ever get to a rupture. But should you get a rupture, then you have some instrumentation that allows the operator to identify quickly what generator he's got and he can mitigate the event more effectively.

I think you `l see something in very general terms in the rule having to do with instrumentation and these general concepts -- when you talk about accident mitigation, you always talk about EOPs and operator training.

So there will probably be something on that. If you look at this thing overall, you'll see that really what we're doing is we're opening up anything that has to do with steam generators, anything to do with steam generators.

You've heard a lot about tube integrity today, but we're looking at the entire issue of steam generators. The bottom line for all this stuff is radiological consequences. Emmett mentioned how conservative we are today. So I think we'll be looking at those assumptions and seeing what's appropriate, what's an appropriate level of conservatism for these types of events.

As I mentioned before, severe accidents has to be addressed to some extent. You're leaving potentially through-wall cracks in service. You've got to ask yourself what does that mean for severe accidents.

If you take a wild guess and the kinds of things - not a wild guess, but a little bit better than a wild guess on what kinds of things would be in a rule, those would be the elements. It will be, again, a performance-based rule and it's an effort that we're trying to do in about two years. So hopefully by the end of 1995 we'll have a rule together.

In the interim, like I said before, for most of the degradation in the United States, at least today, we'll have the generic letter and the NUREG to handle that kind of situation and that should be about June.

So for the tasks for the integrated steam generator plan, those are the major elements involved there, tasks involved, and that's where we stand today and where we hope to get to.

Have you guys got any questions?

MR. SEALE: Questions?

MR. REED: I've got lots of help here for the answers.

[No response.]

MR. SEALE: Thank you very much. Are you folks going to be around while the industry talks?

MR. STROSNIDER: Yes. This is Jack Strosnider. We certainly plan on staying to hear that portion of the discussion. I'd just like to make one little closing statement, I guess, from the staff's point of view.

There were a lot of excellent questions asked today and I sense maybe there's some frustration on your part at the degree to which we were able to respond, particularly with regard to risk and the larger framework of some of these issues.

We recognize those questions. That's part of what we want to address in this activity we're undertaking. What I'd suggest is hopefully the next time we come down, we'll be able to give you some more on that and we'll plan on addressing those issues, to the extent we can.

I suspect the other issue we'll probably see you on certainly early next year or in the spring would be the voltage-based generic letter for ODSCC that we plan to produce. I assume we may want to discuss that. So we'll see you at that point and as this program continues, I think it would be good for us to come down and provide you some status reports so you can see what direction it's headed.

MR. KRESS: Mr. Chairman, are we looking for comments or a letter from us at this time?

MR. SEALE: I was going to ask if you would like to have a letter at this time or -- and, of course, I want to ask the rest of the members of the Subcommittee if they feel a letter is appropriate now. Our intent at this time was not necessarily, but I think that may be conditioned somewhat by the things we've heard today; in particular, this risk question and a few other things like that.

So we'll discuss that at the end of our discussion. Any other comments right now?

[No response.]

MR. SEALE: I will say I think you've addressed the issues that we had on the program here and I think it is important for us to stay in touch. We would imagine that we would hear on the risk side of this thing the next time we do get together and I think we're looking forward to that.

We do want to go ahead and do the industry thing next, but maybe ought to take a ten-minute physiological break.

MR. LEWIS: Isn't it lunchtime?

MR. SEALE: We're going to go right on through, Hal, and try to get through, if we can.

MR. LEWIS: I didn't know that.

MR. SEALE: Well, I guess that was commented on before you came in. It's about another hour. So about a ten-minute break.

[Recess.]

MR. SEALE: Let's resume.

MR. WELTY: My name is Chuck Welty. I'm the Manager of the Steam Generator Strategic Management Project for EPRI. What I want to talk about today -- between John Blomgren and myself, we'll cover four items for the industry; what we see as the status of steam generators, some overview of what the steam generator program being run through EPRI is all about, the industry perspective on the degradation-specific management initiative, and then I'll summarize or conclude briefly by talking about our comments on NUREG-1477, which are very consistent with Emmett's.

In this first part, I want to cover the status of steam generators using some plots from the report, as I indicated, we will forward to Al later on. Then I will talk about the project itself, some of the management options that we've generated and provided to utilities in the last year or so, and then some brief conclusions of the initial part of the presentation.

For a number of years, we've been trying to use some quantitative measures for steam generator performance and its impact on the industry. One of those is the lost capacity factor due to steam generator problems, both replacement and forced and extended outages.

The numbers run, as you see them here, as a percent of capacity. We would like to have that number down around two-and-a-half percent.

MR. LINDBLAD: Is that capacity of PWRs?

MR. WELTY: That's correct. That's capacity of PWRs and this is reflective of this country only. Some of the data in this report, the data are separated out worldwide versus U.S.

How that looks for last year is 2.66 percent of the capacity lost was due to steam generator tubes. Another .65 percent was due to replacement activities for the two units that were in replacement during some portion of 1992.

As I said, our goal here is two-and-a-half percent for this number here related to forced and extended outages. The way we arrived at that goal back in about 1985 or 1986, we tried to come up with some quantitative goals for the programs, and there's been a series of them, which I will show you in a minute, that EPRI has been managing.

We found that the capacity factor lost average on an annual basis 1983-84 was 4.2 percent for forced and extended outages. We felt that the rational approach would be to try to get that number down below two-and-a-half percent.

So this, again, is the breakdown for those early years on an average basis and that's how we're using two-and-a-half percent for one of our goals.

MR. LINDBLAD: Is this availability or capacity factor?

MR. WELTY: Capacity factor. We're using capacity factor.

MR. LINDBLAD: But the 100 percent is the sum of ava.lability plus unavailability, is that right?

MR. BLOMGREN: Yes.

MR. WELTY: Yes, that's correct.

MR. LINDBLAD: My point being you don't know how much you would run when you're shut down.

MR. WELTY: That's correct. But it's measured in a megawatts lost per year.

MR. LINDBLAD: Irrespective of dispatching?

MR. WELTY: Availability reflects the dispatching. Capacity is the amount of time you're on-line, I believe. The numbers are very close to the same. We are using capacity factor loss in the way that they standardly compute capacity factor.

Another measure that we've been trying to follow fairly closely is the number of forced outages due to tube leaks. We don't have a quantitative goal for this number, other than we'd like to keep it as low as possible, and this would include tube rupture events. These are not necessarily outages where the plant exceeded its tech spec allowable leakage limit, but it's where they've attributed their shutdown due to progressing steam generator tube leak.

As you can see, the numbers were fairly high in the early part of the programs and when we were following the data. They've been fairly low recently, four last year. I believe this year we've had five or six already.

Another way we look at that is on a two-leak per operating reactor basis, which, in fact, shows that the trend has been downward. We believe that this is largely a reflection of the inspection process performance more than anything else, though there are people in the inspection community who would argue with that.

The next series of plots I have are again from this report I was discussing earlier where we are looking at the percentage of tubes plugged -- percentage of tubes in service, the percentage of tubes that are plugged for any given damage form on an annual basis.

I did a rough quick calculation. I believe right now currently you could say there's around three million tubes in service worldwide in PWRs, the kind we're interested in. So the annual number is in the range of four to six thousand based on these numbers.

MR. SHACK: So you don't really mean denting in the caption there. You mean for any reasons.

MR. WELTY: No. In this case, it was denting. I'm going to make a couple points about these plots that I have. We use these to try to help us focus where we're putting our research dollars.

Now, this is the kind of plot you would like to see, where originally we had a damage form that came along. We determined what its cause was. We applied some corrective measures and, in fact, we're basically not having any tubes being plugged due to this damage phenomena. That's the plot you would like to see and that's what denting did.

MR. SEALE: Have you been able to determine that those two little ticks out there in later years are due to unlearning the lessons learned and the need to not lose that knowledge?

MR. WELTY: I can't answer that question. I'm sorry, I can't. I do not believe that there is any unlearning of the lessons learned. Our view of the way the industry is performing, and I'll show you that in a minute, with the way the program is structured, is we don't believe that the utilities are unlearning.

I'm not sure why those two blips are there. I could specifically go back and look at the data.

MR. LEWIS: If there's no unlearning process, then this is the only industry in this civilized world in which there isn't.

MR. WELTY: Maybe I overstated no unlearning.

MR. SEALE: Well, things do die hard.

MR. LEWIS: I just think it's important not to substitute aspirations for facts.

MR. WELTY: I stand corrected. There's probably been some unlearning. Another phenomena that could have posed a problem, but the same corrective measures that we feel we applied for denting applied for this, and this is pitting. Again, this is a plot that you would typically like to see. When you find the damage form, which in this case was in the early 1980s when the pitting was a fairly widespread problem, you find it tracing down to virtually nothing now.

I have a plot in the handout that reflects fretting and I won't use that. I'll talk to the next plot, which is another trend that we look at. This is ODSCC or IGA of the tube sheet, either in the tube sheet crevice or sludge pile region of the plants.

This is a phenomena where I'd say we probably understand the mechanism well enough and have applied the corrective measures such as we can in a way that the phenomena is being effectively managed. We're not plugging very many tubes. We, in fact, have a method of inspecting and finding it and locating it and repairing the tubes such that we don't have to plug a lot of them, and it doesn't look like this is a phenomena that would lead to the replacement of many generators.

The next plot is looking at primary water stress corrosion cracking in the expansion zone. Again, this plot is for U.S. only, but you have similar plots for the worldwide experience.

When we first found this phenomena back in about the mid-1980s and based on the European experience and what we were seeing there, we felt like this might, in fact, be the phenomena that led to more replacements than any other and could be the death now for a number of generators.

We understand now pretty well what the cause is and what the corrective measures were for, which was essentially in situ shot or roto-peening. The measures have been applied to all of the plants that had the susceptible tubing. Again, this phenomena is one that we would say is being fairly effectively managed. We're plugging a number of tubes, but not a lot. It doesn't seem to be trending upward rapidly. So you're not likely to have to replace very many generators in this country due to this phenomena.

By the way, this lefthand axis, one of the -- one way to put that in perspective is if the industry were plugging .25 percent of the tubes total on an annual basis and if all generators had ten percent excess heat transfer capacity, that would give you a 40-year life. So that's kind of how -- that gives you some perspective of how well your programs are going.

MR. LINDBLAD: Chuck, during these 18 years of data, did your measurement system have the same level of sensitivity or were some of these discoveries of conditions that might have prevailed earlier but you didn't know it?

MR. WELTY: The latter. The inspection process -- this is relying in reported inspection results. It's the eddy current and its average industry-wide. So clearly as we've improved inspection, we're able to see and identify more things that probably existed earlier.

MR. LINDBLAD: So some of the incidents there, prehistoric, may have been there, just not detected.

MR. WELTY: That's correct. And you'll see that even more markedly on the next one, which is the phenomena we've been talking about most this morning, which is this ODSCC at tube support plates. It's a concern to us for a number of reasons. It clearly has quite an upward ramp.

Something like this, the inspection community would probably refer to it as inspection transient, because it's where you've figured out how to inspect for it a little bit better, but you could probably say that, in fact, this line would come up something more like this had we really understood the phenomena as well as the inspection techniques at the time.

What these figures do is they allow you, again, like I say, to kind of get a feel for what your real problems are and to focus a research program, like the steam generator management project. This is the one that's driving us to focus a tremendous amount of effort on ODSCC at support plates.

MR. DAVIS: Ninety-one looks like an anomaly. Is there a reason for that?

MR. WELTY: There were a lot of tubes plugged that year. Trojan was one of the plants that was in that mix.

MR. DAVIS: Although it wouldn't show up in '92, I guess.

MR. WELTY: That's correct, or '93. The data we have so far from '93 is it's flattening out a little bit, but I wouldn't want to make a real strong assessment on where we are. We think that the damage phenomena is going on. We think it's real. We're not saying it's just an inspection transient.

ODSCC at support plates, we have drilled hole support plates with mill annealed alloy-600 tubing is a real phenomena. We may be seeing a higher growth rate due to some inspection artificialities, but it's real. We do feel that it's very important not just to get the alternate repair criteria, but also to get the corrective measures in place so that we can stop the damage form. Alternate repair criteria won't save you in the long run, we don't think, and that's a qualitative assessment, but it will help.

MR. LINDBLAD: When we're talking about U.S. PWRs, how many tubes are in the U.S. PWR population?

MR. WELTY: Again, by my calculation, what I did just a minute ago, I'd say there's probably about two million of the three million, one-and-a-half to two million, 50 to 70 percent. I'm just doing a real quick calculation on that. Those aren't too bad a numbers.

The trend worldwide is similar, but it's being dominated, again, by the U.S. population. For ODSCC at support plates and mill anneal in all tubing, this reflects all tubing. It's predominantly in plants with mill annealed alloy-600 tubing.

As I say, that information can be generated and is all contained in this annual report we put out, and I will make sure that Al get a copy now and gets on my distribution list so he gets it in the future.

MR. LINDBLAD: Were those all original steam generators or do we have problems with replacement steam generators as well?

MR. WELTY: I can answer that in two ways. First, the total tube population reflects all tubes in service. So in the total population, it includes replacement generators. We have found almost no tubes being plugged in the replacement units. I could talk to that here a little bit on my next slide. There are a couple points here, one of them being that.

One of our reasons for believing that we have a fair handle now is there's virtually no damage in even the early replacement units. So we've had eleven replacements in this country. The time span -- this is coming out of my report. We're going to go back and break these numbers out a little more definitively. In some cases, it reflects the total outage time and in other cases it reflects what the utility reported for the actual steam generator replacement portion of the activity.

Like I believe this outage at North Anna was something like 96 or 101 days, 51 days of which were attributed to the steam generator replacement.

But one conclusion you make from this, plus the additional data that goes with generating this kind of a slide is the replacement activity is a manageable thing for utilities that have to do it. It's not anywhere near the traumatic experience that we would have thought it would be back early on.

The second thing that you would get from all of the data that we have industry-wide, again, as I was saying just a minute ago, that we're seeing virtually no damage in the replacement units. So the lessons that we have learned, given that we forget some of the things, but most of the lessons we've learned we are applying both in the new materials and new design features, as well as in how we operate them, such that we think you'll be restricted or limited to no more than one replacement in the life of a plant and that even if you went to life extension, your generators would last.

And these later replacement units have improved features even over these early ones. We are tuned into the emerging issues. Emmett talked about them and my slide is essentially the same and I believe we're -- there's a broad enough communication network that we understand pretty much what the emerging issues are and we're consistent with what the staff understands as the emerging issues.

Technical area, we have the experience at Palo Verde, both the Unit 2 tube rupture and the circumferential cracking that Emmett was discussing at the Unit 1 inspection results. We are seeing more freespan cracking. We are trying to help the industry understand that that's there, to look for it, to deal with it.

Upper bundle fouling, which, again, was related to the tube rupture at Palo Verde 2 and has been found in a number of Westinghouse units and has caused pressure drop, is something we're more sensitive to and we're going to look at and make sure the utilities are watching it closely.

Prior to Palo Verde, we had not seen it associated with any kind of corrosion phenomena and we're now sensitive to that. High growth rates, both real and apparent, from NDE. The circumferential cracking issue, which is the Palo Verde 1, as well as the Arkansas experience at ANO-2 that Emmett was discussing, which is either -- it may be a PWSCC, we're not sure, but it's a circumferential cracking phenomena at the top of the tube sheet in CE units. Now that they're sensitized and looking for it, there are techniques that can find it and we can inspect for it.

Of continuing concern, because the industry, as well as in the regulatory environment, we don't want to have forced outages due to tube leaks. So we clearly don't want to have tube ruptures. We want to limit those. The adequacy of the ISI process is constantly being scrutinized, both as a self-assessment by the industry, as well as by the outside people looking in on us.

We think we have made great strides in improving it. There are still areas where we would like to improve it more. The use of UT comes up. There are appropriate cases technically where it should be used. We believe it is being used, particularly to characterize damage forms.

There is some increased pressure, again, through the regulatory environment to use it more. We hope in our discussions through the DMS initiative and others that we are responsive to the need to use it where it's appropriate.

There's a large database currently on eddy current testing and where eddy current testing is appropriate, having that large database makes it the preferred inspection technique, if it's adequate to assure structural capabilities.

Then there are some other issues that are driving us. We have ratio control chemistry, which I will touch on in a minute. Chemical cleaning. Now, where we see bundle fouling, like implicated at Palo Verde 2 and some of these other units, chemical cleaning has been around and available in this country and qualified -- I'd say qualified for use for several years now as a result of some of the earlier work done through the steam generator owner's group program.

It's not been widely applied for a number of very understandable reasons, but we're trying to help more utilities that need it make sure that they can apply it and will apply it if it is needed.

Again, as a result of the Palo Verde 2 experience, we find that some of the thermal hydraulic codes that define flow fields and such things as that, when coupled with some of the chemistry modeling codes we've developed, can be used to understand where you might see damage susceptible parts of a bundle and where you could then concentrate your inspection with the appropriate technology. So we're starting to do that.

And I'll touch briefly on some direct tube repair technology that we have in the feasibility study stage right now in just a second.

Now I want to turn briefly and talk about the steam generator management project, because this is where the industry is, in fact, funding a fair amount of effort on an annual basis to manage steam generator problems.

The SGMP stands for steam generator strategic management project, and we purposely dropped that second S. It's a combined program that's funded about 50/50 between the EPRI-based program and the participants in the program, which are essentially EPRI members or some international participants.

Managed by EPRI, oversight provided by the utilities, very direct oversight, as it would turn out. We have 26 -- actually that number now is 28 organizations that are U.S. EPRI member utilities, plus an additional seven international entities that we have agreements that are participating in the program. Those are as you see and we're trying to get the Koreans to join in the program right now.

That is a follow-on to some earlier programs. We've basically been continuously running a steam generator type program through EPRI since 1978. They've been in four or five year increments, as you see.

