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NUCLEAR REGULATORY COMMISSION

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ANN RILEY & ASSOCIATES, LTD.
1250 I St., N.W., Suite 300
Washington, D.C. 20005
(202) 842-0034

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BRIEFING ON STEAM GENERATOR ISSUES

PUBLIC MEETING

Nuclear Regulatory Commission

One White Flint North

Rockville, Maryland

Thursday, June 1, 1995

The Commission met in open session, pursuant to notice, at 2:12 p.m., Ivan Selin, Chairman, presiding.

COMMISSIONERS PRESENT:

IVAN SELIN, Chairman of the Commission

KENNETH C. ROGERS, Commissioner

E. GAIL de PLANQUE, Commissioner

SHIRLEY A. JACKSON, Commissioner

STAFF SEATED AT THE COMMISSION TABLE:

JOHN HOYLE, Secretary of the Commission

KAREN CYR, General Counsel

JAMES MILHOAN, Deputy Executive Director for NRR, Regions and Research

WILLIAM RUSSELL, Director, NRR

ASHOK THADANI, Associate Director for Inspection and Technology Assessment, NRR

BRIAN SHERON, Director, Division of Engineering, NRR

LAWRENCE SHAO, Director, Division of Engineering Technology, RES

P R O C E E D I N G S

[2:12 p.m.]

COMMISSIONER ROGERS: The Chairman has been delayed and he's asked me just to start the meeting.

We're very pleased to have the staff here this afternoon to brief the Commission on the status of steam generator tube integrity rulemaking. The staff is developing a rule that is intended to allow an integrated and generic approach to steam generator tube integrity problems. This generic approach should allow appropriate improvements to be readily implemented across the industry and optimize the use of industry and NRC resources in addressing steam generator issues, while appropriately addressing steam generator tube integrity.

Any Commissioners have any other comments?

Mr. Milhoan?

MR. MILHOAN: Thank you, Commissioner Rogers. As you said, we are here today to brief you on the current status of steam generator tube integrity issues and how the staff plans to address these issues through the regulatory process.

Joining me here at the table is Bill Russell, Ashok Thadani and Brian Sheron from the Office of Nuclear Reactor Regulation, and Larry Shao from the Office of Research. Brian will be making the presentation today, but

first Ashok has some opening comments that he would like to make.

Ashok?

MR. THADANI: Thank you, Jim.

As you know, our regulatory philosophy has been to assure that multiple layers of protection are provided to minimize the likelihood of radiological releases. The key layers of protection are, of course, the fuel cladding, reactor coolant pressure boundary, and then the containment itself. So, any time an issue comes up where one failure could lead to a breach of more than one layer of protection, obviously it's a great deal of attention. Steam generator tubes do provide that potential.

As you also know, I suspect that the steam generator tubes constitute a fairly significant portion of the reactor coolant pressure boundary. Failure of those tubes would certainly lead to bypassing the containment and there is the potential then of releases occurring if there is fuel damage at the same time. So, we think this is a fairly important issue. For that reason, over the last many years it has received a lot of attention, both from the industry as well as the staff.

The 20 years or so of experience seems to indicate that problems that were identified early on in terms of the tube behavior have changed. The degradation mechanisms that

we're observing now are different than what we've seen early on and Brian is going to talk about that aspect pretty soon. It has become very clear to us that the regulatory criteria that we have in place today are really not consistent with what we're seeing out there. They are also perhaps too prescriptive as well as probably not appropriate for the mechanisms that we're seeing today.

As a result of the problems that have been observed over the last few years, both the industry and NRC management have taken a fairly active interest in communicating and working on these issues. There is, in fact, an industry steering group as well as an NRC steering group. We meet every few months to make sure that the focus is placed on all the important issues. If resources need to be made available, both sides in fact go forward. These are public meetings, by the way, that we hold with the industry steering group.

Now, as a result of all these discussions that we've had, it's been clear to us that we needed to go forward with a revised rule which would be flexible and much more performance oriented than the current rule that we have in place. The industry does agree with that approach and, in fact, they support us going forward with such a rulemaking. Brian is now going to go through with the various elements.

MR. SHERON: Okay. Thank you.

On your package, this is not in the general one but there's some glossies back there with cutaways of the three vendor steam generators that are currently in service. These are not the actual -- in other words, there's various models of different ones, but I think these will give you a good idea of what we're talking about in terms of the steam generators.

[Slide]

MR. SHERON: As Ashok said, the real safety significance of this is the fact that the steam generators constitute about 50 percent of the reactor coolant pressure boundary. If you do have certain events, for example a small LOCA, that can bypass containment. Or, as Ashok said, if you have fuel damage, than you can have significant release that bypasses the containment.

Could I have the next slide, please?

[Slide]

MR. SHERON: Now, the steam generators are designed with a number of regulatory requirements behind them. The general design criteria have several which pertain to the integrity of the primary system pressure boundary. With regard to accidents, the steam generators need to perform consistent with the guideline values for dose in 10 CFR Part 100. And, in addition, they have to --

I don't have it down here, I'm sorry -- the generators are designed consistent with the ASME code requirements.

Once the generators are put in operation, they do have operating requirements placed on them as well in the form of technical specifications. We require that they be inspected very outage, that a certain percentage of the tubes be inspected. There are criteria in place for when a tube has to be repaired. We have concentration limits on the primary coolant activity to assure that if there was an accident that involved the breach of the steam generator boundary that the doses would remain below Part 100. And we do have limits on the allowable primary to secondary leakage.

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[Slide]

MR. SHERON: We try and minimize the frequency of a steam generator tube rupture by assuring that plants comply with their technical specifications and with the requirements in Part 50, Appendices A, which are the general design criteria, and Appendix B, which is the QA requirements.

We do have applicants analyze anticipated operational occurrence as well as postulated accidents as part of their safety analyses to ensure acceptable consequences, as I said, with regard to Part 100. This

would mean that a plant in its license application would have to analyze a steam generator tube rupture accident in which you assume a complete guillotine rupture of a steam generator tube with corresponding single active failure. You would also analyze a steam line break event with the technical specification primary to a secondary leakage being assumed. And again, like I said, you must show with these analyses that you remain below the Part 100 guideline values.

In addition, and particularly after TMI, we required all licensees to put in place emergency operating procedures. These are symptom-based that would be able to allow them to handle depressurization events such as steam line breaks, as well as a steam generator tube rupture event. So, the operators have been trained to try and mitigate these events should they occur. The mitigation, for example, of a steam generator tube rupture obviously is to stop the leak. The way you do that is to make sure that you can depressurize the primary system and equalize it with the secondary so there's no driving pressure across the break.

Could I have the next slide, please?

[Slide]

MR. SHERON: As Ashok said also, the current regulatory framework is probably outdated in many respects.

The present technical specifications that most PWRs operate under today were developed back in the 1970s, about 20 years ago, and at that time the prevalent form of degradation was wall thinning and wastage on the tubes which was due to the use of a phosphate chemistry for pH control. Once they discovered that it was this phosphate chemistry control that was causing the problem, they switched to an all volatile treatment pH control which basically stopped that form of degradation.

So, as I said here in the slide, these forms of degradation for which the tech specs had originally been developed has changed. But the fact is that the degradation forms have changed and they are continuing. The tech specs really do not reflect these new forms of degradation that we're seeing. On top of that, we think that they are overly conservative for some forms of the degradation. For example, which you'll hear about a little bit more, if you have axial cracking, for example, at tube support plates where the cracking is axial in nature and is constrained within the tube support plate region, you could actually have a through wall crack that did not leak and probably would not burst under those conditions. Yet the current tech specs would say that because it's more than 40 percent, you would have to take that tube out of service or repair it.

COMMISSIONER ROGERS: It doesn't differentiate the location of the crack?

MR. SHERON: Right. Correct. Anywhere, yes.

And one of the problems is that because the tech specs are outdated, as well as the repair criteria from when you do see this form of degradation, what we have been doing basically is leading to a very plant-specific form of decision making in terms of granting alternative forms. Now, I'll get into that a little bit later.

The next slide, please.

[Slide]

MR. SHERON: The next slide is just to show you graphically how the forms of degradation have changed since about 1975 up through the present. As you can see back in the '70s, wastage and denting were the predominant forms. Denting is where you get basically a build-up of crud at the tube support plate sufficient that it actually pushes the tube in.

