# Official Transcript of Proceedings ACRST-3171

# NUCLEAR REGULATORY COMMISSION

ORIGINAL

Title: Advisory Committee on Reactor Safeguards
Materials and Metallurgy Subcommittee
Steam Generator Action Plan

PROCESS USING ADAMS
TEMPLATE: ACRS/ACNW-005

Docket Number: (not applicable)

Location: Rockville, Maryland

Date: Wednesday, September 26, 2001

Work Order No.: NRC-032

Pages 1-166

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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

MATERIALS AND METALLURGY SUBCOMMITTEE

STEAM GENERATOR ACTION PLAN

(ACRS)

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WEDNESDAY

SEPTEMBER 26, 2001

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ROCKVILLE, MARYLAND

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The ACRS Materials and Metallurgy Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:31 a.m., Dr. F. Peter Ford, Chairman, presiding.

COMMITTEE MEMBERS PRESENT:

DR. F. PETER FORD, Chairman

DR. MARIO V. BONACA, Member

DR. THOMAS S. KRESS, Member

DR. DANA POWERS, Member

DR. WILLIAM J. SHACK, Member

DR. JOHN D. SIEBER, Member

ACRS STAFF PRESENT:

NOEL F. DUDLEY,

ACRS Cognizant Staff Engineer

I-N-D-E-X

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

(8:31 a.m.)

CHAIRMAN FORD: The meeting will now come to order. This is a meeting of the ACRS Subcommittee on Materials and Metallurgy. I am Peter Ford, Chairman of the Subcommittee.

ACRS Members in attendance are William Shack, Mario Bonaca, Thomas Kress, John Sieber, and Dana Powers, and hopefully Steve Rosen.

The purpose of this meeting is to discuss the status of the staff's Steam Generator Action Plan and South Texas, Unit 2, steam generator tube leakage, and to decide what further ACRS reviews should be scheduled.

The Subcommittee will gather information, analyze relevant issues and facts, and formulate the proposed positions and actions, as appropriate, for deliberation to the full Committee. Noel Dudley is the Cognizant ACRS staff engineer at 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 September 11th, 2001.

A transcript of the meeting is being kept, and will be made available as stated in the Federal

Register Notice. It is requested that speakers first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

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

The staff issued the Steam Generator Action Plan on November 16, 2000. The Action plan consolidated half a dozen or more staff regulatory activities related to steam generator tube integrity.

The staff updated the Action Plan on May 11th, 2001, to include items associated with the differing professional opinion associated with steam generator tube integrity.

After hearing the staff's presentation, we will develop recommendations on what activities we want to review and comment on, and when we should schedule those reviews.

We will now proceed with the meeting, and I call upon Maitri Banjeree, of the Division of Engineering, Office of Nuclear Reactor Regulation, to begin.

DR. SHACK: Before we start, Mr. Chairman, I should mention that I have a conflict of interest here because Oregon is doing work on steam generators for the NRC.

CHAIRMAN FORD: A;ll right.

DR. POWERS: Is that why they keep falling apart all the time?

CHAIRMAN FORD: Oh, I'm sorry.

MR. SULLIVAN: My name is Ted Sullivan, and Maitri is the next speaker. I will just take a minute and spent a little bit on the introduction to give you a little bit more information on what we are going to be doing this morning.

Maitri is our first speaker, and she is going to be giving an introduction to the steam generator action plan, and basically tell you what some of the early activities were that led to the development of the action plan, and what it considers, and what it doesn't consider.

One of the major elements in that action plan is NEI 97-06, which is our steam generator regulatory framework initiative that we have been working on for quite some time.

So I am going to get up after Maitri and give a presentation on the status of that, and the issues that we are currently dealing with that are holding us up from completing that initiative.

After the break, Joe Muscara is going to give a presentation on the DPO related issues in the action plan. His focus is not going to be going through the entire set of issues in that portion of the plan.

Rather, he is going to focus more on the near term activities. We thought that would be of more benefit. And then after that, Ken Karwoski is going to do two things. Basically, he is going to discuss two of the action plan items related to the DPO that are NRR responsibilities, as opposed to research.