The total resources are about -- have been in the range of $6 to $8 million annually, research budget, and we have a dedicated staff at EPRI of about eight to ten people -- eight people with two more spending about 60 percent of their time on the program. So it's a fairly expansive program.

The goals, quantitative goals, as I said, we would like to see that annual average for capacity factor loss due to forced and extended outages running something less than two-and-a-half percent. The goal is to provide the utilities individually with the tools to fit within whatever their own framework is such that they can do that. We would also like to assure that all future replacements are less than 100 days and that the information exchange is available to assure that.

Though we don't have a quantitative number, as I said earlier, we would like to reduce the number of forced outages due to tube leaks to an absolute minimum, and that includes tube ruptures, which are the larger of the leaks.

This next slide isn't in your handout, but it does reflect how we're currently looking at the program and have been for some five or six years. What we'd say is that you probably ought to break down steam generator management, whether you're talking about a research program or anything else, into three separate boxes, one of them being mechanism management, one of them being degradation or defect management, and the other one being life extension or major replacement, life extension or replacement activities which could include major repairs.

Mechanism management is where we identify a damage form and it usually comes from some sort of an inspection result, an emerging issue, try to determine, one, what the cause is and then, two, what the corrective actions can be for it so that the existing units won't have to be facing that damage form.

As you're less successful in this block, you move to this next one, which I'll come to. Things we have come up with in this area are things like the water chemistry guidelines, which were the original -- probably the original and most important product out of the steam generator owner's group program. They've evolved through four iterations now.

But that's where we dealt with getting the impurities down, coming up with alternate amines, ratio control, and we're looking at adding a chemistry that could add inhibitors and buffers, and I'll talk to that in a minute.

Sludge control, where we've developed a chemical cleaning process, help the utilities come up with their vendors for improved lancing and activities that would reduce the corrosion product transport, because corrosion product either in the sludge piles or the buildups in the bundle have been implicated in a number of the damage forms.

The other items on here you can read; stress improvement, like the shot peening, roto-peening, the in situ stress relief for the U-bends, and flow-induced vibration and thermal hydraulic models which have been factored into the new replacement designs.

This is the area that more or less the morning session of this meeting was focusing on and a lot of our activities are focusing on. It's where you come up with a scheme where you remove only those tubes from service that are required to be removed for safety reliability and no others. That's an optimum or successful marriage of an inspection process, including the technology that's in that inspection process, with the appropriate repair limits.

That's the first part of it and that's the part that we have worked on extensively in this program. The second part of it -- and I used an abbreviated though -- assess the consequences, but that's the whole back end of the process when it says that you haven't necessarily been successful when you do have tube rupture type events and how you manage those on through the scheme of things.

Now, a lot of activity has been done in the industry, just not specifically done through EPRI. Then finally you get over here into the life extension and replacement. One of the things you want to do is factor all the lessons you learn on this side of the curve and this side of the diagram into this side and make sure that your replacement units, in fact, have the optimum design and materials and that the plants -- the secondary balance-of-plant features are incorporated appropriately so that you can manage and maintain a replacement generator to last out the full life of the plant.

We also have some activities where we are letting -- facilitating the information exchange among the utilities on how to deal with economic decision analysis, which we have not gotten into, but a number of the utilities individually have, as well as the repair and replacement lessons learned. In the eleven replacements you had in this country, plus the probably four or five additional ones worldwide, we try to get them to exchange information on the specific problems and issues that have come up during the replacement activity.

Recent products. Revision 3 to the water chemistry guidelines, which is the fourth iteration since we started on Rev. 0. We have come up with some advanced amine application guidelines. I'll touch on these two in just a minute. John Blomgren will talk about the package which is a follow-on to the discussion this morning, the four topicals that we've submitted for SGDSM, which stands for steam generator degradation specific management.

Finally, a product which Emmett alluded to a bit this morning was the steam generator eddy current performance demonstration package, which we've provided and is being used and pretty widely implemented in the industry for eddy current data analysts training and qualification.

This falls into that lefthand side of the diagram I had where we were talking about mechanism management. For the phenomena we're talking about today, the ODSCC, it really is controlling the secondary water chemistry environment that's going to be -- if we come up with a corrective measure, that's where it's going to have to be, we believe.

The tie here is you have the guidelines as they exist today and where we're heading is to a Revision 4, which would incorporate some advanced amine application guidelines for sludge transport control, molar ratio application guidelines for trying to maintain the crevices neutral, and I'll talk to that next.

We've known for some time that maintaining some sort of ratio between the anions and cations in the bulk water, particularly on ABT water treatment, is very important. The Japanese have been doing it in several plants for quite a number of years. We were aware back probably in the mid-1980s that that was an important issue.

How to control it and what it should be is something that we've been struggling with for a number of years. With Revision 3 to the water chemistry guidelines, there is incorporated in that the requirement or the recommendation that plants start looking at how to maintain the molar ratio, at least in the initial target of about .5.

All other things being equal, this will leave your crevices at a condition of neutral pH, which will prevent ODSCC and hopefully stop it if it's been initiated. It's not meant right now and we don't see it being meant in the future to be any kind of replacement for the earlier chemistry improvements which we employed to stop the denting and the pitting phenomena, which was to reduce the impurity import -- transport and input to as low a value as possible or reasonably achievable.

We're still saying drive the numbers way down. But once you get very far down, it's very easy to get an imbalance that could drive your crevices either very acid or very caustic very quickly with the concentrating mechanisms you see, particularly in drilled hole support plates.

That's why I say in the replacement units, this is much less of a problem because we've basically all got broached holes and once you go to the broached holes, you get a much clearer flow path and a much lower concentrating mechanism generally.

We find that at least 23 plants have currently adopted ratio control and that's just within this one year. Eleven have chosen to manage it using the demineralizers, either the blow-down demineralizers or the condensate polishing system and some form of regeneration scheme there.

Eight others have chosen to inject ammonium chloride, again staying at the very low limits that are already established to prevent denting and pitting.

The question comes up does it work. We don't think it does any harm at all. Where we have good data to relate molar ratios back to damage progression in eddy current data, we would say it is successful. We don't have a lot of that data right now. Not many plants have been controlling it prior to this year. Again, it is -- you've got to tie it to eddy current data and whatever limitations there may be on that.

In the case of the Japanese, they have some plants that have been practicing it since the mid-1970s and the plants that started up with it, they've shown no initiating of ODSCC. Now, there could be some other things that come into play there. We think it keeps their generators quite clean from the standpoint of sludge transport and other such things. But they do a very thorough inspection, to the best of our understanding. They at least historically have had higher both leak limits and plugging criteria than you have in this country.

So we would say the data is real and that, in fact, the molar ratio control has been very successful. They use a ratio of .2 and they control it with condensate polishers, which we're not quite ready to do in this country massively. But we've given guidance for the utilities of how to pick what that ratio ought to be with the initial target being .5.

Again, in the Japanese experience, the plants that came on the molar ratio control after startup, and this is generally some years after startup, show a slower progression rate than we're seeing in this country, but they still have the damage form.

MR. LINDBLAD: How does this relate to blow-down? Is there substantial blow-down with these chemistry systems?

MR. WELTY: They all have continuous blow-down.

MR. LINDBLAD: A 100 gpm, 400 gpm?

MR. WELTY: I can't answer that. I apologize. I don't know what that answer is.

MR. BLOMGREN: It varies.

MR. WELTY: It varies from plant to plant and design to design. We also have advanced amines. Again, for a number of years, we had a feeling, a pretty strong feeling and some strong indication that there were better ammonias, better amines than ammonia. It took a number of years to get plants to shift to morphaline.

We've come out with some that are better yet, and, again, this is for reducing corrosion product transport down the feed train and into the generator. For plants previously on amine, 17 have now in the last year shifted to ETA, which is one of the more advanced amines we're looking at right now, and a number of other plants plan to shift to it.

For plants going from ammonia to ETA, we find a large reduction in ion transport. For plants previously that had shifted to morphaline from ammonia that are now shifting, we find it's less dramatic, but, again, it's still an improvement. The utilities and the vendors are now much more willing to shift to these advanced chemistries, bottom line from that thought.

That completes what I was going to say about the chemistry products. The last thing I wanted to talk about right now before I let John get up and talk about degradation specific management is some direct tube repair work. This, again, is in a very fundamental feasibility stage, but we have high hopes of having a field testable product by the end of this next year.

What we're looking at is a method where you can directly apply a well bead of a corrosion-resistant material to the IDE of tubes, specifically focusing right now on the support plate intersections that are impacted by ODSCC.

It uses a YEG laser with fiber optic delivery system. The advantages we see to it if you compare it to plugging, it's obvious you keep degraded tubes in service. If you compare it to sleeving, we see it as being a far faster, far cheaper -- and, again, this is the developer's thoughts. I think it will be far faster. It's not clear yet how much cheaper it will be and we have to get that. It's going to be an economic consideration.

It will lead to a lower pressure drop. It doesn't have anywhere near the restriction of a sleeve. Smaller crevice, you will have no crevice behind the repair. You have the capacity to repair on up in the bundle after you may have sleeved in the tube sheet region either for PWSCC or in the lower part of the bundle for ODSCC, if you had applied sleeves earlier.

So you don't have to start out repairing at the top, which is kind of the constraint you have now if you decide to repair ODSCC at support plates with sleeves.

There's another process that's being tested right now, which is a service re-melt without laying down a bead, and we see that there are some advantages to this and that it restores the full structural strength, we believe, and it provides a material that's more corrosion-resistant than the material you had in there to start with.

We've proved the feasibility of it. We're in the process now of trying to get the prototype factor that can go up inside tubes in a field kind of a unit application to apply it and then to do the qualification testing to assure that you have an inspectable repair, as well as a repair that does restore the full structural integrity and doesn't negatively impact damaged tubes.

MR. LINDBLAD: And that has no filler metal, you're saying.

MR. WELTY: The bottom one has no filler metal and that's the one that's being tested. It's the Westinghouse product and it's been tested in several plants. I'm not sure what the success rate is on that. So we're looking at adding a filler metal.

MR. LINDBLAD: And that's an IDE application, as well.

MR. WELTY: That's correct. To conclude the status portion of this discussion, our view is that some damage forms have been virtually eliminated. That would pertain to denting, pitting, wastage, sludge pile IGA. This was done with chemistry control measures.

For some units, other types of damage have been related. Some plants with the expansion zone primary water stress corrosion cracking, the NRO U-bend stress corrosion cracking and ABB wear. This is through the various in situ repair techniques.

In some cases, the damage is being managed and this is for the units that may have applied these in situ repairs after the damage initiated and that pertains to expansion zone primary water stress corrosion cracking, which was that plot I showed you that showed a fairly flat rate, but about .05 percent of the tubes in service being plugged on an annual basis, as well as some tube sheet IGA for the plants that have crevices and that remain in service, though most of the tube sheet crevice plants have been replaced.

We are still looking aggressively for a remedy for the tube support plate ODSCC. Molar ratio controls show some definite signs of being at least a partial savior. We also have a fair level of effort in inhibitor or buffer development, which would -- the inhibitor would passivate the film in the crevices. The buffer would buffer the crevice chemistry you get.

We're testing some of those in field tests right now. They would be a follow-on for the ratio control for the plants that need it.

As I said before, if we look at the replacement units, we see minimal damage in any of the replacement units. I don't know how many tubes Surry has plugged, but I think it's on the order of seven to ten. I believe some of those were plugged prior to service. Again, with the Surry units, you're talking 12 years of operation, calendar years, pretty extensive.

The newer units have much less susceptible material. We believe that the thermally treated 690 is virtually immune to primary water stress corrosion cracking and a factor of ten or so more immune to the OD phenomena we're seeing. We also know a lot more about chemistry control.

Broached hole support plates, so you don't have the concentrating mechanisms. You have stainless steel supports, so you don't tend to have the denting phenomena, if that was a problem. We've learned a lot in the TH analyses to make sure that the bundles, in fact, perform thermal hydraulically in a way that don't lead to problems.

This is an important one because -- and that gets back to the question you asked me earlier. We believe that every utility now has some entity, either a person or a task force or a group responsible for steam generator management that meets regularly and aggressively tries to assure that the steam generator managcment program implemented at that utility is the optimum they can get.

So there's a tremendous amount of management attention being paid to steam generators. It varies, though, fairly widely. And we do have improved chemistry control.

That's all I have to say about the status right now.

MR. LINDBLAD: Is the damage done exclusively at power? I'm thinking of the Three Mile Island outage and the damage seen on the unit there. How much happens during shutdown?

MR. WELTY: Other than the one you're talking about, we don't think very much. We assume most of the damage is stress corrosion cracking phenomena or more temperature-driven and concentration-driven and that they're principally an operating phenomena. We've never been able to pull out from the data that there's any large scale damage occurring at shutdown, though that question did occasionally come up when we had these guideline committees generating the water chemistry guidelines.

MR. LINDBLAD: Thank you.

MR. BLOMGREN: My name is John Blomgren and I'm with Commonwealth Edison. I'm going to talk about the new initiative, most of which you heard about from Tim Reed. So I can go pretty rapidly through this. There are only a half a dozen or so points that I'd like to be sure that are made, in addition to those that the NRC and the staff have made as part of their presentations.

This initiative, as a matter of fact, has changed in many respects, but really started roughly in 1985 or 1986. It started as a result of some of the degradation that was seen in Europe in the roll transition areas, primary water stress corrosion cracking specifically in the EDF units, the units in Sweden, the units in Belgium.

You heard a little bit earlier about the primary water stress corrosion cracking alternate repair criteria. One of the things we're starting to discovery that we're going to be working on straightening out is we have a variety of different names that we call the same thing -- interim plugging criteria, alternate plugging criteria, alternate repair criteria.

One of the things that I would like to do today, if nothing else, is try to leave you with a correct impression of how they are related. So that's kind of the objective of what I want to tell you today. So I'm going to skip over some of the things that we've got as part of the presentation and go to those issues fairly directly.

You will see that what we have put together in terms of a mission, I think, matches quite well with what Tim presented earlier. In terms of objectives, you'll see that these also match some of the things that you heard in Tim's presentation and in some of the other presentations, Mr. Karwoski's presentation earlier today.

A couple of things here that we want to particularly hone in on. One, establish the organization links, and I'm going to describe to you how we believe we've done that, to assure efficient and effective resolution of concerns, questions, issues that may come up as part of the NRC's reviews related to steam generator defect specific management.

As was explained earlier, steam generator defect specific management really now is beginning to look more and more like the new steam generator rule that Tim Reed was talking about.

Our objective is to see that these technical issues are resolved by September of 1994. You saw this slide earlier. An organization has been established on the NRC side, consisting of a management oversight committee and a technical steering committee. We've got now a project manager, and the individual is Tim Reed, which will help us expedite these reviews.

On the industry side, you see a similar organization and the specific lines of communication that have been established. Now, you'll see that in general or actually very specifically we've got an executive oversight group that is made up of utility executives, plus NUMARC. A lot of the things that you've heard described today have been the result of EPRI activities.

EPRI is not necessarily expert, nor used to dealing in licensing space. Therefore, NUMARC has -- we've started to cut them into this process. While they've been involved in watching over steam generator issues for a long time, it's been basically on a keep-them-informed basis.j

We also have a technical steering committee, which I have been asked to chair, and we've got some outstanding people here that have got a long history of working on steam generator problems. They also represent a variety of utilities who have several different designs of steam generators. So it's not going to be focused necessarily on Westinghouse units or B&W units or Combustion Engineering units.

As a matter of fact, I think on another slide you will see that one more individual has been added to this technical committee to specifically represent Combustion Engineering. His name is Ken Craig from Florida Power & Light.

To assure that we also include, appropriately, eddy current inspection vendors, the NSSS suppliers, we've also got participating in these activities the parts of the EPRI organization, the steam generator management plant organization that have actually produced the four documents that Tim talked about earlier.

There's an ISI guidelines committee which actually prepared the NDE inspection guidelines for steam generators. They will be involved in some of these reviews and involved in responding to some of the issues. There is the SGDSM ad hoc committee, which actually wrote the SGDSM methodology document and the two alternate repair criteria documents, one for primary water stress corrosion cracking and the other for ODSCC.

The next couple of slides just go to the issue of the organizations, really that each one of the individuals on the various committees, what their organization is. But it also goes to the function of the executive oversight group, in this case. Their main objective is to solve or resolve or take positions on a policy level.

If there are technical issues that the technical groups cannot resolve or cannot come up with appropriate responses to, they are also there to assist in those resolutions. We don't anticipate that there will be anything technically that will be resolved by this executive oversight group.

The other advantage of the executive oversight group is to have this interface with industry entities to obtain the necessary resources. This could be the NSSS supplier owner's groups. It could be EPRi. It could be other organizations, as needed, to obtain resources, be they money, be they people to resolve questions or address issues as they come up.

The technical committee, it's a little bit more apparent what they do. They're there to actually provide the resolution to questions or issues as they come up.

What I would like to do at this point is try to show you in picture form, if I can get to the right picture, what we're talking about. This is the SGDSM concept and I believe that Tim Reed earlier this morning talked about the fact that when this was originally conceived by the industry as SGDSM, which was really about three years ago, two-and-a-half years ago, the concept was to come up with a methodology that could change everyone's technical specifications. The concept was not to come up with a new rule.

So this document was established as a way to define a methodology which could then be applied to different modes of degradation. When we're talking about modes of degradation, and there were a lot of questions about this earlier this morning and Mr. Karwoski was good enough to loan me a slide, ODSCC -- in this case, circumferential or apparently circumferential -- if that is a mode of degradation, that would have a very specific repair criteria. It would meet generally the same structural limit requirements, but may meet them in a completely different way than this, ODSCC axially-oriented mode of degradation.

So when we talk about defect specific management or steam generator defect specific management, those of us at the utilities have to use the steam generator so that we don't get confused with demand side management. But they're the same thing.