SCC is stress corrosion cracking. ID means that it occurs on the inside diameter of the tube. Down at the bottom, SCC/IGA is stress corrosion cracking, intergranular attack. OD means that it occurs basically from the outside of the tube in. The unknown there is not that we don't know what's going on, it just means that these are count for tubes, for example, that were plugged prior to being put in

service for whatever reason. They might have gotten damage from loose parts or many times a utility doesn't really go and find out what form of degradation was causing a leak, they just go in and preventatively plug. So, that's why it says the --

COMMISSIONER ROGERS: It doesn't imply that the 20 percent of effects come from unknown causes.

MR. SHERON: Right.

MR. THADANI: We shouldn't have used that term.

MR. SHERON: Well, it just means we can't identify the specific form of degradation.

COMMISSIONER ROGERS: It's really just plugging.

MR. RUSSELL: You've also had cases where you see both intergranular attack and stress corrosion cracking and denting. So, how you allocate that particular tube within the set of data to go in and actually try and do examination to better define it, once you've identified that it needs to be plugged and taken out of service, you take that action and you don't spend more time necessarily to try and characterize what the particular degradation mechanism is.

COMMISSIONER de PLANQUE: But presumably that category captures only the things we already know about. It's just that you don't know of any particular case which --

MR. SHERON: Yes.

COMMISSIONER ROGERS: Is the growth of the OD SCC, is that coming about from better detection methods, that you're finding more of these or that they really are starting to appear on the outside diameter when they weren't seen before?

MR. SHERON: Let me ask the staff.

MR. RUSSELL: Why don't you use the mike. Emmett Murphy.

MR. MURPHY: My name is Emmett Murphy with NRR.

It's in truth a combination of both. However, probably more a reflection of additional OD activity by virtue of the fact that even if it's being missed by eddy current in 1991, it will become evident in 1993 by more obvious means. But clearly, both are a factor with increase in activity being maybe the more important factor.

MR. SHERON: Okay. Could I have the next slide, please?

[Slide]

MR. SHERON: All of this degradation obviously has implications on the plant operation. The increased plugging and sleeving that has to go on to accommodate the degradation does have costs for the utility. Just to give you an idea, depending upon the extent of sleeving that a utility might have to do, a single sleeve could cost anywhere from $4,000 to $8,000 per sleeve.

COMMISSIONER ROGERS: Just in one tube?

MR. SHERON: Yes, for one tube. Also, for example, if you sleeve just at the tube sheet down at the bottom, you have now precluded being able to repair further up in a tube. So, if you see any degradation further up in a tube later on, you just really have no choice but to plug it. A plug is about $800 on average. These are not exact figures. They obviously vary depending upon the vendor and the specific circumstances. But this is just to give you an idea of what the costs are.

MR. RUSSELL: There are volume discounts also.

MR. THADANI: Yes, yes.

MR. RUSSELL: Obviously, setting up to put in one plug is much more expensive than if you were doing a few hundred or several thousand.

MR. THADANI: Yes. There are considerable setup costs.

MR. SHERON: Right. Also when you plug your sleeve tubes, there is an implication with regard to the power in the plant, whether you can still maintain your rated output. If you plug sufficiently or if you put in too many sleeves, for example, that increase either the pressure drop or reduce the heat transfer area substantially, you may not be able to get your rated power out of the plant. Also, if you have one steam generator that degrades substantially

more than others, so that you have one generator that is excessively plugged compared to others, you may have flow imbalances that have to be dealt with.

The degradation also basically shortens the operating life of a team generator. I think there's about a dozen plants right now that have replaced their generators and there's probably about a half a dozen in the queue right now that are planning to replace within the next several years. Obviously in this day and age of deregulated industry, it really brings into question whether a nuclear facility can remain economically viable due to the costs of replacing the generator.

Also, handling these degradations in the current regulatory framework has really put a substantial burden on the staff resources. Each one has to be dealt with on an individual basis. Many times a utility really doesn't know how they're going to deal with something until they actually go into an outage, open up the generator, go in and look and find out what they have. If it's more than what they ever expected, they're usually scrambling, trying to come up with something for us to review in a very short period so they could put the plant back in service.

Next slide, please.

[Slide]

MR. SHERON: Now, we have an interim regulatory

approach for hopefully dealing with some of these issues in a more generic manner. For example, tube support plate locking, which is a proposal by Commonwealth Edison for the Byron and Braidwood units, is designed, for example, to expand certain steam generator tubes above and below the tube support plate. So, you basically lock the tube support plate in position and therefore it can't move or flex during steam line break and expose any axial cracks that might be at the tube support plates.

We've also seen cracking in the parent tubes of plants that have sleeved. Point Beach, for example, where you now see -- even though you sleeve the tube, you see cracking occurring at the transition where they went from a hydraulic expansion to a hard roll. We've been monitoring the performance of the industry and the problems. We issue generic communications as we learn new information. Numerous information notices on degradation and inspection issues have gone out, repair issues, leakage monitoring and emergency operating procedures. In the past year, we have two generic letters that are either out or in the process of going out. The voltage base repair criteria which applies only to outside diameter stress corrosion cracking at tube support plate intersections, and it's only applicable to Westinghouse plants with drilled hole support plates. That covers something on the order of about 30 plants, I believe.

So, the idea here is that we would allow plants that have axial cracks at the tube support plates, that those tubes could remain in service provided that the cracks remain below a certain voltage level and at the probability of rupture and leakage remains below a certain level.

We have also, as I'm sure you're aware, just issued Generic Letter 95-03, which deals with circumferential cracking. This was a result of the inspection findings at Maine Yankee which I'll talk about in a second.

Next slide, please.

[Slide]

MR. SHERON: Maine Yankee --

COMMISSIONER ROGERS: I wonder if I could just ask on that voltage base repair criteria.

MR. SHERON: Sure.

COMMISSIONER ROGERS: I've always been a little troubled with a criterion that's based on an artifact of a particular method of making a measurement rather than what it is that you're measuring yourself. We've got this voltage based criterion. That's the criterion, not what the crack is that we're detecting.

MR. SHERON: Right.

COMMISSIONER ROGERS: And I'm always a little bit troubled with that. But from a practical point of view, I

can understand why it's easy to do that. But how confident are we that the various probes that are being used really do have the same responses to identical cracks. In other words, this voltage based criterion is a voltage that's coming from a particular probe. Well, everybody doesn't use the same probe, although they may use the same design. There may be some differences there.

MR. SHERON: The probes are qualified to a standard.

COMMISSIONER ROGERS: They are?

MR. SHERON: They're calibrated to that standard.

COMMISSIONER ROGERS: So, that voltage -- well, does that voltage change when -- I mean what does the calibration do?

MR. SHERON: Well, there are artificial flaws, you might say, axial cracks, for example, put in a tube and these probes are calibrated to that to make sure that they all give the same reading for that signal.

COMMISSIONER ROGERS: There's some kind of an adjustment to calibrate them then so that the size flaw and the voltage is always the same after they've been calibrated?

MR. SHERON: No.

MR. RUSSELL: This is probably the most difficult area and it's been debated heavily within the staff. We are

inferring what is going to be the behavior of the tube by correlating pulled tube testing under burst conditions to known voltages that we got from examining the tubes with calibrated instrumentation. So then you do a burst test. We also have the same techniques which are used for qualifying the detector/operator combination for the purposes of examination of a tube because there is a very significant human element involved in doing this review.

In the past, the principal indicator of degradation of the tube was a change in phase angle on a licigue figure for evaluating the magnitude of the flaw. What we're now using is the amplitude of that signal. If you've got a noise signal that's in the range of a quarter of a volt to a half a volt, to say that a one volt signal really is a signal is difficult. Also, geometry changes get to be very significant. For example, when you're in the tube sheet region where the tube's been rolled, you've got a larger diameter than what you progress up into the parent tube. So, you get a change in geometry. That's where we've been seeing the circumferential cracking and that makes it very difficult to pick that signal out unless you intentionally calibrate for that change in geometry. Even with that it's difficult. It's also hard depending upon whether the crack is initiating on the outside wall or the inside wall because what you're really doing is you're

measuring the amount of coupling between a transmitting signal and a pick-up signal. So, one could almost say it's proportional to the amount of loss of material for coupling.

But these have been going on for some time and this is the area that we encourage the industry to do most of its work, that is improve the NDE techniques so that you can physically characterize the flaws by depth, length and orientation. Whether that involves a combination of UT, different types of probes, this is clearly an area where there is a lot of economic incentive to come up with a better ability to characterize the flaws because once you have that and we know what the flaws look like, then you can do a better evaluation of what is required by way of a repair for a particular flaw.