And then he is going to transition into a discussion of what has been going on in the past couple of intervals related to the South Texas use of voltage based repair criteria.

And I agree with what you had to say in terms of the objective. I think that we are not going to get into a tremendous amount of detail, as we are covering a lot of material here. So I think it would be good to decide what additional briefings you would like.

And certainly in the area of NEI 97-06, we are prepared to get into more detail if you are interested in a subsequent briefing.

DR. POWERS: And in what phase of the

briefing will we discuss the iodine spiking issue?

MR. SULLIVAN: It should be covered in the DPO portion, but Joe, can you address that?

MR. MUSCARA: I will have one view graph on the status of the operation.

DR. POWERS: Okay. An in-depth discussion, I can tell. This is an easy issue to solve, Joe.

MR. MUSCARA: That's what they tell me.

CHAIRMAN FORD: Thank you, Ted.

MR. KARWOSKI: The first question is are you related to Sanjo Banerjee?

MS. BANERJEE: Not that I know of.

MR. KARWOSKI: Okay. Then you are okay then.

MS. BANERJEE: That's reassuring. My name is Maitri Banerjee, and I am the NRR lead project manager for the steam generator action plan, and I will provide you a short background and overall status of information on the action plan. Can everybody see this slide?

All right. Here is a historic overview of the --

DR. POWERS: History begins with an IP2?

MS. BANERJEE: And of significant actions taken, and that led to the issuance of the steam generator action plan, and this kind of explains itself.

The purpose of the plan. As Chairman Ford pointed out the plan was originally issued in November of 2000, and it was issued keeping the NRC performance goals in mind, and in maintaining safety in the IP2 area, and renewing public confidence, and also using NRC and stakeholder's resources effectively and efficiently.

And the purpose of the plan is to direct, monitor, and track NRC's activities to completion so that we get to an integrated steam generator regulatory framework.

DR. POWERS: Can I ask what an integrated regulatory framework means?

MS. BANERJEE: Well, I am going to defer answering that question to Ted Sullivan, who is going to talk about NEI 97-06 activities that are going on.

DR. POWERS: Well, maybe you can give me an idea of what we are integrating with what.

MR. SULLIVAN: My name is Ted Sullivan, and I think what we are trying to do is to make sure that all of the various elements involved in ensuring tube integrity are integrated into a steam generator regulatory framework that considers more than just, say, inspection and repair issues.

But that goes beyond that into all the other disciplines that are involved in ensuring tube integrity. Disciplines related to doing risk assessment, and the research that is developed that feeds into that, and that sort of thing. I think that is the general idea, and the radiological issues.

MS. BANERJEE: Do you have any other questions? If not, the action plan consolidates a number of activities, including Indian Point 2 Lessons Learned Task Group Report, and the OIG report that was issued subsequent to that, and then it was revised in May to incorporate the steam generator DPO related issues.

And obviously the milestones related to the staff review of NEI 97-06 is in there, and we will make revisions in the future to incorporate milestones for resolution of GSI 163.

We also anticipate revisions to incorporate GSI 188 and Draft Guide 1073.

CHAIRMAN FORD: Could I just for clarify? The resolution of the steam generator DPO, that is essentially the output from the ad hoc committee, subcommittee from ACRS?

MS. BANERJEE: Yes, that's correct, from the NUREG requisition. The steam generator action plan also includes some non-steam generator related issues that came out of the OIG report. They had issues in the EP area, and also that task group's report.

And the second bullet is sort of a disclaimer. It says that the action plan doesn't address any plan-specific reviews or industry efforts related to voltage-based tube repair criteria.

CHAIRMAN FORD: Is there a reason for that disclaimer? Why the disclaimer?

MS. BANERJEE: I guess these are plan-specific issues that are not addressed in the action plan. The action plan is basically what came out of the Indian Point 2 lessons learned task group, and what came out of the OIG report subsequent to Indian Point 2, and also the DPO related issues.