But the repair basis or the repair criteria for this mode of degradation may well be different than it is for an axial crack. Now, we have not gone and tried to develop repair criteria for every single mode of degradation, but that's possible that it could be done. The measurement, the NDE technique that would be used may be different for every mode of degradation.

For example, I don't recall, maybe it was Mr. Murphy that mentioned this morning that for primary water stress corrosion cracking in the roll transition, which would be this kind of cracking, we use a length-based criteria where you actually measure the length of every individual crack. You then apply it to a standard for the structural margin, do some calculations to determine things like how many of these can I leave in service, and, in fact, you would then have a very specific inspection criteria, a very specific inspection methodology, a calibration technique for that methodology, and then you would apply it in the field.

Another technique would then be ODSCC and it may be different. In this case, ODSCC, we've discovered that it seems to work best from the standpoint of being able to field apply the repair criteria to use voltage-based criteria as opposed to something else that could be used. Phase angle was mentioned this morning. That more relates to depth. Or you could, again, use crack length. But if voltage works best, use voltage.

That's the difference between these different methodologies that we're talking about. So, indeed, there could be a series of, in this case, not interim plugging criteria, alternate plugging criteria, but alternate repair criteria.

We tend to use repair criteria because of one of the questions that was asked today. The repair does not necessarily have to be plugging. The repair could be sleeving. It could be a direct tube repair without filler metal. It could be a tube repair with filler metal. So that's what we're talking about in terms -- that's why we call it repair.

A couple of very important issues. The process for the specific ISI depends upon the specific damage form and similar damage forms in different locations on the tube; for example, ODSCC in a tube support plate crevice, ODSCC on a freespan. The ISI technique for those may be different.

So that's why we look at it for being very specific for that specific damage form and for the specific location. As I indicated before, these alternate repair limits have been developed and used in Europe extensively over five or six years now. To a large extent, these are expansion zone primary water stress corrosion crack, pipe repair limits. They are length-based.

Our document, which the NRC is reviewing, to a large extent, is dependent directly on the EDF, the Swedish State Power Board, and the Belgium databases for expansion zone cracking. ODSCC at EDF, at least, is -- while it's a mode of degradation, it is not as prevalent as primary water stress corrosion cracking at the expansion zone. But they also have a criteria, again, that's similar. It's bobbin coil voltage-based.

In this case, we think we have more data from the United States in this particular area to establish that repair limit than actually is present in some of the French-based limits, but yet we do use and do compare those results and we do use them to supplement each other in terms of repair criteria.

MR. SHACK: You discussed this a little bit earlier. To use this kind of a process, you have to be able to identify the mechanism.

MR. BLOMGREN: That's right.

MR. SHACK: And I see some of the industry comment -- there's a suggestion made that there's a unique eddy current signature for the outer diameter stress corrosion cracking, but I heard somebody else mention this morning that you want to know whether it's ODSCC, you pull a few tubes and you look, which certainly seems much more convincing.

How do you propose to identify each of these specific mechanisms? Is it basically location, historical?

MR. BLOMGREN: It's location, it's historical, it is tube plugging -- tube pulling, I'm sorry, even on a plant-specific basis. I think the question that we talked about this morning relative to how many tube pulls should a plant have goes to not whether you should have them or not, the issue of pulling tubes or not pulling tubes at a plant. It goes more to the question of how many tubes do you need to pull at a specific plant or a specific unit.

You do have to, in each one of these repair criteria that have been proposed, again, down at this level, the requirement is -- and remember there are only two of these documents that have been written to date and if we're successful in this, there could be more.

The premise is a plant must be able to demonstrate that if they're using this repair criteria, they do have that mode of degradation at that location and it fulfills certain other requirements that are defined in the document. Now, they can do that by tube pulls, and most likely would have to, to some extent, but then after that, they may be able to fulfill that requirement by using some kind of enhanced inspection techniques, either rotating pancake coil, multiple coil rotating probes, which are really enhanced inspection techniques.

Those enhanced inspection techniques are also suggested as part of the document as this is the process you've got to use. So there are several ways to get there, but you must show that you've got this in order to use it. You cannot use this alternate repair criteria for primary water stress corrosion cracking at the roll transition.

If you're going to use primary water stress corrosion cracking alternate repair criteria, for example, you must RPC 100 percent of your roll transitions and measure the crack length of every crack.

That's why it becomes confusing or difficult to try to answer questions that seem very direct in terms of how do you calibrate these things. The length-based coils have a very different calibration requirement, for example, to demonstrate that they're working appropriately as opposed to the voltage-based coils and they will not use the same standards. They cannot use the same standards, for example.

Now, indeed, you can come up with a scenario where a given plant would use both this and this repair criteria. This methodology suggests then or describes how those have got to be meshed together.

So I think I'm done. If you've got any questions, I'd be happy to try to answer them.

MR. LINDBLAD: Could you give me a little background about who does the work that we've been talking about all day? Do utility employees do the inspection and interpretation of results or do the vendors do it or are there contractors who specialize in this?

MR. BLOMGREN: In the ISI area, most of the inspections are actually done at most plants by contractors. Those contractors may be NSSS suppliers.

MR. LINDBLAD: And how many are there? Is there some exchange between plant sites to get normalized results in that regard?

MR. BLOMGREN: Yes. Well, that's part of Appendix G and H to the NDE guidelines, which is part of the performance demonstration program. There's a deliberate exchange of information; not necessarily a 100 percent. There's too much data. When you get to do 100 percent inspection of a steam generator that's got 4,500 tubes and you've got a plant with four of those, you've got 20,000 tubes and, I don't know, I think Jack was saying a quarter of a million data points.

You can't exchange it all, but the pertinent things are exchanged.

MR. LINDBLAD: Is this a specialized inspection group or is it a common inspection group working to written procedures? How many such inspection contractors are there in the United States?

MR. BLOMGREN: In the United States, I would say there are about four or five.

MR. LINDBLAD: So it's rather a specialized group.

MR. BLOMGREN: It's a rather specialized group.

MR. LINDBLAD: Who do this almost full-time.

MR. BLOMGREN: That's exactly correct.

MR. LINDBLAD: They're not checking the reactor vessel next.

MR. BLOMGREN: Well, I guess I can't speak to how many of them are actually qualified to do both. There may be individuals at one supplier that are actually qualified to do UT and eddy current, but I don't know how many of those there are.

MR. LINDE'.AD: When you showed your organization, certainly it's a po..cy group and I don't see vendors involved in the pc..cy group. But typically when we have equipment problems like this, we do get vendors involved. Are steam generator suppliers your contractors in some of this work?

MR. BLOMGREN: In a lot of the work, they are. I'm trying to find my organization ones here. They're involved at a couple of different levels. Indeed, in the contract research at EPRI, the vendors do a lot of that. They're also involved in these committees. They are full members of these committees, all of the NSSS suppliers.

For example, in the ISI committee, all of the inspection contractors that do inspections in the U.S., plus a couple of people from Europe, are members of this committee. There are also utility members. But they're all on this committee, all the NSSS suppliers all have membership on this committee.

Now, one of the things that may happen down the road, I should point out, is that there may, at some point, be an effort by the industry to take these two committees, roll them into one committee and call them a NUMARC working group. That hasn't happened yet, but that could happen and we don't see that as a bad thing. That's not why we haven't done it, but that may well happen, which will then bring in the vendors even more directly into this area.

MR. LINDBLAD: We saw that some of the earlier repair procedures actually were the initiation point for some cracking, such as -- well, you know the ones.

MR. BLOMGREN: Such as sleeving, yes.

MR. LINDBLAD: Sleeving and Wextex and expansion and rolling. As you're developing new repair procedures, are you actually doing prototype testing and fatigue testing to see if we're introducing new problems?

MR. BLOMGREN: All of the development on repair technologies are done by the service suppliers, BWNS, Combustion Engineering, Westinghouse. They do most of that. We are doing some of that now with this new direct tube welding process. And there are qualification tests that are done with all of those things.

I think some of the --

MR. LINDBLAD: I should have asked a preliminary question. The incidents of failure traceable to repairs, does that disturb the industry or was it a modest amount that could be tolerated?

MR. BLOMGREN: It disturbs the industry, I guess, or it at least disturbs me.

MR. LINDBLAD: Mr. Welty established some levels of damage that were tolerable and I wondered if the previous repair processes fell within that range, as well.

MR. WELTY: My answer is qualitative. I'd say yes, it disturbs us that any of them occurred. We try to qualify the repair techniques so that they don't, in fact, aggravate it. We're very sensitive to the fact that if you don't properly qualify it, that could happen. Not many tubes have, in fact, been damaged by the repair techniques.

MR. LINDBLAD: So it was a modest level that would have been tolerable.

MR. WELTY: Yes.

MR. LINDBLAD: Thank you.

MR. SEALE: Any other questions?

MR. WELTY: I have two more quick viewgraphs.

MR. SEALE: Yes.

MR. WELTY: You had asked that we comment on our comments on NUREG-1477. What we did was we attempted, so that the NRC staff didn't have a great preponderance of different sources of comments, to consolidate the industry comments through the steam generator management project and we forwarded our comments in a letter on August 12. I believe you got a letter from Westinghouse separately, because there was some proprietary data that was referred to.

Our comments were put together in conjunction with and coordination with the Westinghouse and we knew what our comments were, so that we didn't, again, inundate them with similar, but confusing comments.

So I believe, in general, the comments came through a fairly limited number of sources. The letter format that we provided our comments in, we identified some areas of agreement. We identified some other areas where we thought some degree of accommodation between what our position was initially and what the draft 1477 showed would be required and some suggested improvements in the document.

Our comments were put together from the perspective of looking at the -- more than the interim criteria, but how this would impact what we see as the alternate repair criteria, which is incorporated as part of the DSM effort.

I will just simply put this slide up and it's absolutely consistent with the commentary that Emmett gave you on what the issues are. The number of tube pulls, the support for the proposed leak rate, we think there is a correlation for voltage and leak rate. We need to get into some dialogue. Again, you can read down the list. It's absolutely consistent with the list that Emmett showed you. Those are the issues, we agree, and we need -- we assume we're going to have some dialogue through this technical steering committee that John just talked about.

That's what I have to say.

MR. SEALE: Fine.

MR. LEWIS: I would only urge you to recall that the word "criteria" is a plural.

MR. SEALE: Criteria is more than one. One of them is a criterion.

MR. LEWIS: Next to last slide and various other places.

MR. WELTY: Yes, sir.

MR. SEALE: Any other comments, editorial or otherwise?

MR. LEWIS: I always, when I can, strike a blow for the English language.

MR. WELTY: I appreciate that.

MR. SEALE: I think that ends the formal presentations and I guess we can go off the record now.

[Whereupon, at 1:45 p.m., the meeting was recessed.]

REPORTER'S CERTIFICATE

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

NAME OF PROCEEDING: ACRS Materials & Metallurgy

DOCKET NUMBER:

PLACE OF PROCEEDING: Bethesda, MD

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.

Official Reporter
Ann Riley & Associates, Ltd.

INTRODUCTORY STATEMENT BY THE CHAIRMAN OF THE
MATERIALS AND METALLURGY SUBCOMMITTEE
7920 NORFOLK AVENUE, ROOM P-110
BETHESDA, MARYLAND
DECEMBER 16, 1993

The meeting will now come to order. This is a meeting of the ACRS Subcommittee on Materials and Metallurgy.

I am Robert Seale, Acting Chairman of the Subcommittee.

The ACRS Members in attendance are:

William Shack, Thomas Kress, Harold Lewis, William Lindblad, and Carlyle Michelson.

The purpose of this meeting is to discuss the steam generator operating experience and steam generator rule making activities.

Elpidio Igne is the Cognizant ACRS Staff Member 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 November 30, 1993.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register Notice. It is requested that each speaker first identify himself or herself and speak with sufficient clarity and volume so that he or she 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 Mr. Jack Strosnider of NRR to begin.

ACRS
MATERIALS SUBCOMMITTEE MEETING

DECEMBER 16, 1993

BETHESDA, MD.

J. STROSNIDER, CHIEF
MATERIALS AND CHEMICAL
ENGINEERING BRANCH, NRR

Agenda

8:30-8:45	Introduction	J Strosnider
8:45-9:15	Recent Experience and Regulatory Implications	E Murphy
9:15-10:15	Eddy Current Issues	E Murphy
10:15-10:30	Break	
10:30-11:00	Repair Limit Issues	K Karwoski
11:00-11:30	NUREG-1477 Background and Status	E Murphy
11:30-12:00	NRC Integrated Plan	T Reed

CHANGES AFFECTING S.G. REGULATION

NDE TECHNOLOGY

* DATA COLLECTION/MANAGEMENT

  HUGE AMOUNTS OF DATA CAN BE ANALYZED AND TRACKED

* GREATER SENSITIVITY

  PROVIDES A BASIS FOR REFINED PLUGGING CRITERIA

* UTILITIES FIND IT ECONOMICAL TO APPLY IMPROVED TECHNOLOGIES TO MANAGE STEAM GENERATOR DEGRADATION

DEGRADATION MECHANISMS

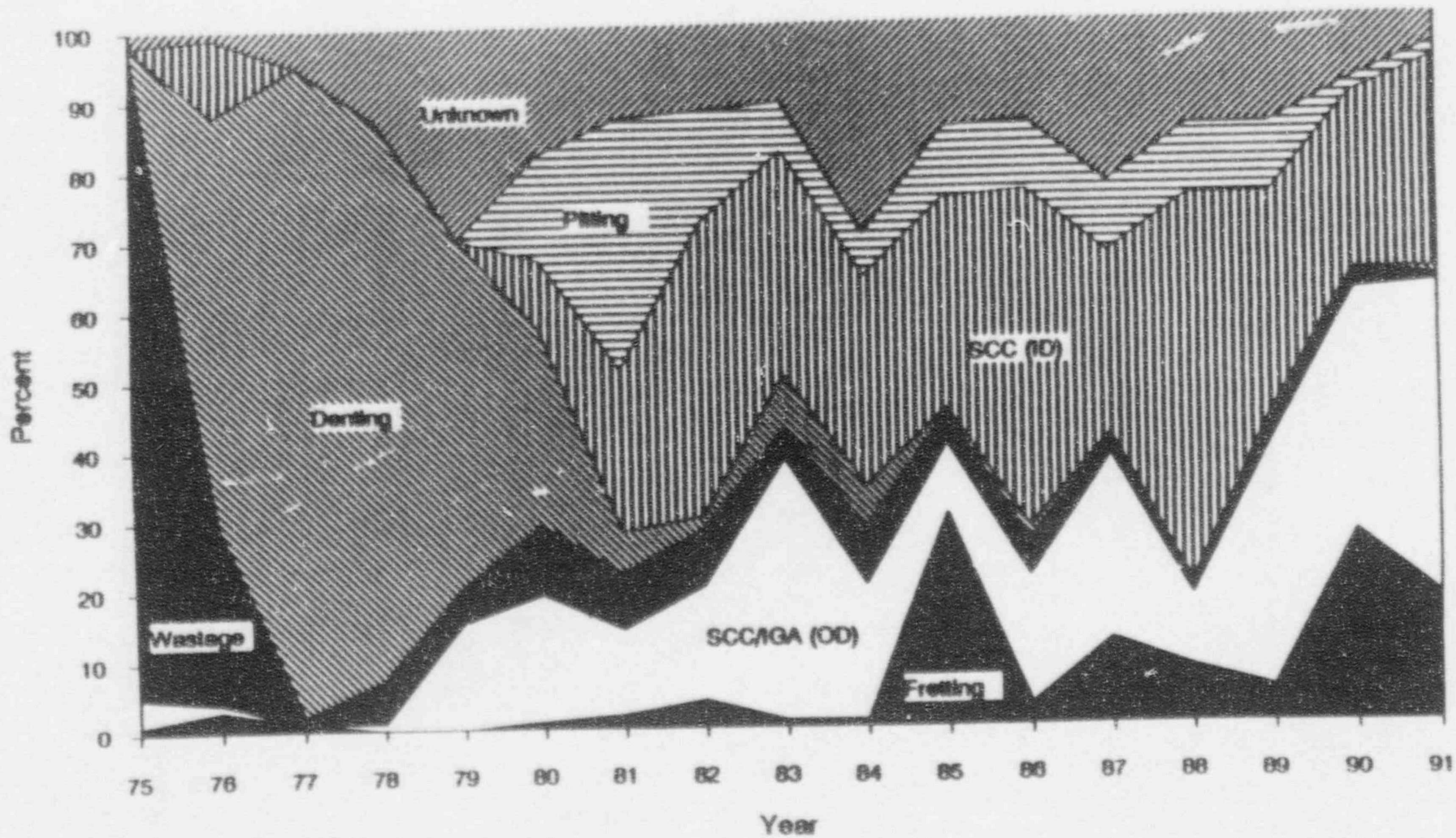
* ODSCC, CIRC CRACKING, FREE SPAN CRACKING, ?