But this is the area where most work needs to be done. We've got significant work going on in the Office of Research, plus substantial work going on in the industry and around the world to try and improve the NDE techniques for steam generator tubes.

COMMISSIONER JACKSON: Are you going to tie that into your discussion in terms of your proposed rulemaking?

MR. RUSSELL: Yes. That is a major element of the rulemaking because what we'd like to do is as you get better NDE techniques, you don't have to have the same margins to account for uncertainty in your ability to characterize a

flaw so that you don't have to repair as early. So, there is an economic incentive plus a safety incentive to better characterize the flaws.

COMMISSIONER JACKSON: Right, because my general question is from a regulatory or rulemaking point of view, how much of a research program is going to be required in order to provide a technical basis for whatever rule or rules you propose. Coupled with that, for instance, you talked about the testing and that was one piece of it. Then the other would be are you applying PRA or some kind of a technique to relate the probability of some catastrophic event, say, with the type of degradation.

MR. RUSSELL: Yes. We're going to come to that in just a moment. All those elements are built in. A couple sentence summary of where we're heading with the rule, we'd like to have a rule that describes a process with some detail as to how one would go about qualifying a particular examination technique, how they would qualify, the repair standard based upon a particular type of defect and address the safety aspects associated with that, lay that out and then have that be able to be done, for example, through a topic report that you would conclude that the technique that they used is acceptable.

So, we'd identify the process by which they would follow to qualify a particular probe, technique, repair

standard. We think that this would create competition amongst various vendors to improve inspection techniques to be able to qualify their probes and would potentially identify relaxations in what would be otherwise unnecessarily plugging or sleeving tubes to take them out of service early. So, there's quite an economic incentive to improve the examination techniques. We want to keep that embedded within the process, but we still need to have high confidence that those new probes are able to perform. One of the big issues is going to be the human factor that's associated with interpreting the data that come out of these probes.

MR. SHAO: To start inspection, they use bottom core probe because this can do very fast. When the voltage with the bottom core reaches certain level, then they send signal that there's some problem. Then they switch to rotating pancake. A rotating pancake is much slower, but much more accurate and they can size the defect much better.

MR. THADANI: If I may go back, there's another part of your comment. That is, are we going to use some risk-based thinking. The answer, as Bill said, is yes. I really want to emphasize that because what we have today, the reason we think what we have is not only too prescriptive but perhaps too conservative, because we have very conservative assumptions in terms of condition of the

fuel, assume a certain amount of fuel is damaged as an initial condition. That leads to then fairly conservative assumptions in terms of what kind of leakage you can get from primary to secondary. It seems to us that that is really not what's controlling risk. Risk is controlled by other factors.

So, our intention is to start from the other end and say, "What are the events and sequences that could lead to substantial risk and how likely are they?" Move backwards, so we know how far we go and what kind of margins we, in fact, have rather than applying conservatisms at each step of the way as we have done in the past.

COMMISSIONER JACKSON: But I'm interested in how well developed or how far along the line you think you are in that regard. And also, that kind of approach does depend very much on your input parameters.

MR. THADANI: Absolutely correct. Absolutely correct.

MR. RUSSELL: This is the area that I've been most disappointed in what's been going on in the industry. Most of the effort to date has been addressing what I'll characterize as the engineering side of the problem. That is, how one improves the inspection techniques, gets them to be faster so they don't take up critical path time, improves the confidence on sizing flaws. But there has not been as

much of an effort to relook at what are the fundamental safety issues that you're trying to address in steam generators and there are two that relate to -- one is tube rupture. As you'll hear in a moment, we're going to use a probabilistic approach. We want to have a relatively low probability of a tube rupture associated with a chemical degradation or a corrosion problem in a generator.

The second is leakage under design basis events. If you have a steam line break or if you have a stuck open steam generator safety valve and you bypass containment and you depressurize the steam generator, you don't want to have high levels of leakage going out to the secondary and out to the public. In the extreme case, you would not like to have the summation of leakage from multiple tubes that are degraded start to approach that which you'd get with a tube failure. Whether that number is on the order of one gallon per minute, which is the current number that's used in the licensing basis for most plants, one gallon per minute primary to secondary leakage, it's probably not until you get in the range of 50 to 100 or more gallons per minute that you have some concern about not being able to adequately cool the core in the long term. But that needs to be evaluated in a risk context.

Then the last area, which is one we haven't really addressed much at all, and that is in the context of severe

accidents, particularly for a high pressure core melt. If you have a loss of feedwater and the secondary side of the generator is dry, and you're not able to make up by way of feed and bleed to the primary to cool the core, the water inventory in the primary will boil off, you'll get hot gases. If it turns out that the weak link in the pressure boundary at that point is the steam generator, you have a potential for core damage with the steam generator pressure boundary failure and a release to the environment. So, there are some implications in the context of severe accidents.

So, while in some areas we are overly conservative, in other areas we have not addressed the issue sufficiently. This whole aspect needs to be carefully looked at in the context of the rulemaking, both from the standpoint of probability of rupture and leakage and what does it mean for leakage, and what does it mean to have a degraded generator if you were to have a severe accident. Are you maintaining containment integrity or not under that condition?

So, there are quite a number of safety issues that need to be addressed beyond just the engineering aspects of detecting and sizing flaws and repairing tubes.

MR. MILHOAN: Go ahead and proceed, Brian.

MR. SHERON: Okay. Next slide, please. We'll

talk quickly about Generic Letter 95-03 and the Maine Yankee experience.

[Slide]

MR. SHERON: Maine Yankee was down in 1990 at the steam generator inspection. I believe they saw some circumferential indications at that time, but not a lot. They shutdown in July of '94 as a result of tube leakage. At that time, they went in with the rotating pancake coil. They also did a few other things. They used a thing called a drain plot which allows you to basically roll out what you're seeing with the rotating pancake coil on a three dimensional picture. From that, they realized that they were seeing circumferential cracks. They went back, they looked at the 1990 data that they had taken and they found that they had actually missed about 300 circumferential indications at that time. Had they used the techniques they were using in '94, they probably would have picked these up in 1990.

They plugged these 300 indications that they had and some were fairly substantial. They were more than 79 percent through wall. What that means is that if one were to do a structural analysis, 79 percent was what Maine Yankee calculated was the ASME limit that they would have to meet. In other words, if it was above that, they would not meet the ASME limits. They did do pressure testing in situ

on ten of these tubes that exhibited these large cracks and confirmed though that they did not see any burst. Three of them originally leaked before they reached the design delta P.

Let me just point out that the structural limits basically are for normal operation the tubes are required to withstand three times the normal differential pressure across the tube. Under an accident condition, it's 1.4 times the accident pressure differential. We do impose some conservatism because if you analyze the steam line break, the way that accident proceeds is you assume a break in a steam line. The secondary system will rapidly depressurize. The rapid depressurization and the high mass velocities through the steam generator, in essence, over cool the primary system. In the primary system, pressure comes down pretty much with the secondary. So, the delta P stays very close to what the normal delta P was.

What happens is that you will most likely trip the ECC system. The HBI pumps will kick on. They will start pumping water into the primary system. The primary pressure and level and everything will now start to recover. Remember, as you overcool the primary system, the reason the pressure is going down is you're shrinking the coolant. The coolant is physically cooling down and shrinking. So, you're expanding the steam in the pressurizer. As the

safety injection water comes in to the primary system now, you start repressurizing the primary system. The operators would normally terminate the high pressure injection once they achieve the conditions for terminating, which I believe is usually like about 50 degrees subcooling and having a level in a pressurizer. We assume that the operators failed to do that. They make a mistake, they just don't take the action so that they repressurize the primary system back up to the safety valve set point, which is about 2500 pounds pressure. The secondary is now blown down to atmospheric, so you have basically 2500 pounds across these steam generator tubes. Then we apply the 1.4 factor to that.

So, you can see that for the accident condition you're looking at around maybe 34, 3500 pounds as a design basis delta P. Under normal operating conditions, three times the normal delta P would put you up around 4800 pounds. So, many times that the actual normal operating delta P is what governs. They pressurized, as I said, these tubes. Seven of them they actually pressurized up in the 4,800, 5,000 pound range and did not get any burst or leakage. Three of them were pressurized and they began to leak somewhere between 2,500 and 3,000, but because you're probably using a very low capacity pump, they basically reached the pump capacity to around .6 GPM leakage.

They did go back in a later outage and retest

those three tubes with a higher capacity pump and confirmed that they, in fact, did not burst even at the high pressure, the 4,800, 5,000 pound range.