And so we didn't go into addressing Generic Letter 95-05, any kind of industry work being done in that area, or any kind of plant-specific licensing work related to voltage-based tube repair criteria.

CHAIRMAN FORD: But surely as you go through the action plan, which is your calculations, experiments, and studies, there has got to be a feedback into what the plant is actually doing.

MS. BANERJEE: Ultimately, yes.

CHAIRMAN FORD: And so when does that occur? That second bullet is saying, hey, we stopped short of actually calibrating our calculations against what is in fact happening. Isn't that a over simplification of what that statement is saying?

MR. SULLIVAN: I think what we were trying to say is that there is a lot of plant-specific reviews that are going on. They continually go on.

They might have to do with ultimate repair criteria that we maybe reviewing, and what we are basically saying is that they are tracked in other systems, and so we weren't going to track them in the action plan.

And then related to the second half of that, they are a number of issues that industry has been asking us to take on, their proposed modifications to GL 95-05, and that in a sense would be relaxations.

And the staff's view was that the priority effort should be on the action plan when resources are available, and we will get back to taking those kinds of reviews on. So for the second half of that, it was really more of a priority of resources matter.

MS. BANERJEE: Thank you, Ted. This slide presents an overall status of the action plans. Currently, we have 40 major items, milestones, in the action plan, 11 of which consist or came out of DPO.

And 20 of the 40 major milestones are completed, and there is one milestone with a schedule to be determined. This has to do with how we communicate risk to the public.

The agency has done some work in the area of communication plan and currently NRR is looking at ways to improve that. And that is the overall status.

This slide lists some of the significant activities in the action plan. A regulatory summary was issued in November of 2000, with experience from Indian Point 2 and ANL, and a number of issues were raised by both task groups, and the OIG related to steam generator inspections, GSI inspections.

And in response to that the base line inspection procedure was revised. It focuses on the steam generator ISI inspector, in terms of how the licensee is going condition monitoring, and how they are meeting the performance criteria, versus looking at any current testing.

A risk informed significance determination process is being developed for ISI inspection results, and NRC's findings related to that, and with inspector training, we will be providing written material, written packages, for inspector training related to the new inspection program in October.

And formal training will be provided to the regional inspectors in February. In terms of steam generator tube leakage, technical guidance is being developed and will be provided to the regions some time in the very near future.

And this has to do with helping the regional inspectors oversight of PWRs with steam generator tube leak, and help them understand the role of the primary to second leaking monitoring in assuring steam generator tube integrity.

And in the area of steam generator performance indicators, we have done some review, and a decision was made not to add any new PI related to steam generators.

And our next bullet has to do with conference calls during outages. The NRR staff will continue doing the conference calls with the licensees during -- the selected licensees during the outages, and we will docket the telephone summary.

And we will also formally review their ISI results report, which sometimes is called the 90-day report. A steam generator workshop was held with stakeholders in February, and the regulatory information conference also had discussions on steam generator issues.

The next slide is a continuation of this slide. Both the task group and the OIG made recommendations for some improvements to NRR's process for license amendment reviews, and changes were made in response to that.

As I mentioned before, NEI 97-06, Ted Sullivan will provide a detailed discussion on that. Subsequent to Indian Point 2, as you all know, the staff stopped its review of NEI 97-06, and we recommenced in January of this year.

And so a lot of activities are going on in that area. And then a web page was developed and being maintained for internal and external access. And risk communication, that has already been mentioned on what we are doing.

And milestones for ACRS' recommendation on the DPO, and we have a much more detailed presentation by Jim Muscara as Ted mentioned; and the last bullet, as I mentioned before, are future activities.

CHAIRMAN FORD: Is there a particular reason why this NEI 97-06 was put on hold?

MR. SULLIVAN: Dr. Ford, I am going to be getting into that. I plan to cover your question.

CHAIRMAN FORD: Okay.

MS. BANERJEE: This slide is on the management of the action plan. We will formally document completion of each major milestone, and we will be coordinating a resolution of issues with external and internal stakeholders. Like all of our meetings with NEI, they are open to the public.