  DIFFICULT TO MEASURE DEPTHS RELIABLY

  da/dt DIFFICULT TO DETERMINE

Figure 4-1

United States Causes of Steam Generator Plugging



CONSEQUENCES OF CHANGE

* REGULATORY CRITERIA OUT-OF-DATE

* AD HOC REGULATION RESULTS IN:

  INCONSISTENCIES

  UNSTABLE REGULATORY ENVIRONMENT

  DRAIN ON RESOURCES

  ISSUES REGARDING NRC PROCEDURES FOR ADDRESSING GENERIC ISSUES

* NEED FOR A GENERIC APPROACH

  PERFORMANCE BASED

  ADAPTABLE

  PROVIDE INCENTIVE

  INTEGRATED APPROACH (SYSTEMS, MATERIALS, RADIOLOGICAL)

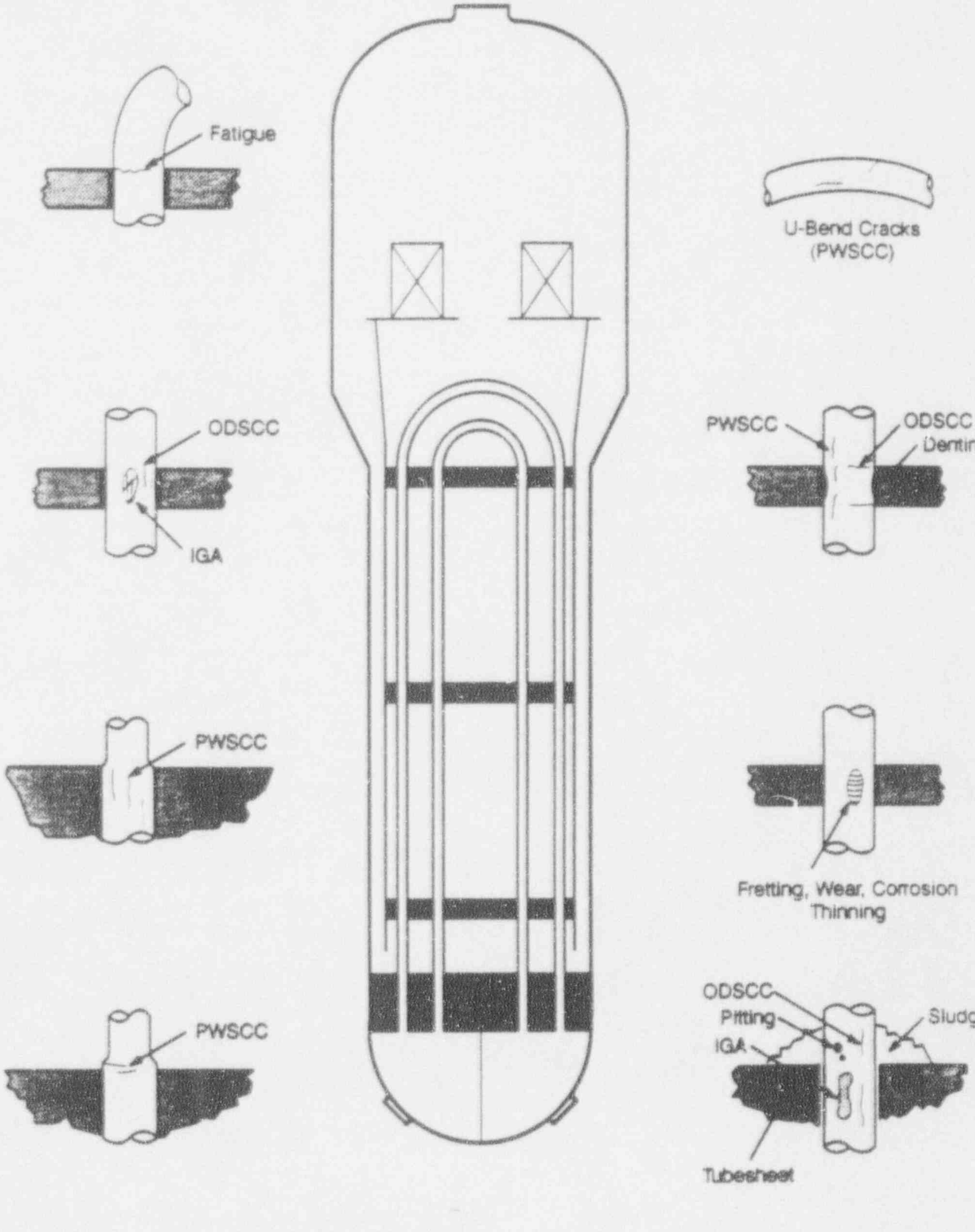
  SHOULD ADDRESS ALL PWRs

STEAM GENERATOR OPERATING EXPERIENCE

- SG TUBE DEGRADATION PROBLEMS ARE WIDESPREAD:
  - 7 SGTR EVENTS
  - SEVERAL FORCED OUTAGES/YEAR
  - SG REPLACEMENT AT ELEVEN PLANTS TO DATE
  - EXTENSIVE TUBE REPAIRS & OUTAGE EXTENSIONS
  - SIGNIFICANT PERSONNEL EXPOSURE

- NO END IN SIGHT TO THESE PROBLEMS FOR PLANTS OPERATING WITH THEIR ORIGINAL STEAM GENERATORS

EXAMPLES OF SG TUBE DEGRADATION MECHANISMS



Recent Trends of Concern

- SCC has emerged as the dominant degradation mechanism affecting SG tubing
  - SCC detection and sizing poses a significant challenge to current eddy current test capabilities in the field
    - -- due to low signal amplitude and signal-to-noise
  - Apparent crack growth rates can be very high
    - -- mid-cycle inspections are sometimes neccessary to ensure that cracks are detected before Regulatory Guide 1.121 margins are exceeded
- SCC in freespan is becoming more prevalent
  - e.g., McGuire 1 and 2, Palo Verde 2, Farley 1, Braidwood 1
  - Caused the two most recent ruptures (McGuire 1, Palo Verde 2)
  - Extraordinary measures to ensure a quality inspection have been neccessary to provide assurance of tube integrity at McGuire and Palo Verde

Recent Trends of Concern (Continued)

- Circumferential SCC is becoming more prevalent (see IN 92-80)
  - High tube integrity significance
  - Can only be detected if licensees use RPC probes at susceptable locations

- Since beginning of 1992, at least 5 plants experienced periods during which 1 or more tubes had insufficient margins per RG 1.121 to sustain MSLB pressure
  - McGuire 1, 2 (1 tube each)
  - ANO-1 (at least 3 tubes)
  - Palo Verde 2 (possibly 4 tubes)
  - Summer (1 tube)

- Experience shows that tubes with freespan axial cracking or with circumferential cracking may become vulnerable to rupture without significant precursor leakage

Implications

- Need for Improved Inservice Inspections
  - There have been widespread deficiencies in inspection programs throughout the industry (see Information Notices 90-49, 91-67, 92-80)
- Need for flaw-specific plugging criteria
  - The standard TS 40% T.W. limit is over conservative for some flaw types; can lead to unneccessary plugging of tubes
- Need for more restrictive limits and improved monitoring of primary to secondary leakage

NRR Response

- Continue to monitor SG operating experience
  - Issue information notices as appropriate
  - Communicate issues/concerns with Regions
- For plants experiencing significant SG degradation problems, continue to interact with regions and with licensees to ensure that licensee programs provide adequate assurance of tube integrity and public health and safety
  - Recent examples have included Palo Verde Units 1, 2, and 3, McGuire Units 1 and 2, and ANO-1
- Evaluate plant specific proposals for alternative plugging limits
  - W^*, F^* criteria
  - interim voltage based plugging criteria (IPC)
- Continue to implement the NRR SG Action Plan

Potential Issues for Plants Experiencing Significant Degradation

- inspection scope
- inspection equipment and procedures
- operational limits/monitoring procedures for primary-to-secondary leakage
- measures to mitigate further degradation
- tube integrity assessment
  - projected crack growth rates
  - tube integrity margins per RG 1.121
  - need for mid-cycle inspection?
- risk/safety assessment
- EOPs
- operator training

SG INSERVICE INSPECTION ISSUES

Status

- INSPECTION DIFFICULTIES
  - flaw detection
  - flaw sizing

- THESE DIFFICULTIES STEM FROM
  - small initial sample sizes
  - equipment limitations
  - limitations in test and evaluation procedures
  - personnel limitations

SG INSERVICE INSPECTION ISSUES

Status (Cont)

- INSPECTION DIFFICULTIES ARE MOST ACUTE FOR CRACKS

  - due to low amplitude, low signal to noise

  - 40% T.W. cracks cannot be reliably detected or sized with NDE technologies and practices currently being applied in the field

  - Cracks can be reliably detected before tube integrity is impaired, but only if the licensee uses the appropriate test equipment (including probes), test procedures, and data analysis procedures and if the analysts have been adequately trained and tested on these procedures

    -- There have been widespread deficiencies in this regard throughout the industry (see Information Notices 90-49, 91-67, 92-80)

SG INSERVICE INSPECTION ISSUES

Status (Cont)

- INSPECTION PRACTICES AND CAPABILITIES HAVE BEEN SIGNIFICANTLY UPGRADED IN RECENT YEARS
  - digital multifrequency ECT systems
  - alternatives to the conventional bobbin probe
    - -- e.g., MRPC probe
  - 1990 addenda to ASME Section XI, Appendix IV
  - EPRI SG Examination Guidelines
    - -- however, degree of adherance to these guidelines varies widely among different utilities

- MUCH REMAINS TO BE DONE

- NEED FOR IMPROVED/UPDATED REQUIREMENTS

- NRC INTEGRATED STEAM GENERATOR PLAN
  - includes consideration of EPRI guidelines

EPRI SG EXAMINATION GUIDELINES, REV 3

Summary

- QUALIFICATION OF NDE PERSONNEL
  - generic (QDA program)
  - plant-specific
- PERFORMANCE DEMONSTRATION GUIDELINES FOR EDDY CURRENT TEST TECHNIQUES
- GUIDELINES FOR DATA ACQUISTION
  - digital multifrequency techniques should be used
  - recommended test frequencies
  - probe types and their recommended applications
  - use appropriate NDE diagnostic methods to characterize new, distorted, or undefined signals

EPRI SG EXAMINATION GUIDELINES, REV 3

Summary (cont)

- GUIDELINES FOR DATA ANALYSIS

  - each plant should have written data analysis procedures

  - independant data analysis teams should be used

  - appropriate data analysis methods are recommended for each situation

  - establish criteria for "noisy data" and monitor data quality

  - analyze all appropriate data channels

- SAMPLE SIZE RECOMMENDATIONS

  - 20% programmed random sample

  - augmented inspection of suspect regions

  - expand sample size as appropriate

LESSONS LEARNED

- LOCATIONS SUBJECT TO CIRCUMFERENTIAL CRACKING SHOULD BE INSPECTED BY MRPC PROBE OR EQUIVALENT

  - CIRC. CRACKS NOT GENERALLY DETECTED BY BOBBIN

  - LOCATIONS SUBJECT TO CIRC. CRACKING INCLUDE:

    -- TUBE SHEET EXPANSION TRANSITIONS IN CE UNITS

    -- WEXTEX AND FULL DEPTH ROLL EXPANDED IN (W)

    -- TUBE SUPPORT PLATE HEAVILY DENTED INTERSECTIONS

- TUBE LOCATIONS WITH >5 V BOBBIN DENT SIGNAL SHOULD BE INSPECTED ON A SAMPLE BASIS WITH RPC

  - THE BOBBIN DENT SIGNAL CAN MASK A FLAW SIGNAL, RPC IS NOT AFFECTEDLY THE DENT

- U-BENDS POTENTIALLY SUBJECT TO STRESS CORROSION CRACKING SHOULD BE INSPECTED WITH RPC, SUCH AS:

  - (W) SMALL RADIUS NON-STRESS RELIEVED U-BENDS

  - PALO VERDE, UNITS 1,2 AND 3 (CE)

- ALL EDDY CURRENT INDICATIONS SHOULD BE REPORTED AND DISPOSITIONED AS PLUGGABLE OR NON-PLUGGABLE IRRESPECTIVE OF SIGNAL AMPLITUDE OR S/N RATIO

  - THERE IS NO BASIS FOR MIN. VOLTAGE THRESHOLD CUT OFF (PLUGGABLE INDICATIONS HAVE BEEN FOUND IN NOISE)

LESSONS LEARNED (CONT.)

- UTILITIES SHOULD HAVE A BASIS FOR DISPOSITIONING "UNDEFINED, NON-QUANTIFIABLE & DISTORTED" BOBBIN INDICATIONS AS NON-PLUGGABLE

  - BASIS WILL TYPICALLY USE MRPC OR UT TO CONFIRM

  - PULLED TUBES CAN PROVIDE INSIGHT INTO INDICATIONS

- BASIS SHOULD BE DEVELOPED BEFORE RELYING ON E/C DEPTH MEASUREMENTS FOR DISPOSITIONING STRESS CORROSION CRACKING AS PLUGGABLE OR NON-PLUGGABLE

  - EVIDENCE FROM PULLED TUBES AND NRC RESEARCH INDICATES THAT CRACKS CANNOT BE ACCURATELY SIZED

  - FOR THIS REASON, IT HAS BEEN USUAL INDUSTRY PRACTICE TO PLUG ALL CRACK-LIKE INDICATIONS REGARDLESS OF THE INDICATED DEPTH

- ELECTRICAL NOISE NEEDS TO BE ADEQUATELY CONTROLLED

- FOR STEAM GENERATORS WITH PILGERED TUBING, UTILITIES SHOULD DEVELOP APPROPRIATE TEST AND ANALYSIS PROCEDURES TO ENSURE THAT PILGERING NOISE DOES NOT IMPAIR THE ABILITY OF EDDY CURRENT TO DETECT AND SIZE FLAWS

TUBE PLUGGING LIMITS

- REGULATORY GUIDE 1.121
  - CODE CALCULATED MINIMUM WALL
  - MARGIN FOR ECT ERROR
  - MARGIN FOR DEGRADATION GROWTH BETWEEN INSPECTIONS

- TYPICAL T.S. PLUGGING LIMIT: 40% OF TUBE WALL THICKNESS

- APPLICABLE TO ALL DEGRADATION ᵔᵉCHANISMS

REPAIR CRITERIA

- 40% DEPTH BASED LIMIT DEVELOPED FOR UNIFORM THINNING

- 40% DEPTH LIMIT CONSERVATIVE FOR CERTAIN FLAW TYPES

- CONSERVATISM HAS LED TO FLAW SPECIFIC REPAIR CRITERIA:

  - PWSCC IN TUBESHEET: F*, P*

  - PITTING: INDIAN POINT UNIT 2

    PLUGGING LIMIT APPROXIMATELY 60% TW

  - AXIAL ODSCC AT TSPs: VOLTAGE-BASED

VOLTAGE-BASED LIMITS

- APPLICABLE TO AXIALLY ORIENTED ODSCC AT TUBE SUPPORT PLATE ELEVATIONS

- VOLTAGE LIMIT DETERMINED FROM BOBBIN VOLTAGE/BURST PRESSURE CORRELATION

  - NDE UNCERTAINTY AND VOLTAGE GROWTH ACCOUNTED FOR IN DETERMINING PLUGGING LIMIT

- IMPLEMENTATION REQUIRES, IN PART:

  - SPECIFIC ECT PROCEDURES AND SCOPE
  - MORE RESTRICTIVE OPERATIONAL LEAK RATE LIMITS

- THROUGH-WALL DEFECTS POTENTIALLY LEFT IN-SERVICE UNDER THIS APPROACH

  - LEAKAGE UNDER MSLB CONDITIONS MUST BE ACCOUNTED FOR

INTERIM VOLTAGE-BASED LIMITS

- MORE RESTRICTIVE VERSIONS APPROVED FOR FIVE PLANTS
  - APPROVED ON A CYCLE-BY-CYCLE BASIS

- TENTATIVE CONCLUSIONS REGARDING INTERIM VOLTAGE LIMITS DOCUMENTED IN NUREG-1477
  - LEAKAGE UNDER MSLB DIFFERENTIAL PRESSURE CONDITIONS IS DIFFICULT TO PREDICT
  - TUBE PULLS NECESSARY
  - ENHANCEMENTS IN ISI PROGRAM REQUIRED
  - PROBABILITY OF DETECTING CRACKS MUST BE ASSESSED
  - PLANT SPECIFIC ANALYSES

LENGTH-BASED LIMITS

- APPLICABLE TO AXIAL PWSCC AT ROLL TRANSITION

- PLUGGING LIMIT DETERMINED FROM CRACK LENGTH/BURST PRESSURE CORRELATION
  - NDE UNCERTAINTY AND GROWTH ARE ACCOUNTED FOR

- SIMILAR TO VOLTAGE-BASED LIMITS
  - PROGRAMMATIC
  - COMMITMENTS TO:

    SPECIFIC INSPECTION METHODS
    INSPECTION SAMPLING PLANS
    REDUCED PRIMARY-TO-SECONDARY LEAK RATE LIMITS

  - THROUGH-WALL CRACKS POTENTIALLY LEFT IN SERVICE

NUREG-1477

Status

- Draft NUREG-1477 issued in June 1993
- Federal Register Notice issued on July 2, 1992 requesting public comments
- Draft report evaluating comments expected by December 17, 1993
  - circulate for task group review
- Final report evaluating comments by January 28, 1994
- Complete revisions to NUREG 1477 in March 1994
- Issue proposed generic letter by April 1994 for public comment
- Issue generic letter & NUREG 1477 in June 1994

Public Comments on NUREG 1477

Major Issues

- Major issues include:
  - Need for additional tube pulls
  - Methodology for estimating SLB leak rate
  - POD estimates & how to use
  - How to consider bobbin indications not confirmed by RPC
  - Treatment of Outliers
  - Implications of large voltage growth at Summer
  - Eddy current test issues
  - Appropriate confidence intervals for assessing deterministic compliance
  - Realistic assumptions for offsite dose assessments
  - Severe Accidents

<u>NRC INTEGRATED STEAM GENERATOR PLAN</u>

* THE PLAN ADDRESSES THREE MAIN AREAS

  - *VOLTAGE BASED TUBE REPAIR CRITERIA FOR ODSCC*

  - *INDUSTRY PROPOSED DSM*

  - *STEAM GENERATOR RULE/REG GUIDE*

* EMPHASIZES GENERIC APPROACH

* REQUIRES COMMITTED RESOURCES

* MULTI-DISCIPLINED EFFORT *(RADIOLOGICAL, SYSTEMS, MATERIALS, RISK, SEVERE ACCIDENT)*

VOLTAGE BASED PLUGGING CRITERIA

* HIGH PRIORITY

  - *AFFECTS MANY STEAM GENERATORS*
  - *NEED A GENERIC POSITION*

* NUREG 1477/GENERIC LETTER

  - *PUBLIC COMMENTS UNDER REVIEW*
  - *NUREG 1477 WILL BE FINALIZED AND A GENERIC LETTER ON INTERIM VOLTAGE BASED APC ISSUED IN SPRING 1994*
  - *THE GL WILL PROVIDE AN INTERIM POSITION ON VOLTAGE BASED CRITERIA FOR ODSCC UNTIL COMPLETION OF THE LONGER TERM PROGRAM*

DEGRADATION SPECIFIC MANAGEMENT (DSM)

* INDUSTRY HAS SUBMITTED FOUR TOPICAL REPORTS:

- *SG DEGRADATION SPECIFIC MANAGEMENT*
- *SG INSPECTION GUIDELINES*
- *REPAIR CRITERIA FOR ODSCC*
- *REPAIR CRITERIA FOR ROLL TRANSITION CRACKING*

* PROPOSED DSM/APC GENERIC TOPICAL REPORTS WILL BE REVIEWED

- *FOR CONSIDERATION IN RULE AND REGULATORY GUIDE DEVELOPMENT*
- *EVALUATION REPORTS WILL BE ISSUED*

* PLANT SPECIFIC DSM/APC REVIEWS WILL BE DEFERRED, TO THE EXTENT POSSIBLE

RULE MAKING

* A NEW RULE AND REGULATORY GUIDE WILL BE DEVELOPED TO IMPLEMENT DSM

  - *APPLICABLE TO ALL PWRs*

  - *PERFORMANCE BASED*

  - *ENCOURAGE AND REWARD IMPROVED INSPECTION METHODS*

  - *FLEXIBLE (i.e., accommodate changes in operating experience/technology)*

STEAM GENERATOR RULE

OBJECTIVE

PROVIDE ADEQUATE ASSURANCE OF STEAM GENERATOR TUBE INTEGRITY (i.e., an extremely low probability of steam generator tube leakage that could result in core damage or exceeding allowable off-site doses) WHILE ALLOWING A MORE FLEXIBLE DEGRADATION SPECIFIC APPROACH TO MANAGING STEAM GENERATOR SURVEILLANCE AND MAINTENANCE ACTIVITIES.