It was interesting because if one assumed that one had a coplaner crack, in other words if you think of a circumferential crack all on the same plane that's more than 90 percent through, it would be calculated to burst. But what we're seeing, if you were to roll these tubes out, is you're not seeing a single circumferential crack, you're seeing small cracks that exist over maybe a quarter of an inch or so. So, there's in essence a lot more ligament in a tube than if you had a single coplaner crack. So, that's the reason these tubes were not bursting at these high pressures, even though they had indications of these high circumferential cracks.

As I said, they operated about another six months. They came down a little early. They were scheduled to go down in February for refueling. They came down a month early, I understand, for other problems. They went in, they reinspected the generator. They found a few more high indications, high depth, crack depth indications. They then used what is this new plus point probe, which is -- right now it appears to be perhaps more sensitive. It's basically like a rotating pancake type of probe. They went in. What they found doing a sample of I think it was around 1,000

tubes or so, was they estimated something on the order of 55 percent showed indications of circumferential cracks. At that point they made a decision. They didn't complete the inspection, they just made a decision that they wanted to sleeve all of the steam generator tubes.

Could I have the next slide, please?

[Slide]

MR. SHERON: Maine Yankee now has made a decision. They are proceeding. They've gotten approval from their board of directors, as I understand, to go forward with sleeving the entire steam generators. That's about 17,000 tubes total. There's about 5,700 in each generator. These sleeves are going to range anywhere from probably around 12 inches to 36 inches, depending upon where in the generator that they go in. As you get to the outer periphery and you're near the channel head, you can't physically get these tubes to slide up in there because it will just hit the channel head and so forth.

So, we were told that they made a decision. The vendor will be Westinghouse and they will use the laser-welded sleeves. Basically what this is is you put the sleeve in, they expand it at the lower part and the tube sheet and in the upper part they run a laser weld right around the top edge. So, there is no physical bending of the tube through an expansion process. Usually it is this

bending that has been putting the residual high stresses in the tube, which is what promotes the cracking.

We were told, just for your information, that this is about $40 million effort to sleeve the entire three generators. They're going to start sleeving the beginning of June, this month, and I understand they expect to be completed some time in the October time frame.

We issued Generic Letter 95-03 on April 28th and basically we asked the industry to examine the Maine Yankee experience with this new probe that appears to be picking up circumferential cracks that the earlier RPCs were not picking up. We asked them to tell us what this means for their plants. Do they believe they have the same kind of problem or not? We asked them to tell us what their inspection plans were on their steam generators on their next outage and we informed them also that we felt that the ability to do good steam generator inspections and detect the degradation mechanisms that are going on in their generators is, in fact, consistent with the requirements in Appendix B, which means that if you don't go in and do a good inspection using the right tools and you miss stuff, it could put you in an enforcement space.

We've asked them to respond in 60 days. So, the 60 day period would be up the end of June.

MR. RUSSELL: Let me add one point here. It's not

just the experience with the new plus point probe, it's also the experience that Maine Yankee had in looking back at prior years' data that had indications of circumferential cracking that were missed with prior reviews. So, the intent is for the plants to look at the data that they have from prior inspections and see, based upon a new understanding of what those signals may look like now, whether they in fact do or do not have circumferential cracking and then to identify and provide a rationale to us, if they have conditions that looked like Maine, why would that be acceptable to continue to operate until such time as they perform their next inspection.

CHAIRMAN SELIN: Just to give an example, a little understanding of what the status quo ante is, what would we have done if Maine had not decided to sleeve all these tubes, if they had tried to argue that, "No, it's really not such a serious problem?"

MR. SHERON: Well, these were circumferential cracks and right now the industry really has not provided us anything substantial to support leaving circumferential cracks in service in terms of both the ability to size the cracks accurately, as well as to tell us what the crack growth rates are and to demonstrate why and how long they could be left in service. So, without that information, I think our position would have been you need to plug them

unless you can provide us with a technical basis on why they can be left in service.

CHAIRMAN SELIN: And would we have required them all to be plugged or would we have gone by a sleeve --

MR. RUSSELL: They could have done inspections to justify some number that didn't need to be plugged. At this point in time I think they are looking at -- they'd identified 55 to 60 percent that would have required plugging. They had some other tubes that did not have indications of any circumferential cracking that they could have left in service. I think the expectation was that with time those would probably also show cracks. So, the better approach would be to repair them all at one time if, based upon that repair, you had confidence you were not going to get degradation in other parts of the tube. So, they had pretty careful inspections of the rest of the tube length to ensure that the likelihood would be that this repair would, in fact, be a permanent repair and allow them to operate these generators to the end of life.

So, there was some part of it, 50, 60 percent, which would have been required by the technical specifications that were in effect for Yankee at that time. There was another 35 to 40 percent that they chose to repair preemptively so that they would not get into a forced outage later and have to do other repairs.

CHAIRMAN SELIN: Now, run a Gadankin experiment. Make believe this new rule that had been written was in force two years ago or a year ago. Would their course of action be any different? Would they still have had the same considerations that you just described?

MR. RUSSELL: I think they would have gone through the same considerations because at this point in time the staff has not accepted -- and with the exception of one country, no other country operating light water, pressurized water reactors permits circumferential cracking to remain in service. The difficulty is by the time you detect the crack you've exceeded what has been traditionally the depth criteria for repairing the tube. So, you don't see it unusually until you're on the order of 40, 50, 60 percent which exceeds the point where you'd be required to repair. So, it's very difficult to get information on growth rates.

CHAIRMAN SELIN: How would the new rule lead to a different outcome from the current situation?

MR. RUSSELL: The new rule, if there were improvements in inspection techniques such that you were able to identify indications of circumferential cracking say at 20, 30 percent and you were able to identify the arc length of that circumferential crack, you may be able to justify based upon that better characterization a rationale for leaving that in service.

CHAIRMAN SELIN: So, the rule gives us a framework to accompany not yet available improvements in inspection technology?

MR. RUSSELL: That's correct.

MR. THADANI: The rule will give them, in fact, incentive to try and develop an information base so that they could say, "Here is the crack growth rate as well as the initial characterization."

CHAIRMAN SELIN: So the benefit of working on the rule today is without the rule we're concerned that people wouldn't even bother to try and improve the techniques because there's no incentive to do so?

MR. RUSSELL: Right now we have essentially a 40 percent through wall criteria that is out of date. We know it's not accurate for certain types of cracking, axial cracking in particular. Crack length is being used in a number of countries as a basis for repair and it's not until you get a crack that's on the order of a half an inch or greater, up to maybe three-quarters of an inch in length before you're at the critical crack size where you could have that crack burst. So, length may be a criteria. It may be arc length that's a criteria with a combination of depth. The issue is we are not able at this point in time to accurately characterize the geometry of the flaws. We just get a voltage signal.

CHAIRMAN SELIN: Right. I understand.

Dr. Shao?

MR. SHAO: France is very advanced in this area, the French. They have a lot of cracks. They even use leak before break clearly for generator tubes.

CHAIRMAN SELIN: I'm trying to get at a very concrete question. Why do the rulemaking now? The problems that you -- I mean I'm easy to convince on that, but still that's the key point. You're describing not so much problems with the current rule as with our current inspection technology. What I hear you saying is the rule is so tied to an obsolete technology that even if we improved our inspection we would still be stuck with an obsolete rule.

MR. RUSSELL: We have even a more difficult situation in that the regulatory requirements flow from a draft regulatory guide. It's not even a final regulatory guide, which has then been incorporated in a lot of plant-specific technical specifications with variability in those tech specs from plant to plant. So, there is not a consistent approach to this and that's frankly consuming a tremendous amount of staff resources. In some instances, the earlier requirements that were put in place are arbitrarily conservative and are requiring action when action is not necessary.

CHAIRMAN SELIN: So, even before there are improvements in inspection technology, in Maine Yankee this same outcome would have happened.

MR. RUSSELL: That's correct.

CHAIRMAN SELIN: But that was a pretty far advanced case. Are you saying that in other cases --

MR. RUSSELL: In other cases this would provide relief. It would reduce personnel exposure associated with repairs to the generator which is a real safety benefit.

CHAIRMAN SELIN: Because the current rule requires repairs in situations where we don't believe the repairs are necessary.

MR. SHAO: The current rule requires 40 percent and anything that reaches 40 percent get to plug it --

MR. RUSSELL: The current tech specs require that.