And the status of the milestones are updated, and a complete copy of the milestones is maintained in NRR's Director's Quarterly Status Report, and an abbreviated version in is the CTM.

The CTM is updated monthly and the QSR is updated quarterly. And the overall management of the action plan is the responsibility of the projects in NRR. This completes my presentation.

CHAIRMAN FORD: Maitri, as I look through all the milestones and their completion dates, starting back from the earliest of these action plans, a tremendous number of them are way, way behind, a year behind in completion. Is there a reason for this?

MR. SULLIVAN: When you say behind, do you mean delayed or do you mean scheduled for some time?

CHAIRMAN FORD: Well, in these lists here, I see the targeted completion date, and you are way, way beyond. Like NEI 97-06, there is just one, but there are many others.

MS. BANERJEE: Like DPO has a lot of milestones.

CHAIRMAN FORD: Well, I am just putting this in general. All of them are way, way behind on schedule. Is there a particular reason for this delay?

MS. BANERJEE: As far as I can tell, some of the actions are a little bit behind, but in terms of scheduling those milestones into the distance or future is because of all the activities that needed to be completed before we can get there.

And that is a considerable amount of work that needed to be done, especially in the area of the DPO recommendations.

CHAIRMAN FORD: So it is manpower and dollar constriction on completing those?

MR. SULLIVAN: I think that is true, along with all the other work that was already in place before we developed the action plan.

CHAIRMAN FORD: Okay.

MR. SULLIVAN: I think the major delays are in the NEI 97-06. A number of other items -- you are right -- they did slip, but usually on the order of not too many months; and the DPO work, I wouldn't characterize it as having been slipped.

The schedules were based on the research plans that were pretty much in existence when the ACRS report came out.

CHAIRMAN FORD: Okay. Thank you.

MS. BANERJEE: Any other questions?

DR. POWERS: I am curious about the train of reasoning that went about to decide that there would be no performance indicator for steam generator tubes.

And I am perplexed in this area because I remind myself that steam generator tube rupture accidents are risk dominant for a number of plants; and bypass accidents in general are risk dominant.

And seldom do you have a more direct indicator of risk than steam generator performance. So what was the rationale that went about not having a PI for steam generator performance?

MS. BANERJEE: The way I understand it is that the staff considered three potential Pis. One had to do with tube degradation, and one had to do with integrity of the tube integrity; and another one had to do with primary to secondary leakage.

The purpose of a PI is to give you only indications of things going south, and in the case of the first two, they are only information or new information is only available during outages, which happens every 18 to 22 or 24 months.

So the staff concluded after a lot of consideration that it doesn't really provide you with an indicator in all cases. And then in terms of primary to secondary leakage, the relationship of the steam generator performance with the leakage is not very clearly established, and we don't even know that it could be established.

Because like in the case of Indian Point 2, we have not seen a tremendous amount of leakage to happen before an event occurred. So considering all of that, a conclusion was made that at this point we don't have a real good parameter which we can use as an early indicator of problems. Does anybody on the staff want to add more to that?

MS. KHAN: I think that summed it up pretty well. By the way, my name is Cheryl Khan, and I work in materials in the chemical engineering branch in NRR.

But that pretty well sums it up as far as the main viewpoints, and as Maitri indicated, the first two that she mentioned didn't really fit the typical type of performance indicator, the parameters.

It needs to be an ongoing parameter that you are monitoring continuously; and with respect to the third one, as she indicated, leakage is not necessarily correlated to the real condition of what is going on, and to generate as far as how significant the issue is.

And in fact the issue may be more significant compared to the leakages. So it was not felt that that really was an appropriate term to monitor a performance indicator.

The ones that we took beyond that was that what the performance indicators would have provided to us was the capability to take some type of actions if there were signs of degradation occurring in the steam generators or issues of significance occurring in the steam generators.

And so the way that we tried to address that is through the inspection process in lieu of using performance indicators, because it is typically an either/or.