DESIRED ATTRIBUTES

PERFORMANCE BASED: *The rule should establish regulatory/safety objectives without being prescriptive in how they are to be accomplished. The objectives should be clearly defined, measurable and verifiable with acceptance criteria that allows a common understanding between the NRC and licensees as to how the performance will be judged.*

INTEGRATED APPROACH: *The rule should establish objectives that are derived from safety and risk considerations and focus on the attributes of the design features, programs and processes needed to achieve adequate protection of public health and safety. It should provide for consideration of the overall factors of safety provided.*

INCENTIVE: *The rule should provide a regulatory framework that will encourage and reward improvements in technology and operations.*

FLEXIBLE: *The rule should provide a regulatory framework the will accommodate changes in operating experience and technology and allow licensees the freedom to select cost-effective methods for implementing the objective.*

BALANCE: *The rule should provide balance between the elements of defense in depth (i.e. initiating events, tube integrity, mitigation).*

STEAM GENERATOR RULE

a) APPLICABILITY

b) DEFINITIONS

c) REQUIREMENTS

1) LICENSEE SURVEILLANCE AND MAINTENANCE PROGRAM

i) PRESERVICE AND INSERVICE INSPECTION PROGRAM

ii) TUBE INTEGRITY

iii) REPAIR CRITERIA

iv) REPAIR METHODS

v) NDE CONSIDERATIONS

vi) NORMAL OPERATING PRIMARY-TO-SECONDARY LEAKAGE RATE MONITORING

2) ACCIDENT MITIGATION

i) ACCIDENT CONDITION PRIMARY-TO-SECONDARY LEAKAGE MONITORING

ii) EOPs

iii) OPERATOR TRAINING

3) RADIOLOGICAL CONSEQUENCES

4) SEVERE ACCIDENTS

d). IMPLEMENTATION

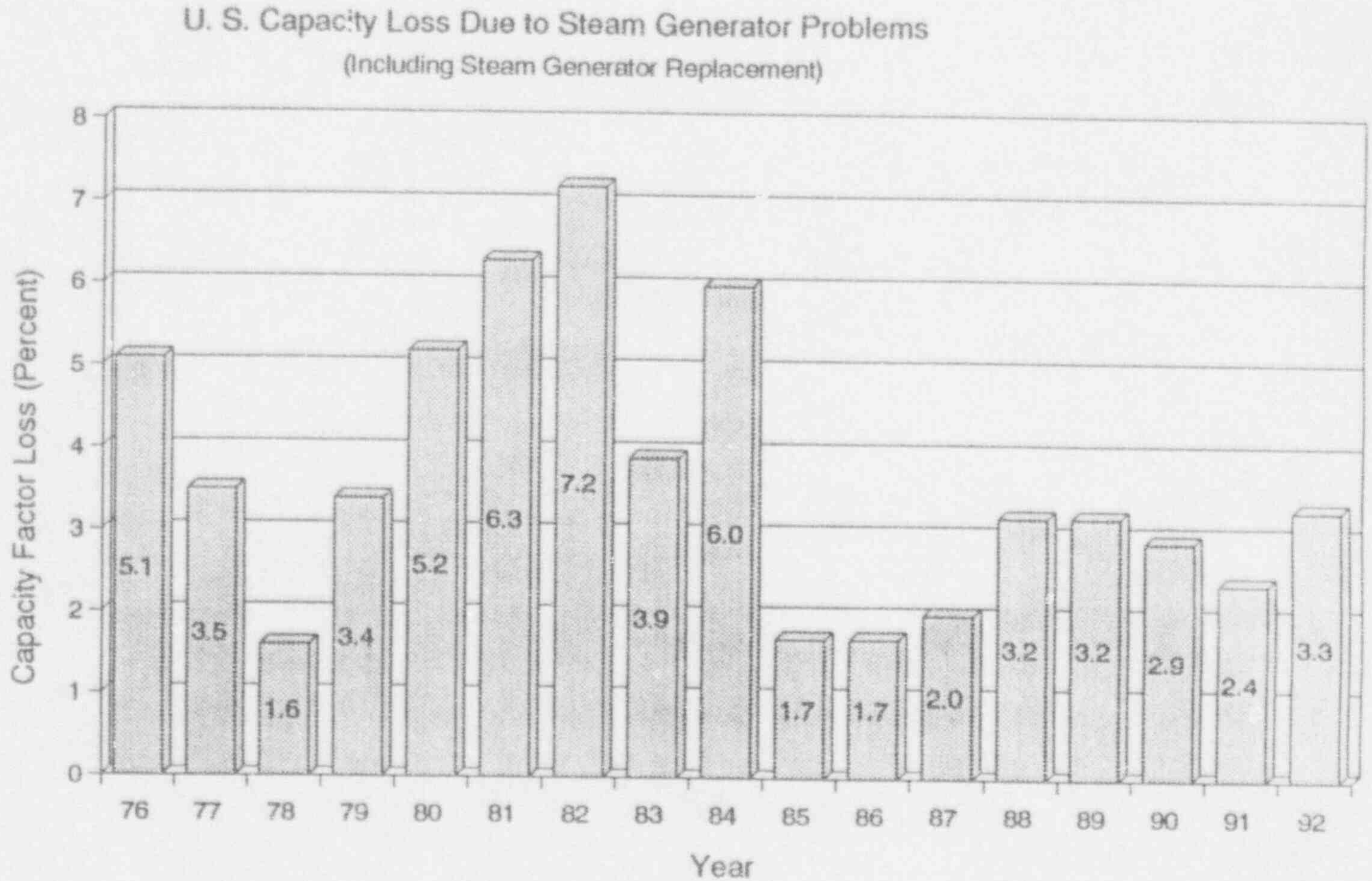
STEAM GENERATOR STATUS/STEAM GENERATOR STRATEGIC MANAGEMENT PROGRAM 12/16/93

C. WELTY
EPRI

SUBJECTS/OUTLINE

- U.S. SG Status
  - status plots, emerging issues
- Steam Generator Strategic Management Program (SGMP)
- SG Management Options
  - water chemistry control
  - SGDSM
  - laser tube weld repair
- Conclusions

FIGURE 5



U. S. Capacity Loss Due to Steam Generator Problems
(Including Steam Generator Replacement)
Capacity Factor Loss (Percent)
0
1
2
3
4
5
6
7
8
5.1
3.5
1.6
3.4
5.2
6.3
7.2
3.9
6.0
1.7
1.7
2.0
3.2
3.2
2.9
2.4
3.3
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
Year