CHAIRMAN SELIN: In the absence of a rule, we're requiring tech specs that are variable. In some cases they're too restrictive. So, we believe that even today, without any further improvement in inspection technology, we would have a more rational regulatory regime if this rule were in place.

MR. THADANI: That's right.

MR. RUSSELL: We're seeing amendments to technical specifications on a cycle by cycle basis now for a number of plants. We're probably handling between nine and 12 of

these a year. They always come up in the middle of an outage when you get the latest information. It's crisis management on an individual plant basis and we've just got to change that process.

MR. SHAO: You know, I think both the staff and the industry believes in "the effect specific management." There are many types of degradation. For each degradation they show a different criteria. For wastage you use 40 percent. For denting you use some kind of strength criteria. For outside damage stress corrosion cracking you use voltage criteria. For the circumferential cracking you use another type of criteria. For each defect there's a different type of criteria.

COMMISSIONER JACKSON: And you intend to have one criterion?

MR. SHAO: No.

COMMISSIONER JACKSON: You intend to maintain the different --

MR. SHAO: No. We used to have only one criteria.

COMMISSIONER JACKSON: You used to have only one. But now --

MR. SHAO: Now we want to change it to defect-specific management.

MR. RUSSELL: With a process that you would go through that would characterize what are the margins to

structural integrity for particular types of defects. Another example is pitting. A pitting issue is not that significant from a tube structural integrity standpoint and we have had case by case reviews where we have allowed pits greater than 40 percent to remain in service. So, what we're really looking at is establishing a performance objective by way of leakage and probability of burst, relating that to a particular size and type of defect and relating that to the ability to characterize that defect through inspection techniques.

COMMISSIONER de PLANQUE: But if I understand your approach correctly, the rule itself is going to be the performance based, the initial criteria that you mentioned and that the details are going to be in the reg. guide.

MR. RUSSELL: So, how you qualify the inspection techniques, how you do the structural mechanics would be in a regulatory guide. For each individual flaw type and each inspection type there would be a topical report which will be the basis to say, "This technique meets the regulatory guide, therefore the performance-based rule."

COMMISSIONER de PLANQUE: And if I understand your approach correctly, you intend to have both those things available at the same time.

MR. SHERON: Absolutely. A rule and a reg. guide.

MR. MILHOAN: I think we've covered the next three

slides during this discussion.

COMMISSIONER JACKSON: That's good because I actually have a question about that. You indicated the research has initiated a new tube integrity program plan and that NRR and Research are coordinating their efforts. In spite of what you seem to be saying, you're saying that you're far enough along that you can adhere to this schedule both for developing the rule as well as developing the reg. guide.

MR. RUSSELL: That's correct. We believe that the generic activity can be developed and we would likely, for the first type of degradation, would be outside diameter stress corrosion cracking which would be the pilot that we would extend from the generic letter into the rule and look for the development using the reg. guide for that particular type of cracking.

COMMISSIONER JACKSON: Well, you have also come to closure on your severe accident scenario work by that time?

MR. RUSSELL: That's why I highlighted this. I raised it at the regulatory information conference. Mr. Thadani has been raising it with the steering group. In my view, some of the systems aspect, that is what should be the standard for how much leakage is acceptable if you have multiple tubes degraded? Is it 50 gallons a minute? If so, with what confidence? Is it one gallon per minute? Is it

100 gallons per minute? The tube rupture probabilities were basically trying to ensure that they are not worse than what our current experience is. That is, something on the order of 10 to the minus 2 per reactor year of operation for a tube rupture event.

We have not yet gotten to closure on the issue of what kind of leakage primary to secondary might be acceptable under the conditions of a high pressure core melt or whether that is, in fact, a weak link. Some are arguing that the surge line or other components would fail before the steam generator would fail. That's clearly the case if you were to put water on the secondary side of the generator.

COMMISSIONER de PLANQUE: But the question is the basic assumptions that go into that rather than the specific radiological consequences.

MR. RUSSELL: That's correct.

COMMISSIONER de PLANQUE: The second part you can do. It's the first part that's the problem.

MR. THADANI: That's right.

MR. RUSSELL: That's right. It's the assumptions and the basis for those assumptions that need to be developed.

MR. THADANI: But I think, Commissioner Jackson, you have hit upon what I think is probably the weakest part

of where we are, in fact, in terms of the work we've done so far or the work that the industry has done so far. We've been pushing the industry. There's a need to do additional analyses at least in better understanding high pressure melt conditions. As Bill said, the argument up to now has been that other parts of the primary system will fail first, such as reactor coolant pump seals as an example. Unfortunately, we say that's so if you have fairly good tubes. Now, if we go in to operate with fairly degraded tubes, it may be that the pump seals are not the weak link anymore. So, there's a need to understand, and this is also in the context of the question you raised earlier in terms of research. There's a need to understand how far you can have degraded conditions in the tubes and what happens in the presence of these hot gases and aerosols and so on that would be present if severe accidents were to occur.

So, what we're getting at -- I'm not talking about experimental work, but there is a need -- there are some codes available. There is a need for the industry to do a fair amount of evaluations. Ultimately it could be that for many of the plants high pressure core melt scenarios may not actually be that significant.

MR. RUSSELL: They may be sufficiently low in probability that they need not be addressed.

MR. THADANI: But this issue has not been

addressed almost at all by the industry and we've been really pushing them.

CHAIRMAN SELIN: So, the rule basically says operate safely, see reg. guide for details.

MR. THADANI: That's right, and the reg. guide actually adopts industry --

CHAIRMAN SELIN: All performance based rules are -- they just have different titles.

MR. RUSSELL: We would hope that it would set some clear objectives as to --

CHAIRMAN SELIN: Well, to be a little more serious, you can't just write a rule that says you're qualified due to an exemption. We need to have enough so that the licensees have some assurance that if they do certain things they're off the hook, but that they've done the proper --

MR. SHERON: Yes. The rule is going to be a balance, I think, between preventive and mitigative actions. Okay? We're leaving that as the flexible part of it for the industry to deal with. In other words, if they want to do better prevention through whatever reasons, whatever processes they want versus if they want to spend more money on the mitigative aspects of it. But I think the biggest problem I see right now is that there is still a lack of a lot of data that will be needed to support, for example,

relaxation. For example, the circumferential cracking. I'm not aware really of any extensive programs right now that are in place to try and characterize how well one can quantify the size of a circumferential crack, what growth rates, what the distribution is, for example, of growth rates, and to come up with some sort of an integral probabilistic assessment of the likelihood of a tube rupture due to a circumferential crack being left in service.

Without that data, then -- while the rule will allow them to do that and hopefully will encourage them to give them incentive, unless they do it they won't get the credit.

CHAIRMAN SELIN: I think I've heard the following, but I want to make sure that even if there were no research program, if we stopped doing all research, we'd be better off with this rule than with the current one.

MR. RUSSELL: That's correct.

CHAIRMAN SELIN: Not just the charter for a large future research -- and the more research we do, the more explicit we can be in the guidelines and the more narrowly what we think are ultra conservative regimes can be tightened down and therefore allow more efficient plant operation. But I think the Commission would be disappointed if we approved the rule and then the next month we got a request for $50 million more in the research program which

is required in order to implement the rule.

MR. RUSSELL: The experience we've had with about 15 to 20 case specific reviews now for OD stress corrosion cracking based upon current technology and information available, that's really the basis for our saying that it's time for a rule now. We shouldn't be doing those case by case, each refueling outage. We've done those enough that we know generally how to process them.

CHAIRMAN SELIN: Why do you think there was so little public response to that also? We basically got one answer with two different letterheads.

MR. RUSSELL: I think part of it is because the industry also sees a value to this. We would expect that the regulatory guide will be based substantially upon the EPRI guidelines as it relates to how you qualify examination techniques. So, this is, in fact, being supported by the industry and I look at that favorably, that we didn't have 10 or 15 industry comments, that there really is, in fact, a steering committee that's keeping the industry focused. The issues that we're discussing here, I would expect that we will see some comments from others because it is clear that in some areas we're going to be relaxing standards. We think appropriately so based upon new information, but that will engender some comments from others as to whether that's an appropriate relaxation or not. So, I think we'll really

see the action at the proposed rule stage.

MR. MILHOAN: I did want to respond to your question on the research. There is a research specific plan for steam generators. We've reviewed it. There's been good coordination between NRR and Research.

CHAIRMAN SELIN: But it's not rule specific, is it?

MR. MILHOAN: No, it is not.

CHAIRMAN SELIN: It is something we need to do in your opinion.