And so through the inspection process the intent is that there are periodic inspections that are being performed under in-service inspection procedure, and it incorporates with the in-service inspection program, as well as steam generator inspection activities.

And there are -- there is a means, that dependent on the outcome both of the inspection, the NRC's inspection, as well as what the licensee is finding, that there is the potential to take immediate action, meaning further NRC inspection and involvement.

And we felt that was more appropriate, because that is when the degradation and issues would be clearly identified, and then we would be able to take immediate action if they were significant enough.

DR. POWERS: So from that I conclude that the first decision was that since we couldn't get information, except for every 18 months or every outage, we would take no PI at all.

And that the second one is that because the correlation between leakage and tube condition, which is good enough for the alternate criteria, is not good enough for monitoring the plant?

MR. SULLIVAN: Excuse me, but what do you mean by good enough for alternate repair criteria?

DR. POWERS: Well, it's used. The correlation is used as part of the alternate repair criteria.

MR. SULLIVAN: I think that one of the factors that we considered in terms of primary to secondary leakage was that the information that was -- we had originally proposed that we go down that road and look, and what we were advised was that it wasn't necessary to put this in as a performance indicator in order to get that information.

We get that information on a daily basis from plants that are experiencing leakage. And we are involved in it in the sense that the regions will typically inform us of when the leakage is increasing, and they are going to have phone calls with licensees, and we get involved in those phone calls.

So we really felt that adding a performance indicator in this arena wasn't really going to substantially add to our ability to conduct oversight.

MS. BANERJEE: That is one thing that the resident inspectors review in their daily status inspections.

CHAIRMAN FORD: Thank you very much.

MR. LONG: This is Steve Long, and I am in NRR in the risk assessment group, and I just wanted to add something on the relationship for the performance indicators and the parameters we measure.

When the reactor is operating the only thing we are really getting information on is leakage during normal operation. We don't know what the leaking would be if there was an off-normal condition because the off-normal condition isn't there.

So it is very hard to relate a very small operational leakage number to anything that will help us figure out what the actual risk at that time is. When we shut down the plants and inspect the plants, then we have good information.

And the thing that was not mentioned here that I want to add is that at that point, if there are findings of degradation, we are developing a significance determination process for those findings.

Those actions go into the action matrix, like the performance indicators go into the action matrix, for making a decision about how we are going to inspect and regulate the plant.

So instead of having a performance indicator that is being updated every three months, and that only be tied to an observation every three months that is not necessarily in any quantitative way tied to the risk, we decided to go with the determination of significance of inspection findings when something is determined not to be needing the performance -- you know, the performance on tube integrity, leak tightness and structural integrity, and that sort of thing.

But that information is still going under the action matrix, just like a performance indicator would, and we are still making regulatory decisions on that information. It is a timeliness thing.

DR. POWERS: And we don't have a SDP for these findings right now?

MR. LONG: That is one of the action matrix -- excuse me, but that is one of the action plan items, and where that stands at the moment is we are just signing out a review of what needs to be done, and some suggestions that are going down to the branch that is responsible for implementing that into procedures. So that is in the process.

DR. DUDLEY: Do you have a feel for when that might be available for ACRS review?

MR. LONG: It is supposed to be in ADAMS now, but we had a little glitch. It is going to be in ADAMS by the end of the month I promise.

DR. POWERS: Yes, but when can we get it?

MR. SULLIVAN: I previously introduced myself as Ted Sullivan, and I am going to be talking about NEI 97-06.

DR. KRESS: And you are still Ted Sullivan?

MR. SULLIVAN: Yes. We have had a number of briefings with the ACRS, and I am going to actually go through that towards the end of this view graph a little bit.

I had gone over this, but I thought it would be worth it to spend a very brief time on some background, starting with something that I think we have started all these briefings with, which is to state that the current requirements, particularly as imbedded in the text specs, are prescriptive and out of date.

They go back to the '70s. These requirements are not focused on the key objective of ensuring tube integrity for the entire period between in-service inspections.