FIGURE 6

U. S. PWR Capacity Factor Components (1980-1984)

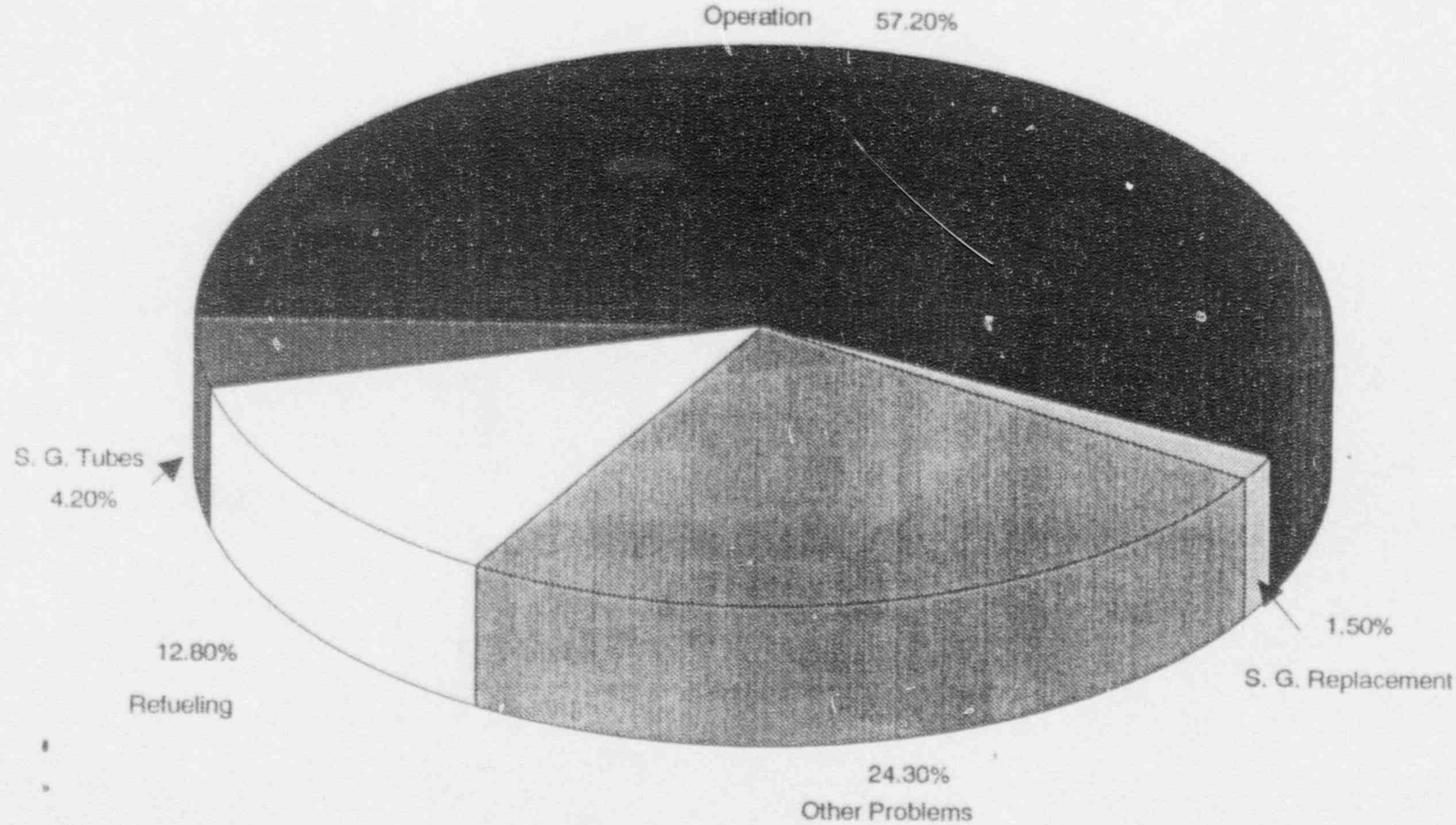


FIGURE 7

U. S. PWR Capacity Factor Components (1992)

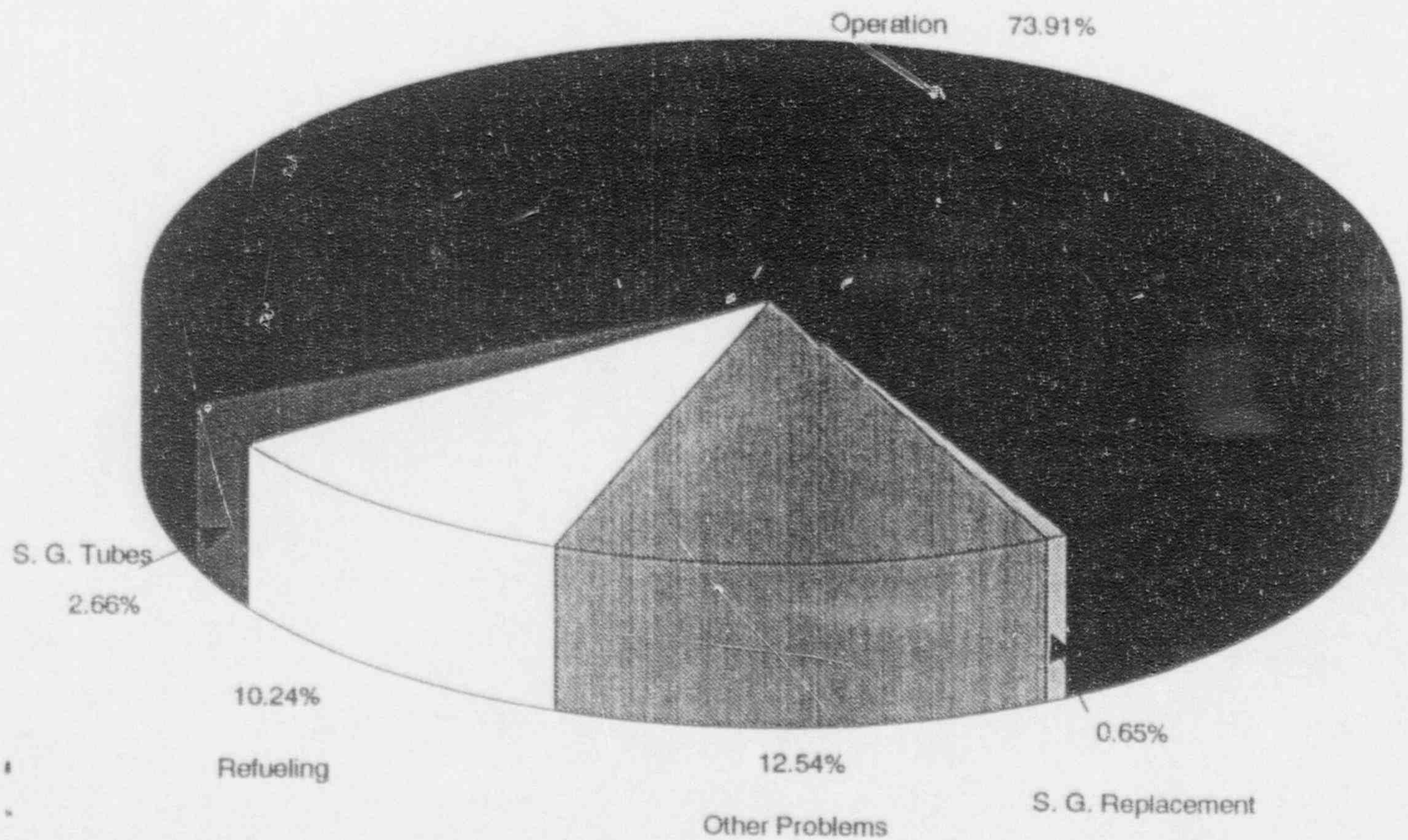


FIGURE 8

U. S. Steam Generator Tube Leak Forced Outages

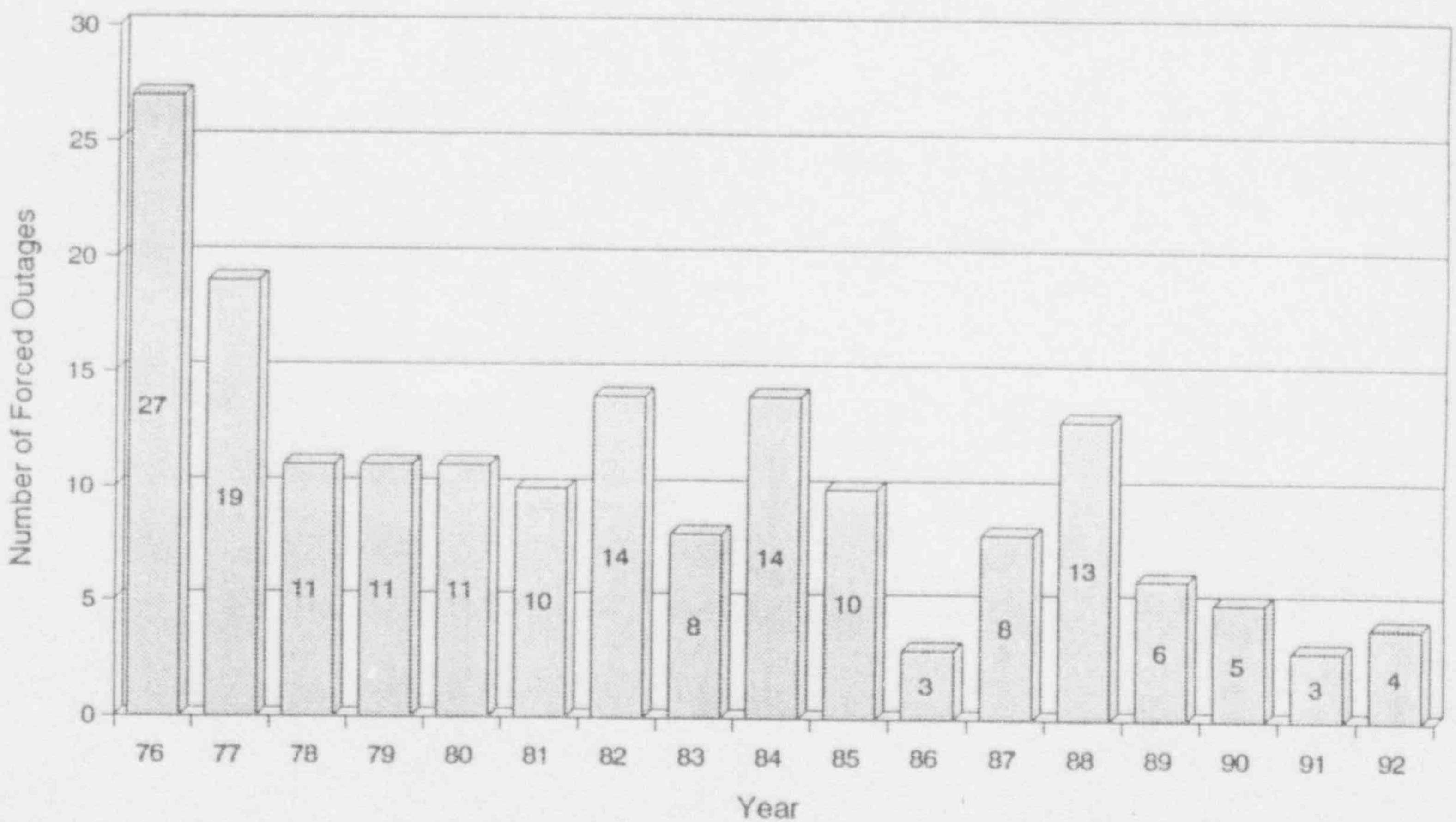
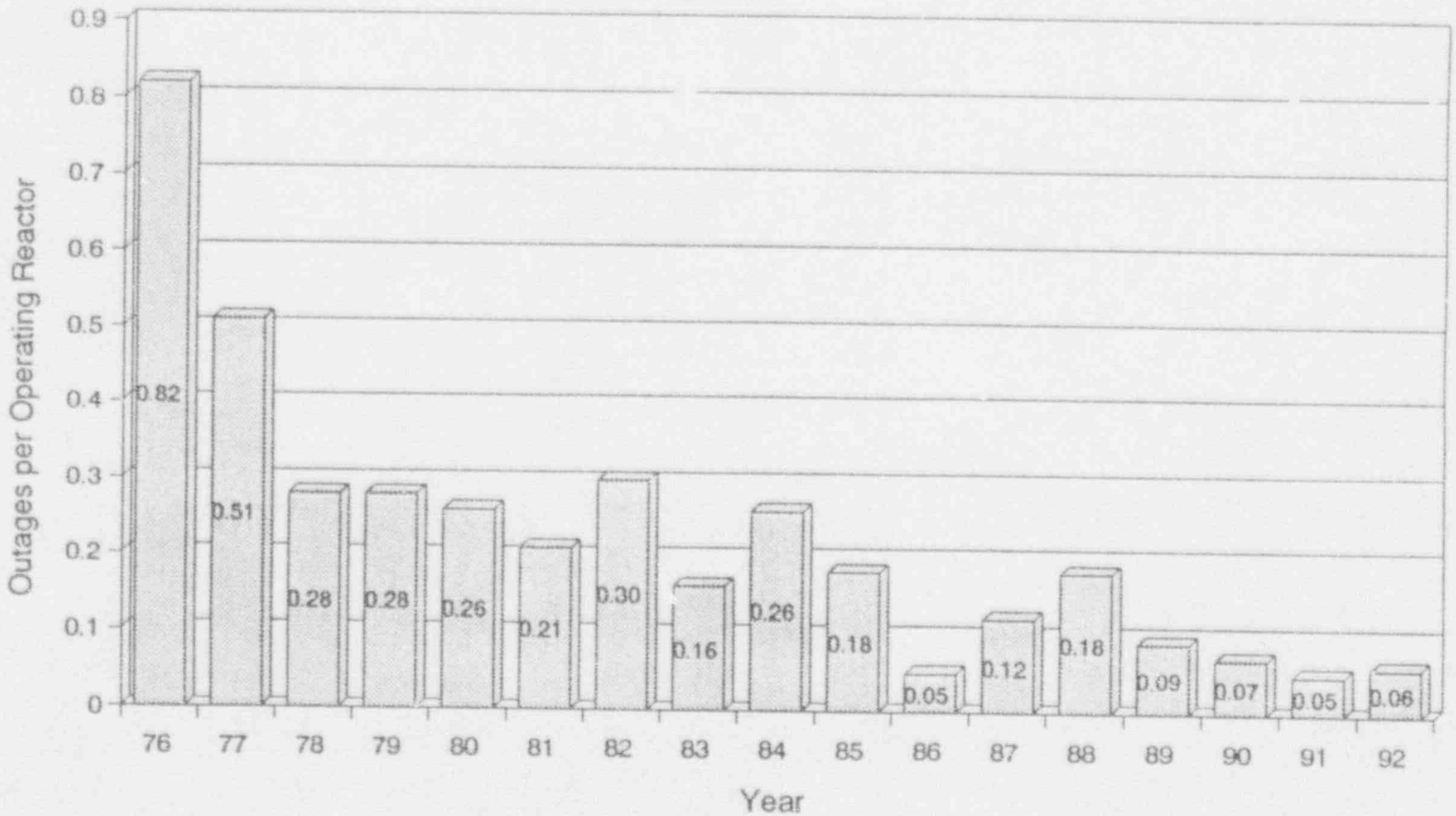
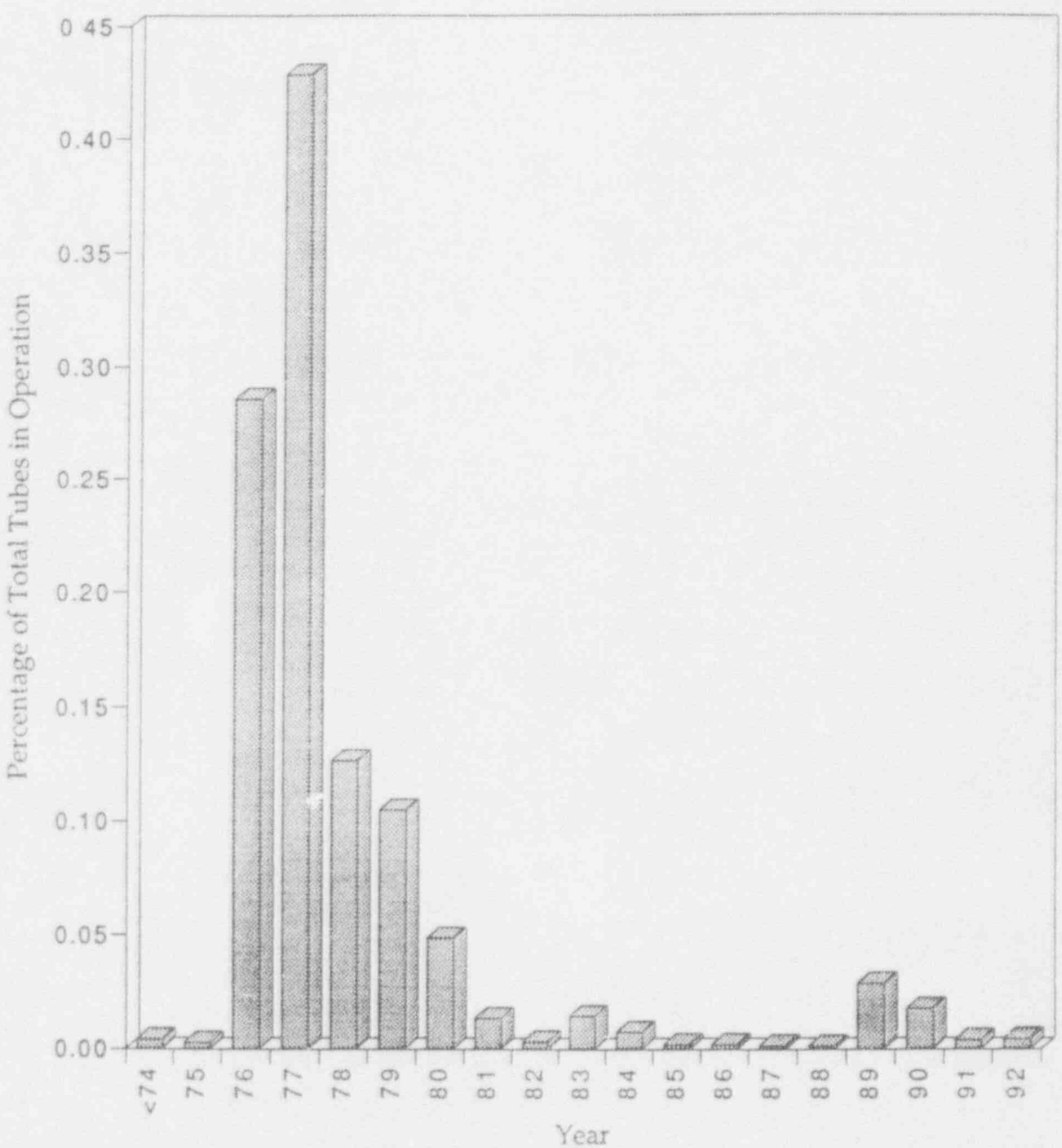


FIGURE 9

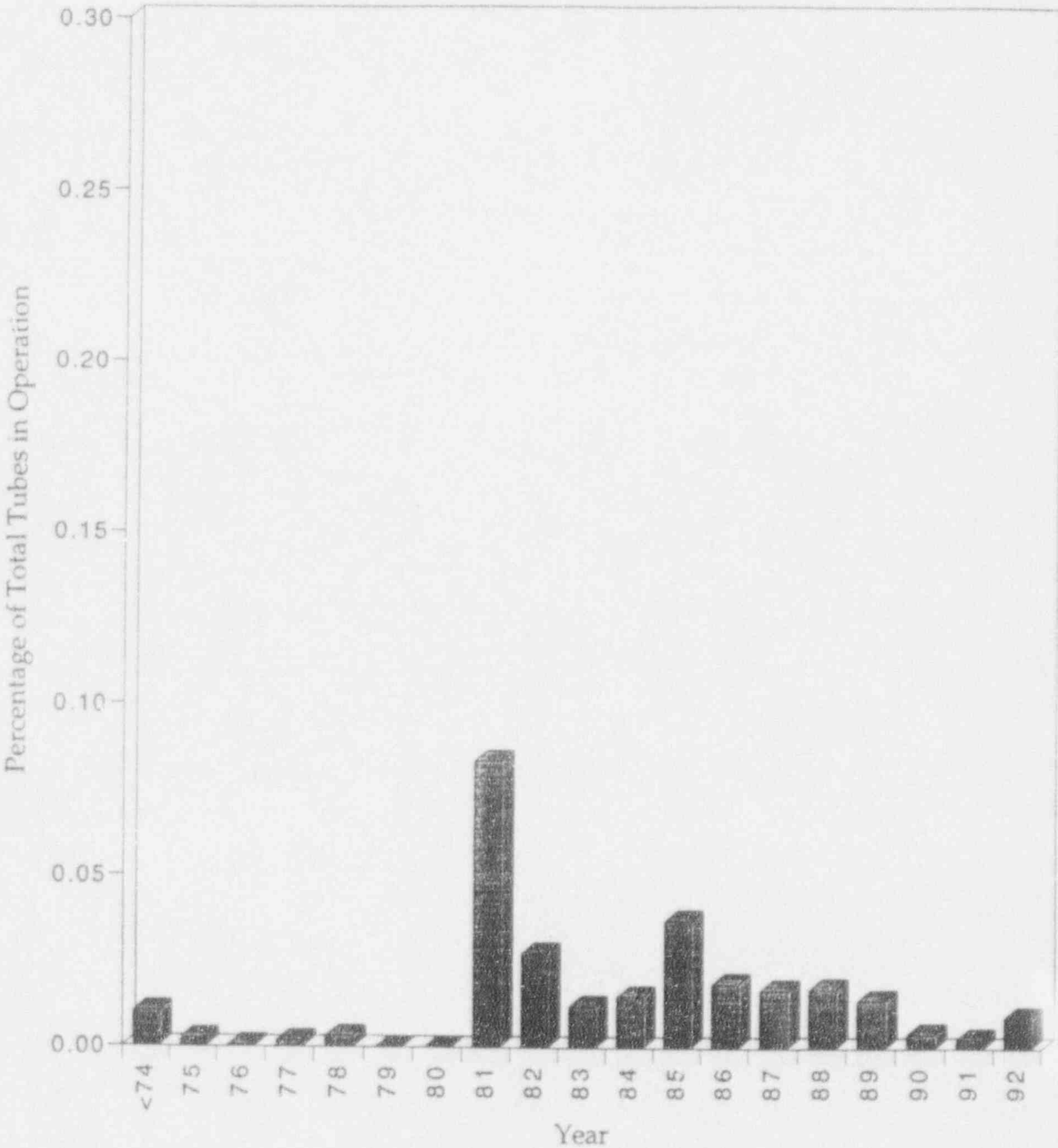
U. S. Steam Generator Tube Leak Forced Outage Rate



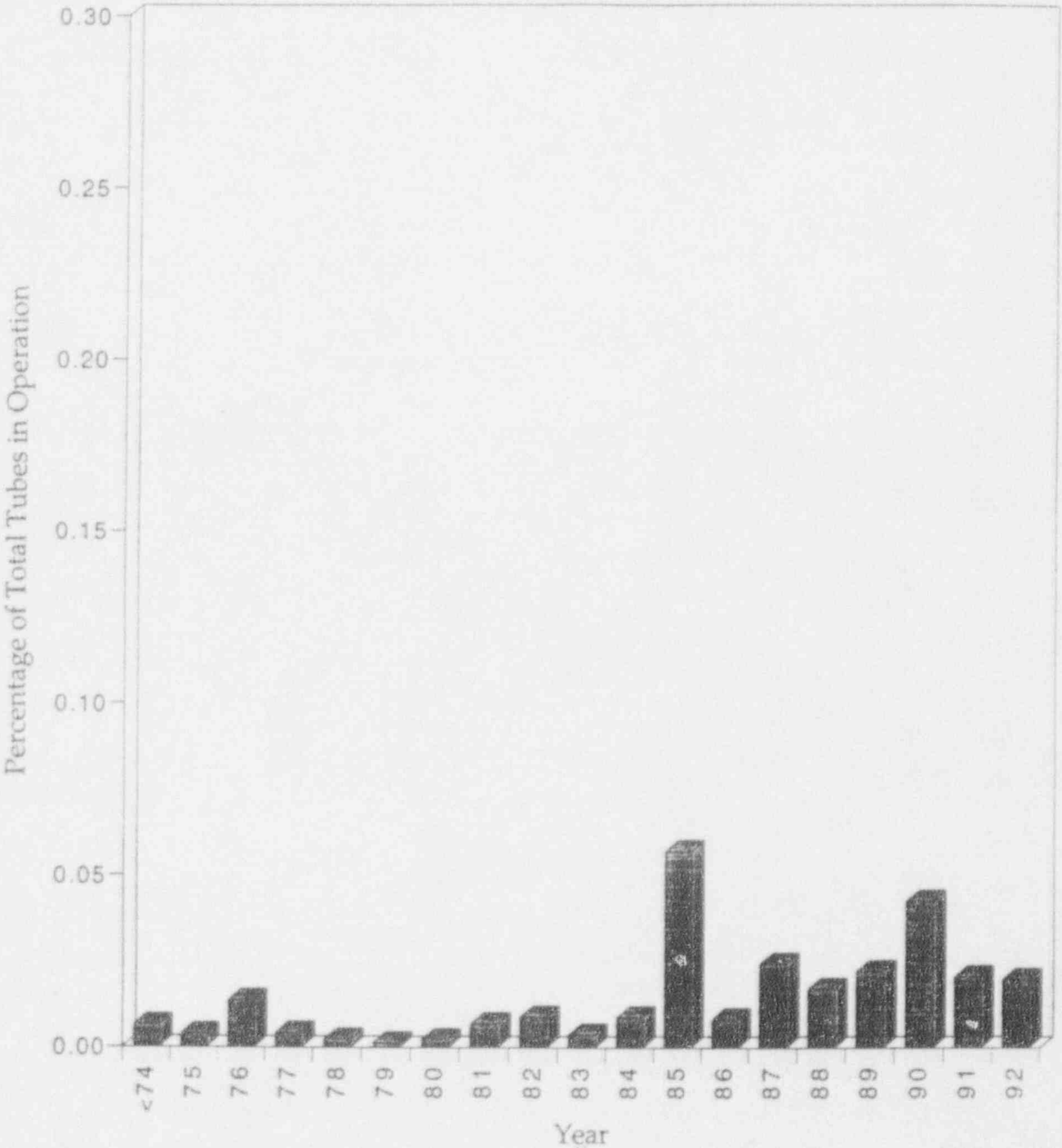
Percentage of Steam Generator Tubes Plugged Due to Denting in Worldwide PWRs