MR. MILHOAN: Oh, no, no. But it will be used in relation to the performance-based rule from the standpoint of just what you said, of reducing conservatisms and providing us the additional data that will be useful in the regulatory process. It is one that we can accommodate within, I think, the '97 budget process.

MR. RUSSELL: If we had it to do over again, I would have liked to have had a lot more research earlier, particularly as it relates to capabilities of probes and sizing different sized flaws and what that means with respect to tube integrity. What we have found is that we've had to rely on experts that Research has had in their program coming to assist us in case-specific reviews where we've had them providing assistance to us on a plant by plant basis as these new issues have arose.

So, I think it's important for us to have a good understanding as to where we're going. I think we're there with the outside diameter stress corrosion cracking. There are still issues associated with circumferential cracking. There are issues associated with the free span degradation and all of these relate to examination techniques. Right now there's a substantial debate as to whether you can or cannot characterize the physical flaw with an inferred parameter such as a voltage or a phase angle.

COMMISSIONER JACKSON: Let me ask a question more generically. With your proposed rulemaking, you're going to be weighing potential relaxations against risk.

MR. RUSSELL: Yes.

COMMISSIONER JACKSON: That weight, that balancing is how dependent on your research program? I mean this goes back to Doctor Selin's question. Can you do that balance in the absence of a research program because your answer was that you didn't need --

MR. RUSSELL: For the particular type of degradation that we are experiencing most now, which is outside diameter stress corrosion cracking, I believe we can proceed without additional research. There are questions, however, that would potentially provide more relaxation. For example, the probability of detection of a flaw of a certain size. As the flaw gets bigger, the probability of

finding it is higher. What's the threshold and how does that threshold of probability of detection relate to sizing of flaws of certain types? That's an area where there's been a lot of debate within the community on the industry side and on the staff side. That's an area where I think some independent views would be helpful and it's not just pulling tubes and doing destructive examinations of tubes afterwards and saying, "Well, what did you report versus not?" because you don't want to really take tubes out of service that don't have flaws. So, we're only taking the ones out of service that have relatively large flaws.

MR. THADANI: Yes. I guess the key here is not how much more research NRC needs to conduct. The key is the approach that we're going forward with is going to give industry opportunity to try and learn more. As they learn more, they can actually take credit for their understanding. The more information they collect about characterization of cracks and the growth rate of these cracks, the more credit they can take in this approach that we're talking about.

So, I do think that the industry would get a lot out of it if they were to start developing that kind of information and they understand it.

CHAIRMAN SELIN: I'm glad you brought that up because I want to stress that we have a confirmatory research part.

MR. THADANI: Yes.

CHAIRMAN SELIN: The basic inspection methodology is the responsibility of the industry. They come in and say, "Here are the techniques we propose to use." We audit them and say, "Are we satisfied? What else do we have to do?" We shouldn't be doing the exploratory work in better determining --

MR. MILHOAN: That is correct.

CHAIRMAN SELIN: I mean that statement is too flat.

MR. THADANI: The second point, I wanted to respond to a comment you made, Chairman Selin. That was, I was also surprised. Industry comments were coordinated and that's why we didn't get the many independent comments. But I was surprised that there weren't other commentors on this issue. It's a significant issue. I was surprised also.

MR. RUSSELL: Let me identify one other area we've not talked about yet that relates to the rulemaking which I think is fairly significant. That is in the area of operator response to tube rupture events. The scenario that Brian went through earlier was dependent upon operator action and the key action that's needed early is to identify the faulty generator, isolate it and then manage water level in that generator so you don't challenge safety valves and end up with a bypass scenario. The procedures in the

Westinghouse emergency response procedures, in some cases if it's a relatively small slow leak rate, you can maintain subcooling with your ECCS equipment. In other cases you have to go to saturated conditions. You'll form a bubble in the vessel head, but that's the vehicle that you use to stop breakflow. Very dependent upon early identification of the faulted generator.

The best of doing that is with instrumentation that identifies which generator in particular is faulted. N-16 monitors on the steam lines, when they're appropriately shielded, provide you that information and they tell you with a much higher degree of accuracy when you're having increases in primary to secondary leakage. Then you can obtain currently from the air ejector condenser vents which do not tell you specifically which generator and it's not practical to have continuous grab samples and the blow-down monitors are not very accurate for identifying a faulted generator. So, we're looking at also requiring as a part of this rulemaking a better capability for early detection of which generator would be faulted if there were primary to secondary leakage, the objective being to shut down when that leakage occurs before it ruptures. But, if not, to have the identification of the faulted generator early on such that the generator could be isolated and you could enter the EOPs.

COMMISSIONER de PLANQUE: You mentioned the N-16 monitoring problem in the paper and mentioned some disagreement in the industry as to the value of that. Is there really a disagreement on this issue?

MR. RUSSELL: There are some that don't want to spend the money for the capital improvements to put N-16s in and would like us to justify with a detailed regulatory analysis why this provides additional improvement. It's really something that provides better information to the operators in the context of an emergency. Plus it gives them early indication of a faulted generator before it ruptures.

COMMISSIONER de PLANQUE: So, it's not the capability of it, it's the need for it that's at issue.

MR. RUSSELL: That's correct, it's the need for it. I can tell you from discussing this with operators in control rooms, for those plants that have them, they really like them.

MR. MILHOAN: But we'll have to address that in the regulatory analysis.

MR. RUSSELL: That will be a part of the regulatory analysis for this rulemaking as well.

MR. MILHOAN: Mr. Chairman, I think that concludes the staff presentation and discussion.

CHAIRMAN SELIN: What happened to those pretty

pictures of yours?

Commissioner Rogers?

COMMISSIONER ROGERS: Yes. Is there any information available on crack growth rates as a function of the operating parameters of the steam generator? In other words, if a licensee chose to operate their steam generator at lower temperature pressure or whatever so there's less of a challenge to it in a sense, could that be a tradeoff in some way, they would get less power and so on and so forth in terms of how long they might be able to operate? Is there enough information available so that choices of that sort could be made?

MR. SHERON: Yes. They could do that if they were able to quantify say crack growth rate as a function of temperature or pressure or whatever.

COMMISSIONER ROGERS: I mean if somebody came to us with such a proposition, could we handle it?

MR. SHERON: Yes. In the context of the rule, yes, we could do that, as long as there was a database to support it and the rule would allow us to give credit for it.

MR. RUSSELL: Let me give you some practical results from experience to date in situ. We see outside diameter stress corrosion cracking more predominant in the first, second, maybe up to the third, fourth support plates.

Temperature varies as you go around the hot leg. We know that the hot leg temperature is very dependent upon crack growth rates and onset of cracking in alloy 600. Generally the higher the temperature, the more likely you are, particularly when you're substantially above 600 degrees. In some instances, plugging has exacerbated that because in the past as they plugged, they would allow hot leg temperature go up to compensate for the reduced heat transfer area to be able to get the same power out. So, you'd have a database which was based upon a lower temperature before, slight temperature increase, and you get higher growth rates for cracking.

We have generally required that they maintain hot leg temperature after repairs to ensure that the database which you're extrapolating on a specific generator basis is not changed as a result of changing temperature because a few degrees temperature change can make a significant change in growth rates. What we're worried about is the tails of the distributions. Average growth rates are relatively small. Sometimes they can be negative on a tube to tube comparison. But we also see some fairly high growth rates and what we're worried about is a few tubes or one tube out of literally thousands of tubes that may have high growth rates.

So, we've been generally driven by a few tubes

that have very large voltage signals from one inspection to the next, which is why we're still into a case by case review.

COMMISSIONER ROGERS: That's all I have.

CHAIRMAN SELIN: Commissioner de Planque?

COMMISSIONER de PLANQUE: You mentioned earlier, Dr. Shao, and I've seen myself that the French are doing an awful lot of work in this area. Is our research group taking advantage of what the French know and is our industry taking advantage of what the French have done?

MR. SHAO: This research program just started. We intend to learn from the French.

MR. RUSSELL: NRR has been dealing with DSIN in France and with EDF for close to two and a half to three years now. We've had fairly substantial technical exchanges with them, going back to the summer of '92. Much of that information has been discussed broadly and we have encouraged industry, EPRI and NEI to obtain the data. EDF is participating with the degradation specific generic activities. So, that information is being exchanged. Much of the information that we've received from the French is subject to non-disclosure publicly in the U.S. because it is proprietary information. They spent a lot of money and critical plant time to obtain some of it, particularly with some of the high pressure hydrostatic testing that was done

on generators where they hydrostatically tested at pressures that would be greater than the differential pressures you would see under accident conditions in some instances for a best estimate. Not an accident as Brian described it, but any best estimate accident DP, the hydro pressures that they were using, these exceeded it and they did not have substantial leakage or ruptures and yet they have fairly substantial cracking. It's basically the same cracking mechanisms that we have. Their calibration techniques are different and a French volt is not equal to a U.S. volt with respect to how they're calibrated. There's been a lot of effort to try and do comparisons between the two so that the data could be exchanged. But that's probably --

COMMISSIONER de PLANQUE: But there's potential there, at least on the industry studies.