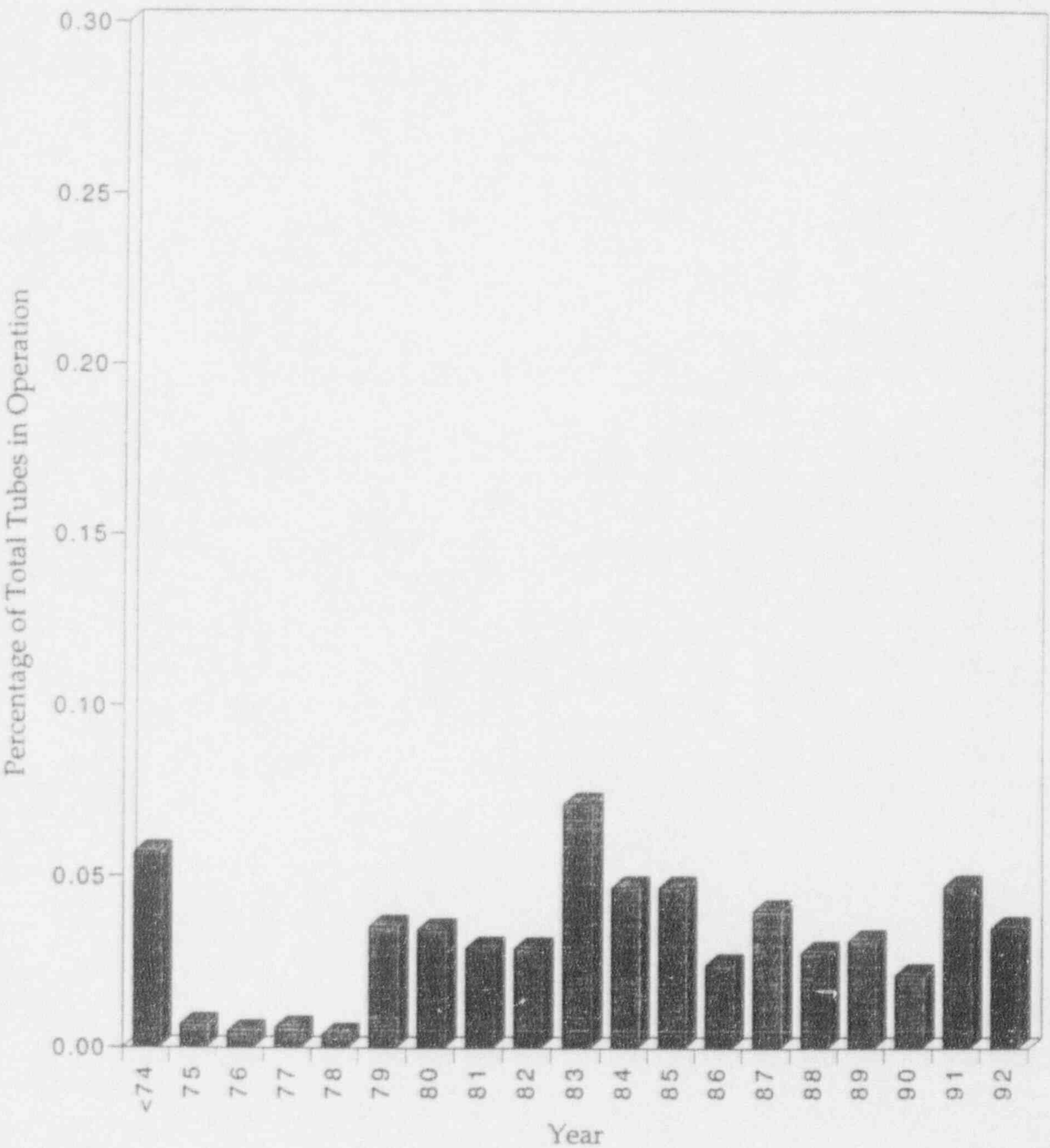
Percentage of Steam Generator Tubes Plugged
Due to Pitting in Worldwide PWRs



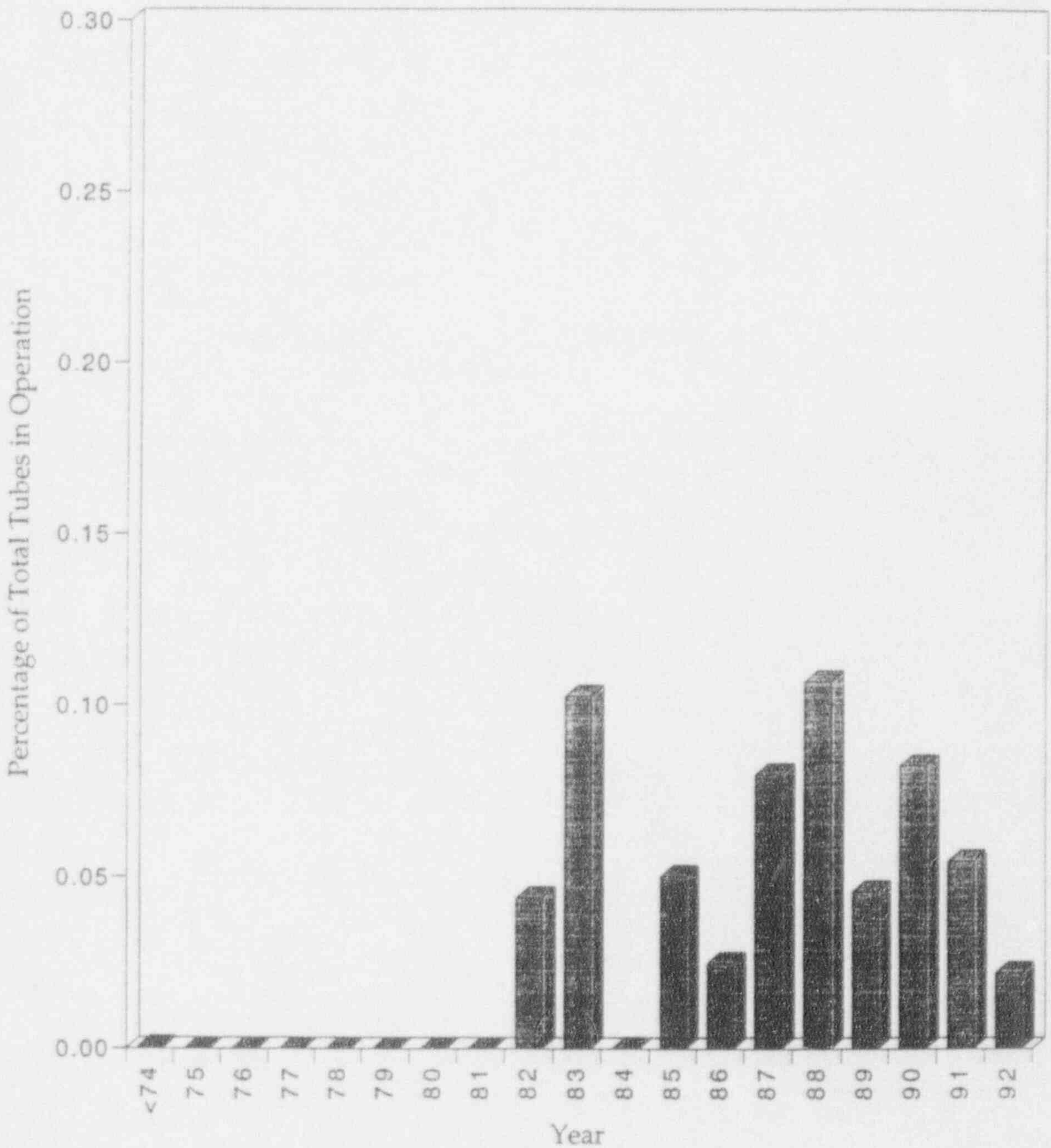
Percentage of Steam Generator Tubes Plugged
Due to Fretting in Worldwide PWRs



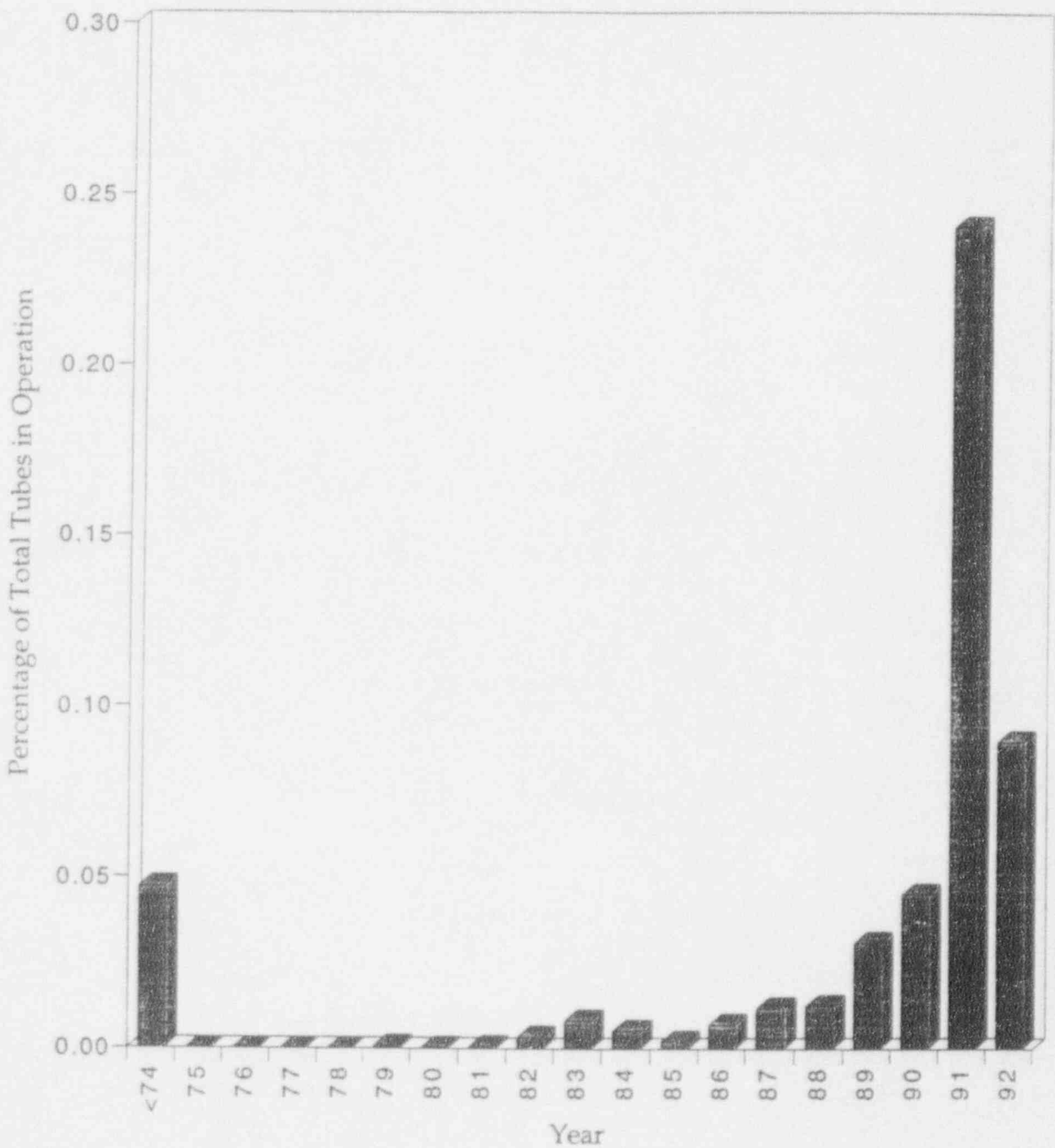
Percentage of Steam Generator Tubes Plugged
Due to OD SCC/IGA at Tube Sheet in Worldwide PWRs



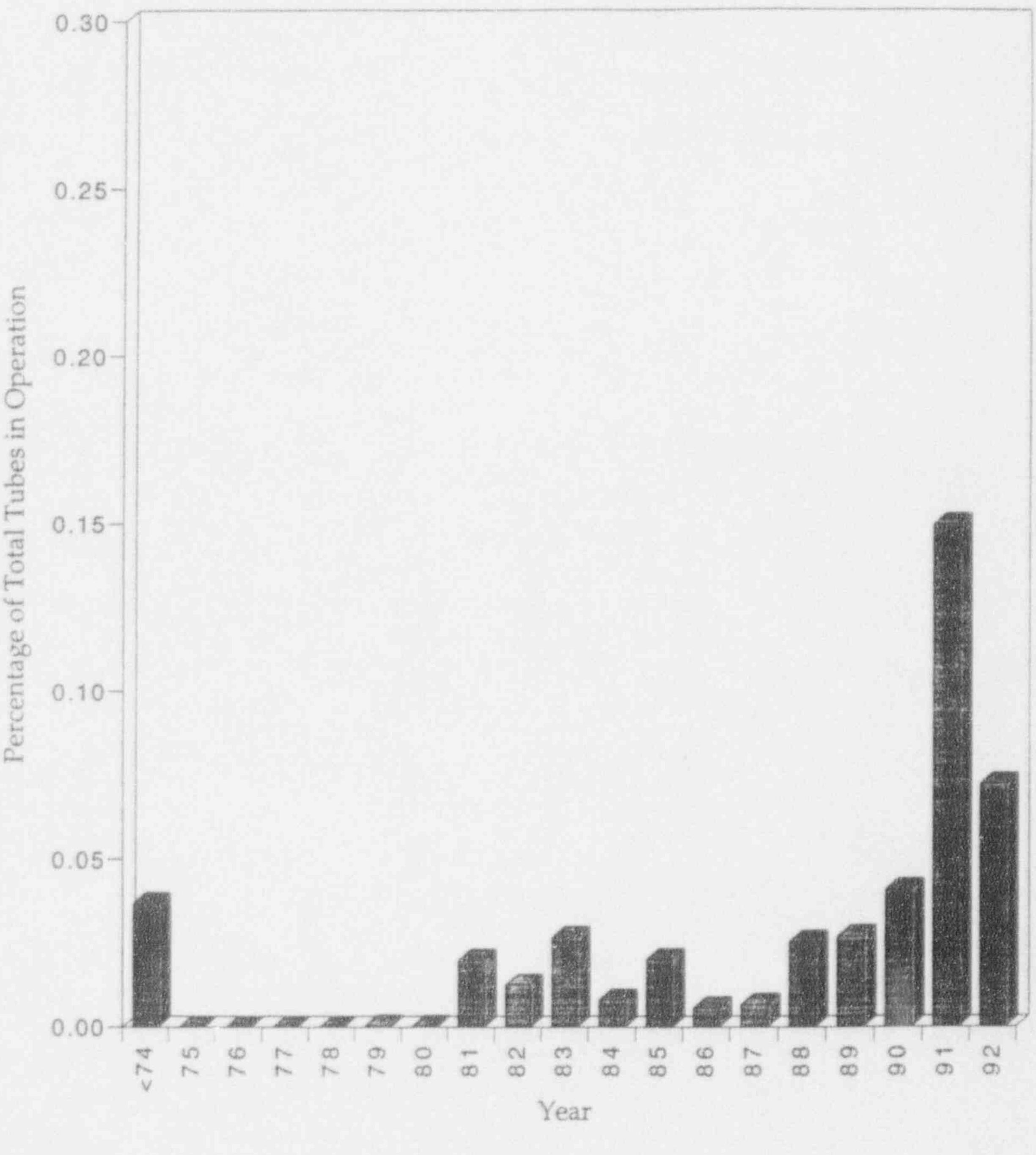
Percentage of Steam Generator Tubes Plugged
Due to ID SCC at Tube Sheet in U.S. PWRs



Percentage of Steam Generator Tubes Plugged
Due to OD SCC/IGA at Support Plate in U.S. PWRs



Percentage of Steam Generator Tubes Plugged
Due to OD SCC/IGA at Support Plate in Worldwide PWRs



US Replacements

Plant	(yr)	Duration
Surry 2	Sep 80	[illegible]
Surry 1	Jul 81	2[illegible]0
Turkey Pt 3	Apr 82	217
Turkey Pt 4	May 83	150
Point Beach 1	Mar 84	118
H. B. Robinson	Oct 84	130
D C Cook 2	Mar 89	175
Indian Pt 3	Jun 89	140
Palisades	Mar 91	121
Millstone 2	Jan 93	192
North Anna 1	Apr 93	51

Emerging SG Issues

- Technical
  - Palo Verde
    - Unit #2 SGTR, Unit #1 ISI results
  - Free-span Cracking
  - Upper-bundle Fouling
  - High Growth Rates
  - Circ. Cracking/PWSCC in CE units
  - Adequacy of ISI process/use of UT
- Regulatory
  - SGDSM initiative/NRC rule making
  - Pressure to increase use of UT
- Other
  - Ratio-control chemistry
  - Chemical cleaning-why not more?
  - ATHOS 3/MULTEQ bundle modeling/insights
  - Direct tube repair (DTR)

STEAM GENERATOR STRATEGIC MANAGEMENT (SGMP)

- SGMP- EPRI funded program directed at solving problems related to steam generator operation
  - Managed by EPRI -- oversight provided by utility management and technical personnel
- Participants
  - US EPRI-member utilities

    26 Organizations
  - International entities (7)

    CRIEPI, EdF, Electrabel, Nuclear Electric, Ontario Hydro, Spanish Utilities, Vattenfall

    Discussions underway with Korea
-

SGMP (Cont'd)

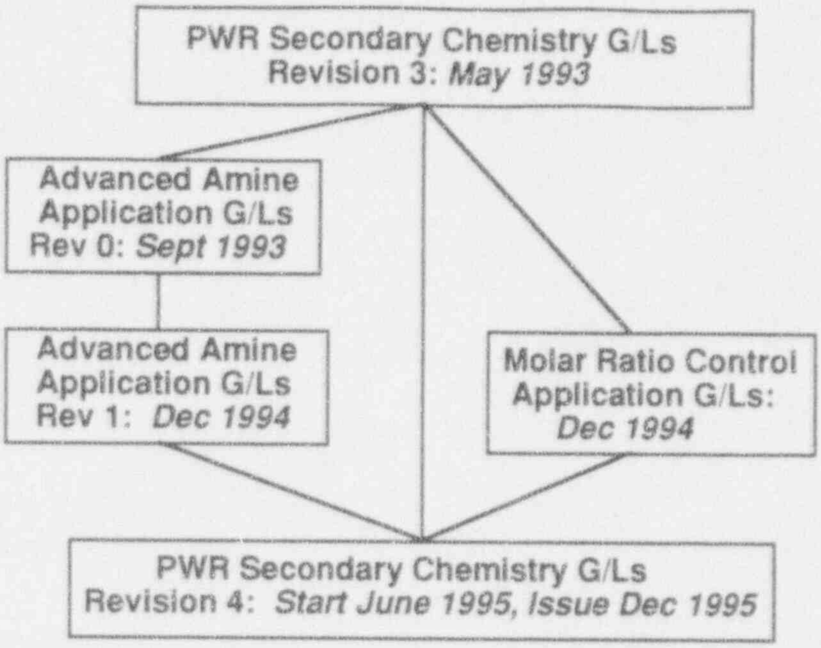
- Phase I - five year program (1993-1997)
  - Possible Phase II 1998 - 2002
- Follow-on to earlier programs
  - Steam Generator Owners Groups (SGOG)
    - SGOG I 1976 - 1982
    - SGOG II 1983 - 1986
  - Steam Generator Reliability Project (SGRP)
    - SGRP 1987 - 1992

SGMP PROGRAM GOALS

- Industry-wide
  - reduce capacity factor loss
    - <2.5% for forced/extended outages
    - <100 days/replacement
  - reduce leaker outages (number/year and rate)
    - also SGTRs
- Individual utility
  - varies widely
    - type, age, history, PUC, locale, management philosophy, etc.

RECENT SGMP PRODUCTS

- PWR Secondary Water Chemistry Guidelines: Rev. 3
- Advanced Amine Application Guidelines
- SGDSM Package - Four Topical Reports: Submitted for NRC Review 8/93
- Steam Generator ECT Performance Demonstration
  - Qualified Data Analyst (QDA) - Package



SG MOLAR RATIO CHEMISTRY CONTROL

- Provided as a "diagnostic parameter" for plants susceptible to IGA/IGSCC
  - initial target Na/Cl ratio (BD) of ~0.5
    - objective - near-neutral SG crevice pH
      - reduce initiation andgrowth of IGSCC in affected plants
  - not meant to be a replacement for ALARA chemistry
    - source-term reduction is preferred approach to ratio control
      - increasing counter-ion(e.g., Cl) is permissible when more cost effective
  - at least 23 US plants have adopted
    - 11 using demins to control, 8 injecting ammonium chloride
- Does molar ratio control work?
  - difficult to evaluate where there is a lack of adequate historical NDE and chemistry data
    - where good data available, results are encouraging
    - some PWRs in Japan have been practicing since mid 70s
      - mixed success, ratio of ~0.2, control w/ CP regenreration
      - if employed since SU (up to 16 years) no initiation of IGSCC
      - if employed after onset of IGSCC, rate slowed but not arrested

ADVANCED AMINE APPLICATIONS

- 17 US PWRs adding ETA
  - for plants previously on ammonia
    - large reduction in iron transport
      - FW, HDT and MSR - factors of 3 to 10
    - minimal increase in organic acids and cation-conductivity
      - longer polisher run lengths - minimal impact on ionic leakage
  - for plants previously on morpholine
    - reductions in FW iron transport but smaller than plants shifting from ammonia
    - more significant decrease in MSR iron transport
    - slight decreases in organic acids and cation conductivity

PROPOSED WTR PROCESS

- Background
  - currentlydefective tubes are either plugged or sleeved
  - WTR method will apply corrosion resistant weld metal to tube ID at damaged/cracked location
    - uses YAG laser and fiber optic delivery system
- Advantages
  - Compared to plugging
    - Keeps degraded tubes in service
  - Compared to slee ng
    - faster, less pressure drop, smaller crevice, capability to repair above existing sleeves or other weld repairs
  - Compared to laser surface remelt process
    - restores full structural margin
    - provides corrosion resistant barrier to continued degradation

CONCLUSIONS

- Some damage eliminated
  - chemistry control measures
    - denting, pitting, wastage, sludge-pile IGA
  - in-situ repair
    - PWSCC, AVB wear
- Some damage "managed"
  - EZPWSCC, TS IGA
- Still looking for TSP ODSCC remedy
  - molar ratio control chemistry, inhibitor development
- Replacement units
  - minimal damage in units replaced to date (>12 years)
  - much less susceptible
    - A690 (TT), SS broached supports, T-H analysis
  - improved SG management
  - improved chemistry control

SGDSM INITIATIVE

J. BLOMGREN
CECo/Lead Plant Group

C. Welty
EPRI

SGDSM INITIATIVE MANAGEMENT STRUCTURE

- Mission
  - Using resources of: PWR utilities, NUMARC, NRC, SGMP, and EPRI
    - define and implement a new metthodology for management and regulation of SG tube integrity (steam generator degradation specifc management - SGDSM)
  - Provides for
    - assurance of PWR safety
    - utility flexibility in SG operation and repair
    - adequacy and reliability of SG ISI
    - effective management of emerging degradation modes

SGDSM INITIATIVE MANAGEMENT STRUCTURE (CONT'D)

- Objectives
  - Focus SGDSM-related industry activities
  - Achieve SGDSM acceptance by utilities, NRC, NUMARC
  - Define scope of potential analyses and changes to plant design basis, EOP's and ERG's
    - minimize/eliminate impact of necessary changes
  - Establish organizational links to assure industry suport and efficient NRC reviews
  - Establish efficient and effective communication links
  - Resolve SGDSM technical issues by September 1994

STEAM GENERATOR RULE MAKING TASK GROUP

MANAGEMENT OVERSIGHT COMMITTEE

W. RUSSELL NRR	T. SPEIS RES	A. THADANI NRR	J. CALLAN NRR

TECHNICAL STEERING COMMITTEE

J. STROSNIDER NRR	R. JONES NRR	E. BUTCHER NRR	J. CRAIG RES

PROJECT MANAGER

T. Reed
NRR

TASK GROUP

MATERIALS

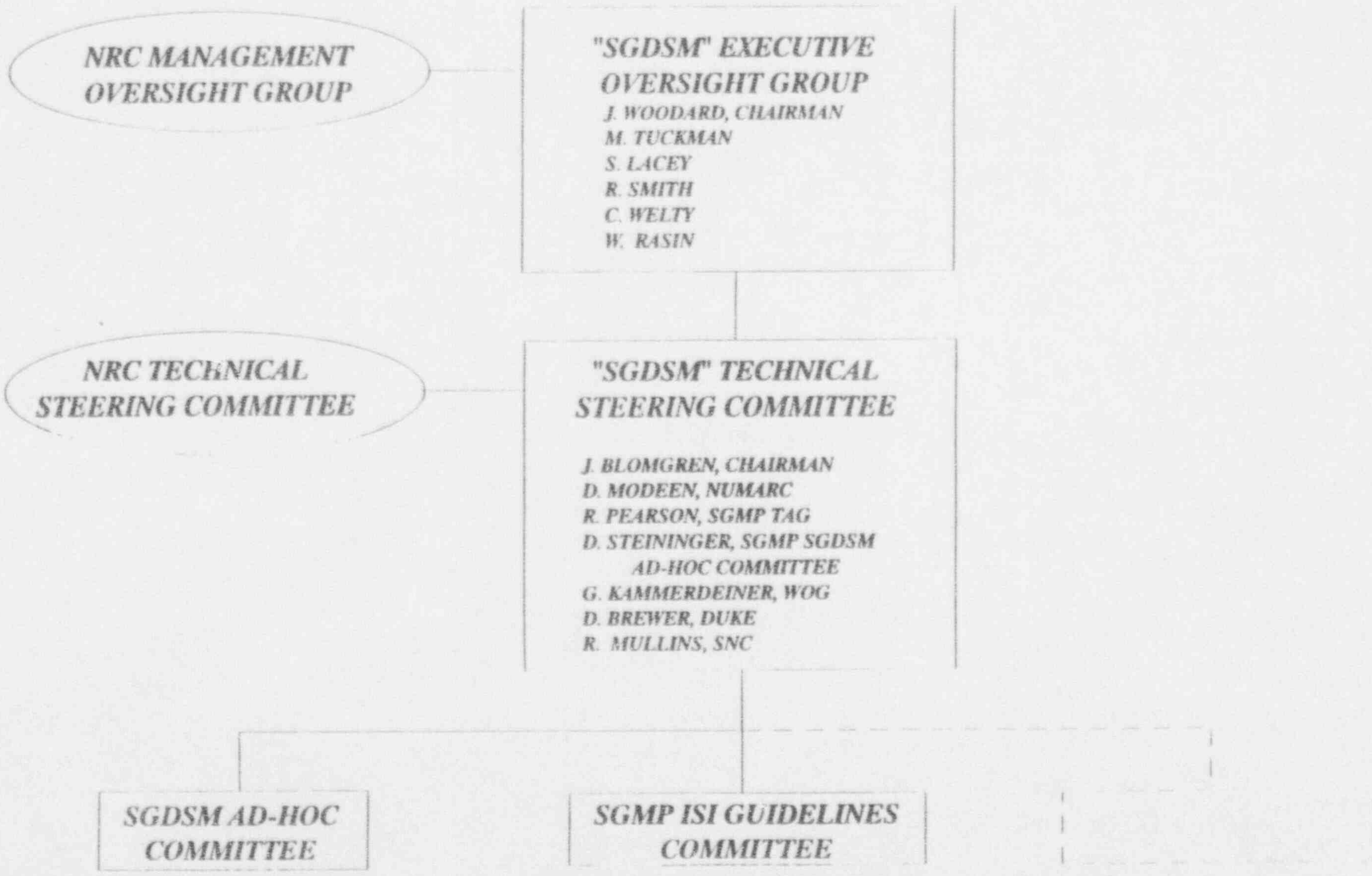
SYSTEMS

RISK ASSESSMENT

RADIOLOGICAL

SEVERE ACCIDENT

INDUSTRY ORGANIZATIONAL RELATIONSHIPS



SGDSM INITIATIVE MANAGEMENT STRUCTURE (CONT'D)

- SGDSM Executive Oversight Group
  - J. Woodard (SNC) Chairman, M. Tuckman (Duke Power), S. Lacey (Duquesne Light), R. Smith (RG&E/SGMP), C. Welty (EPRI), W. Rasin (NUMARC)
  - Interface w/ "NRC Management Oversight Group"
    - Resolve policy issues
    - Resolve technical issues that cannot be resoved by technical groups
  - Interface w/ "industry" entities to obtain resources

SGDSM INITIATIVE MANAGEMENT STRUCTURE (CONT'D)

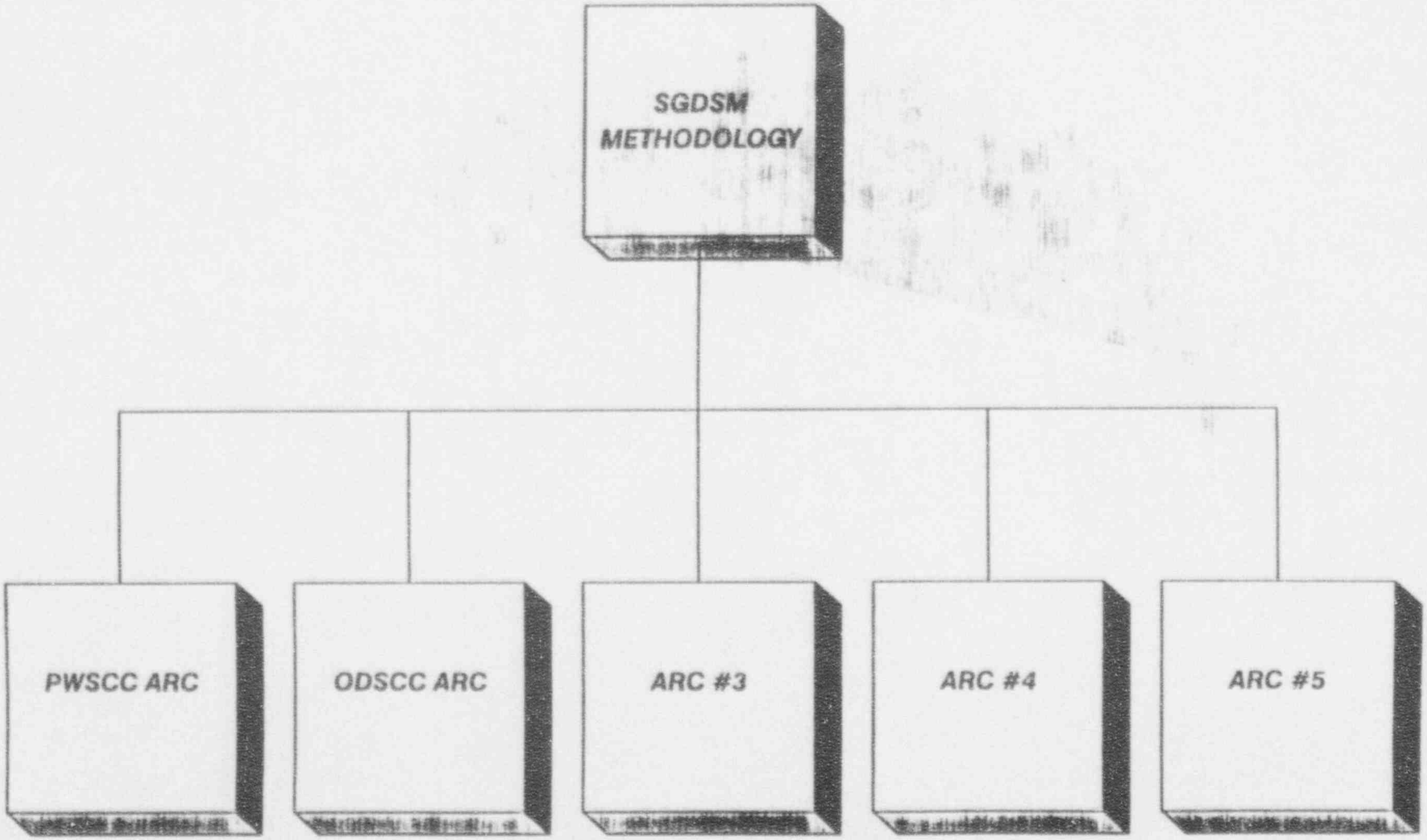
- SGDSM Technical Steering Committee
  - J. Blomgren (CECo) Chairman,D. Modeen (NUMARC), R. Pearson (NSP/SGMP TAG), D. Steininger(EPRI/SGDSM Ad-hoc Committee), G. Kammerdeiner (Duquesne Light/WOG), D. Brewer (Duke Power), R. Mullins (SNC), K. Craig (FP&L/CEOG)
  - Manage/coordinate technical interface among
    - SGDSM Ad-hoc Committee, SGMP TAG, NUMARC, EPRI, NRC technical staff
  - Manage/focus "industry" interface w/ NRC Technical Steering Committee
    - respond to issues
    - define scope of issues
      - allocation of resources
    - resolution of NUREG-1477 issues
    - coordinate communications
  -

SGDSM

- *PROCESS* for ISI and plugging/repair based on specific damage form
  - margin against rupture
  - improved ISI
  - control accident leakage (dose limits)
  - reduce allowable operating leakage
- Alternate repair limits have been developed (modeled after European [EdF] approach)
  - expansion zone primary-side cracking (EZPWSCC)
    - length-based limit
  - support plate ODSCC
    - bobbin coil voltage-based limit
- USNRC proposing a "rule making" approach
  - "front end" - ISI and repair limit work submitted by SGMP
  - "Back end" - plant/operator response to design basis events
    - being defined

INDUSTRY COMMENTS ON NUREG 1477

"SGDSM" CONCEPT



HOW WILL THE UTILITY INDUSTRY FORMALLY COMMENT ON NUREG 1477?

- Letter to NRC August 12, 1993 from EPRI/SGMP
  - Consolidated "industry/utility" comments
- Letter format
  - Significant areas of agreement
  - Imperatives
    - » some degree of accommodation required
  - Suggested improvements
- Letter written from the perspective of a full alternate repair criteria (ARC) under Steam Generator Degradation Specific Management (SGDSM), a generic approach; not solely motivated by "Interim Criteria" concerns
  - NUREG references proprietary material not available for review
  - NUREG's proposed requirements have implications on successful SGDSM and full ARC implementation

WITHIN THE FRAMEWORK OF NUREG 1477, WHAT ARE THE IMPERATIVES REQUIRING ACCOMMODATION FOR SUCCESSFUL SGDSM IMPLEMENTATION?

- Limited tube pull requirement
- Recognition of statistical support for industry proposed leak rate correlation
- Acceptance of industry's POD curve for bobbin coil interrogation of ODSCC at tube support plates
  - Credit taken for dual analysis
- An acceptable probability and confidence value on tube burst is set for MSLB conditions
- An acceptable probability value is specified for the safety criteria of interest (i.e., radiological dose) only; not on all individual variables that dictate the dose due to steam generator leakage under faulted load conditions
- Treatment of radiological consequences of a MSLB with SG leakage include a simple I^{131} spike of less than 500
- Voltage based repair criteria is superior to a length/depth based approach
- Different eddy current probe sizes can be utilized