MR. RUSSELL: The French have been very good in exchanging information. The Belgians, in fact many of our international partners, have been quite open in sharing that information with the NRC.

MR. SHAO: They have a very aggressive steam generator program.

COMMISSIONER de PLANQUE: Okay. Thank you.

CHAIRMAN SELIN: Commissioner Jackson?

I notice our research programs are mostly in countries that have very good cuisine. I haven't heard

about any of the problems in the more exotic areas.

MR. MILHOAN: Staff does not have a comment on that.

CHAIRMAN SELIN: This is a very good program. Clearly it ties together all of the strong elements of a well thought out research program, a more performance oriented approach, real consciousness of the fact that these issues are going to get more serious, not less serious as time goes on. I don't know if a single integrated industry response is enough to feel comfortable, but remembering how useful the boiling water owner's group has been on that simpler set, but still important set of issues on internal cracking, I think that's very encouraging as well.

I do admonish you to remember the point you so strongly made about what's the proper role for us to be doing as opposed to the industry to be doing. But I think this is really just very positive, very well thought out program. Clearly in the mainstream of what the big issues are going to be for the next several years.

Thank you very much.

MR. MILHOAN: Thank you.

[Whereupon, at 3:27 p.m., the meeting was concluded.]

CERTIFICATE

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

TITLE OF MEETING: BRIEFING ON STEAM GENERATOR ISSUES - PUBLIC MEETING

PLACE OF MEETING: Rockville, Maryland

DATE OF MEETING: Thursday, June 1, 1995

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

Transcriber: Carol Lynch

Reporter: Peter Lynch

STEAM GENERATOR TUBE INTEGRITY

June 1, 1995

Brian W. Sheron, Director
Division of Engineering, NRR

SAFETY SIGNIFICANCE

- Steam Generator (SG) tubes constitute over 50% of the reactor coolant pressure boundary (RCPB)

- Loss of SG tube integrity has important safety implications:
  - Small LOCA bypassing containment
  - Additional failures of mitigating systems could lead to direct release of significant radioactive fission products

REGULATORY REQUIREMENTS

- Design Requirements
  - General Design Criteria + ASME Code reqmts
  - Offsite Dose Consequences per 10 CFR Part 100 Guideline Values
- Operating Requirements
  - Technical Specifications:
    - Inspection and Repair Criteria
    - Coolant Activity Concentration Limits
    - Primary-to-Secondary Leakage Limits

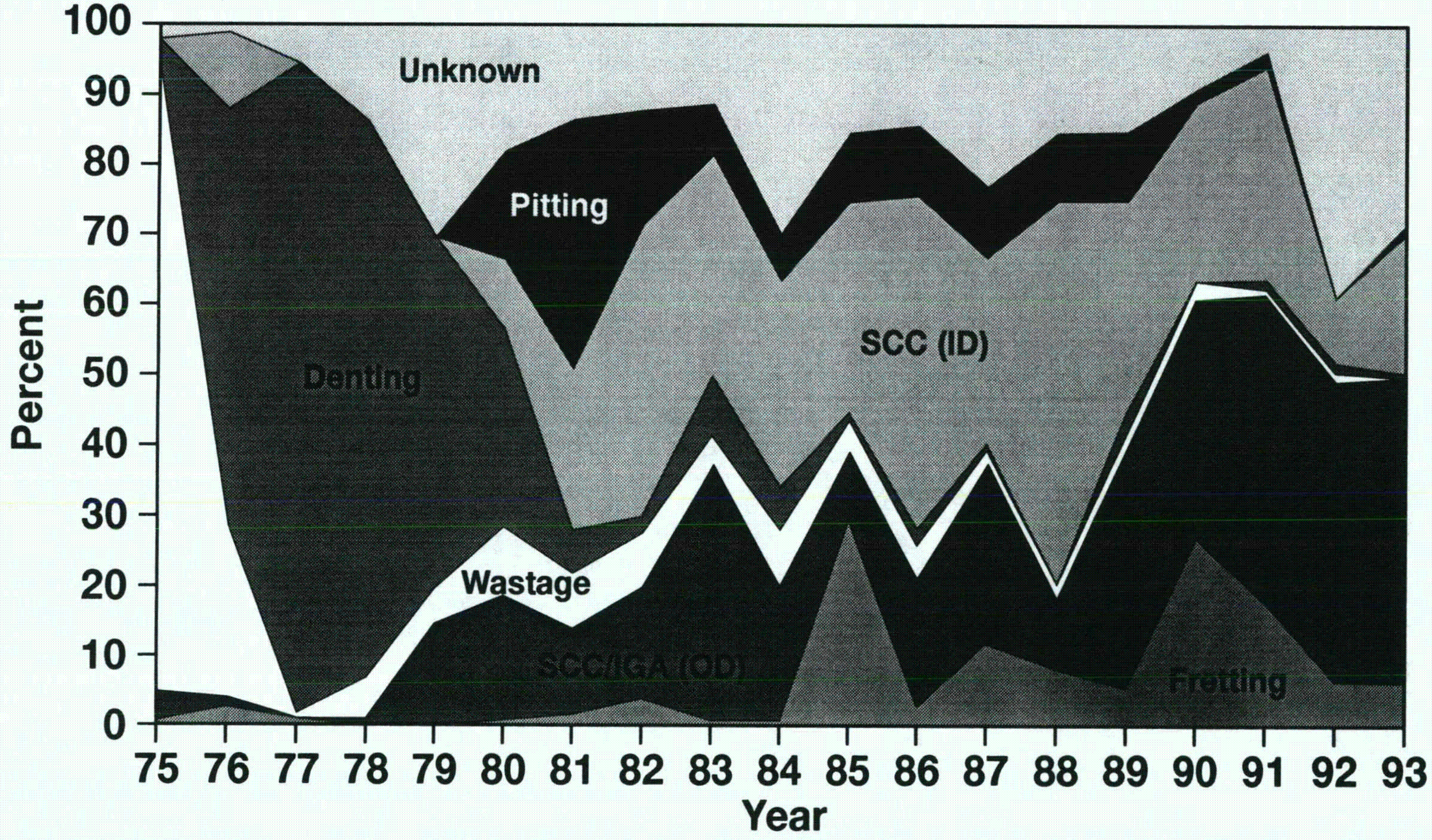
SAFE OPERATION OF STEAM GENERATORS

- Minimizing frequency of SG tube rupture events by ensuring compliance with TSs and 10 CFR Part 50, Appendices A and B, concerning RCPB integrity
- Analyzing anticipated operational occurrences and postulated accidents to ensure acceptable consequences pursuant to 10 CFR Part 100
- Establishing emergency operating procedures for depressurization events

CURRENT REGULATORY FRAMEWORK

- Present technical specifications (TS) developed about 20 years ago when prevalent forms of degradation were wall thinning and wastage
  - Forms of degradation have changed
  - Older SGs are experiencing an increasing amount of degradation
- TSs do not reflect either current degradation modes or inspection technology and are overly conservative for some forms of degradation
- Inspection and repair criteria outdated and present framework leads to frequent plant-specific decision making

U.S. CAUSES OF STEAM GENERATOR PLUGGING



PLANT OPERATIONAL IMPLICATIONS

- Increased plugging/sleeving and associated costs

$4,000 - 8,000 per sleeve

- Potential for power reduction as SG plugging increases

a plug is $800

- Shortened operating life of SGs/continued facility viability can become a major concern

- Regulatory framework results in large expenditure of staff resources

INTERIM REGULATORY APPROACH

- Plant specific reviews (e.g., Tube Support Plate Locking, Sleeved Tube Cracking)
- Generic Communications
  - Information Notices on degradation and inspection issues, repair issues, leakage monitoring, and emergency operating procedures
  - Generic Letters
    - ▶ Voltage-Based Repair Criteria for ODSCC at TSP intersections
    - ▶ Circumferential Cracking of Steam Generator Tubes

GL 95-03: MAINE YANKEE

- Circumferential indications were first detected in 1990
- Plant was shutdown in July 1994 as a result of tube leakage
  - ~ 300 circumferential indications were detected and repaired
  - Eddy current data analysis guidelines were refined
- Plant operated approximately 6 months until refueling outage inspections
  - Initial inspection results revealed several indications which were larger than anticipated
  - Licensee pursued state-of-the-art inspection techniques to improve inspection; ~55% of tubes estimated to be cracked

GL 95-03: MAINE YANKEE (cont'd)

- Licensee plans to sleeve all tubes in the three SGs (~17,000 tubes)

- Generic Letter 95-03 was issued in 4/95

$ 40.0 mill
– start June
Complete Oct

response due by end of June

STEAM GENERATOR RULEMAKING

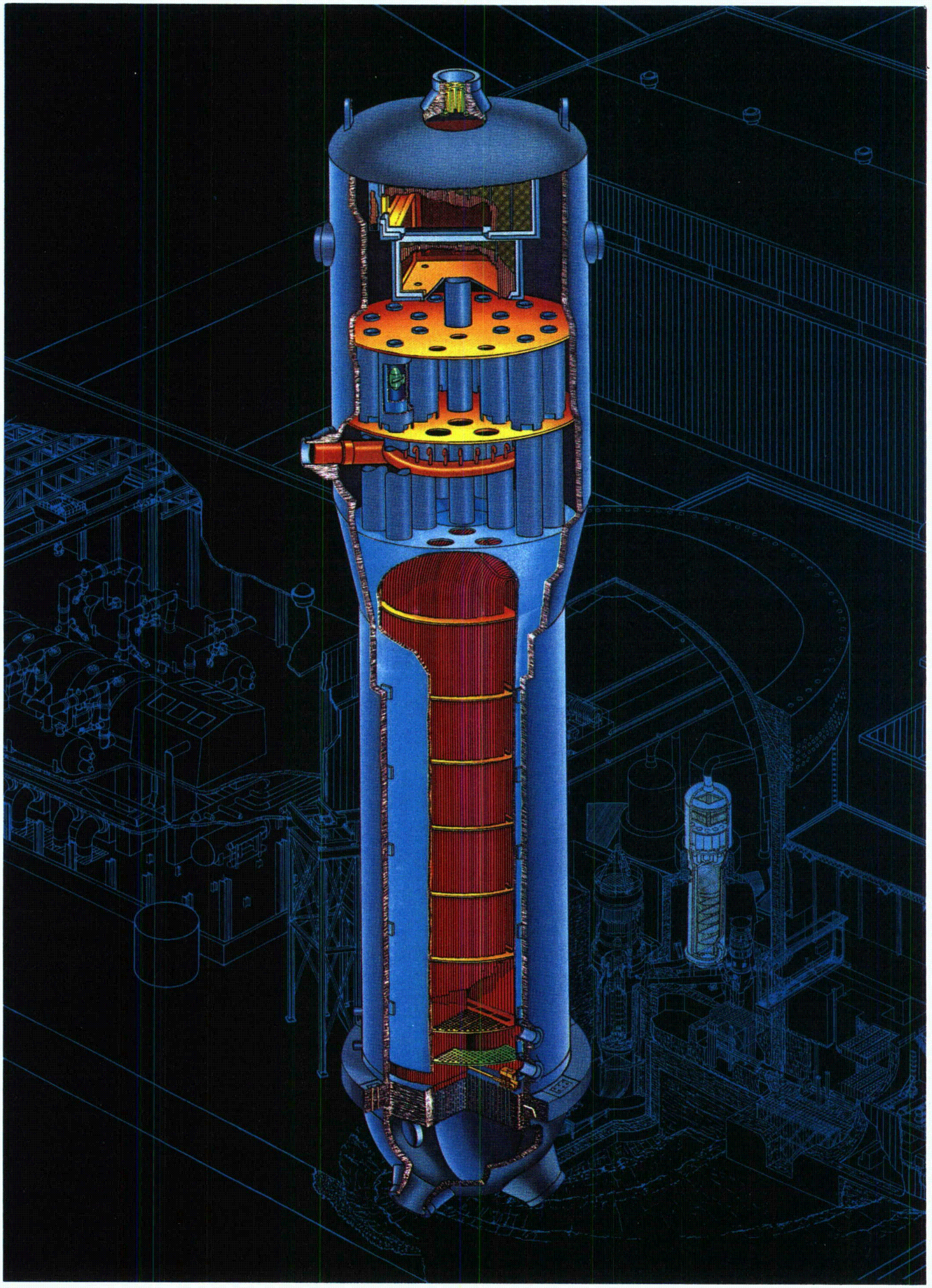
- Rulemaking approach to address current problems:
  - Performance-based
  - Adaptable
  - Providing incentives
  - Integrated - systems, materials, radiological
  - Framework for degradation specific management

STEAM GENERATOR RULEMAKING (cont'd)

- Issued advanced notice of proposed rulemaking soliciting public comments on September 19, 1994
- Public comment period expired December 5, 1994
- Public comments were supportive of a performance-based SG rule
- Performance-based rule would establish high level criteria. Accompanying regulatory guide would provide guidance on industry SG programs
- Staff continues to conclude that rulemaking is best regulatory instrument for addressing SG problems

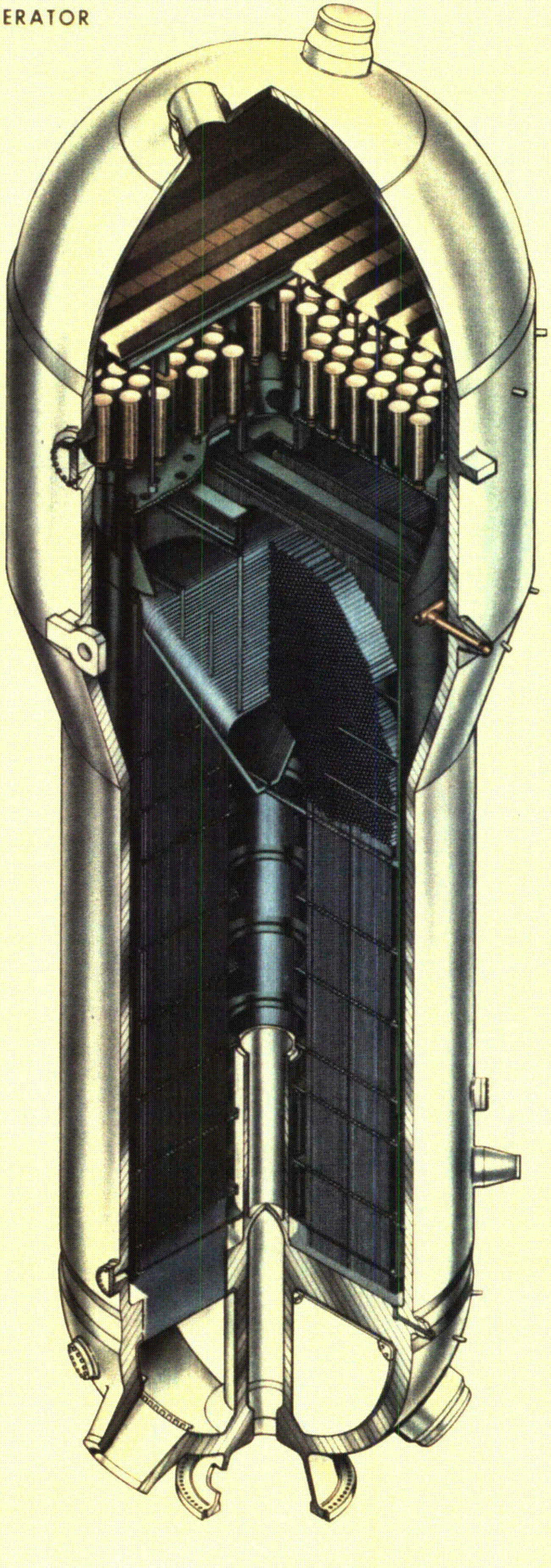
STEAM GENERATOR RULEMAKING (cont'd)

- RES has initiated a new SG tube integrity program plan
  - NRR and RES are coordinating efforts
- Staff schedule for SG rulemaking:
  - Draft rule/regulatory guide for public comment: 12/95
  - Final rule/regulatory guide: 6/96



Westinghouse STEAM GENERATOR

SYSTEM 80 STEAM GENERATOR



C-E POWER SYSTEMS
COMBUSTION ENGINEERING, INC.

Once-Through Steam Generator