Rather, they are inspection and repair oriented, and they don't focus on the time that steam generators can operate between inspections and maintain safety margins.

And recognizing that the staff began initiatives in probably the early '90s, beginning with a rule making initiative in the mid-1990s that turned out not to be a vehicle that we could use.

We briefed the ACRS on that in '96, and several times in 1997. We discussed with the ACRS in 1997 a change in strategy to a generic letter. We proceeded down that path for probably a year or a year-and-a-half.

And at the same time as that was going on, NEI was developing its 97-06 steam generator program guidelines initiative, and I believe in the '98 or early '99 time frame -- I think the '98 time frame -- we began discussions with NEI regarding putting the generic letter on hold, and switching our focus to a new regulatory framework based on NEI 97-06.

Throughout a lot of 1999, we held meetings and discussions with NEI and other industry counterparts on a generic change package that was being developed. The generic change package is kind of a centerpiece of proposed technical specifications.

And we had reached some tentative agreement on drafts of the generic change package in late '99, and NEI then went through its process of issuing it. It was issued on February 4th of 2000, shortly before the Indian Point-2 tube rupture, less than two weeks before that.

I think as Maitri mentioned, we suspended are review after the Indian Point-2 rupture for basically two reasons. One was that our resources were devoted or diverted to Indian Point-2 recovery.

A lot of staff resources went into reviewing the restart plans and the operational assessment that Con-Ed was producing and working on. Prior to that, we were reviewing and participating in NRC inspections related to the Con-Ed steam generator inspections.

And also some of our staff was diverted to the lessons learned task force. So that was sort of reason number one. Reason number two was that we really wanted to wait and see what came out of the Indian Point-2 lessons learned, and factor them back into the review.

So we didn't want to really make a false start. It wasn't that we had a lot of time that we were sitting anyway. The two things came together nicely, but we did deliberately indicate to various constituents that we weren't going to do the review, or commence the review, until the lessons learned study was finished and until we had a chance to look at it.

DR. SHACK: Ted, every time we look at a license renewal with a steam generator and we look at GALL, everybody seems to be using 97-06. So that means that they are under a dual sort of system. They use 97-06 for their own tracking and monitoring purposes, and yet they still meet their tech specs also? Is that the way that the system is working now?

MR. SULLIVAN: That's correct. Licensees have all committed in a manner that I think Jim Riley could elaborate on if you want, but it is basically an internal industry arrangement that every PWR licensee is committed to implement NEI 97-06 for a couple of years now. And I think it was at the first refueling after January of 1999.

DR. SHACK: Now, how many PWRs are actually running under 95-05? That is, at least for their tube support plate degradation, and they are really controlled by 95-05 rather than the old 40 percent through wall kind of thing.

MR. SULLIVAN: For that mode of degradation, yes. If the controlling document is tech spec amendment dealing with 95-05, and it is on the order of a dozen plants, I am not sure if that is accurate.

DR. SHACK: So there is still 600 mil anneal plants that don't use 95-05?

MR. SULLIVAN: Yes, there are quite a number, probably on the order of about two-thirds of them, I guess. I mean, I think about half of the plants have replaced roughly, and so that is on the order of about -- between 30 and 35.

DR. SHACK: Yes, I was just looking at the Mil Anneal 600 plants, yes.

MR. SULLIVAN: And that is what I am talking about. About half still have Mill Anneal 600, and half have replaced, and a dozen of that 30 to 35 reactors use generic letter 95-05 for ODSCC tubes or plates.

The staff review of the generic change package when we commenced that review included a consideration of issues associated with the lessons learned report.

A regulatory issue summary of 2022, which Maitri mentioned, but I will just elaborate very briefly to say that it described technical issues that came out of the staff review of Con-Edison's Indian Point-2 restart assessment, as well as an operational assessment of Arkansas Nuclear Unit-2.

And that basically led to a mid-cycle

inspection. It was not exactly mid-cycle literally. It was sort of late cycle inspection, an additional inspection, during the summer of 2000.

And then we have also considered the DPO action plan issues that were developed in response to the ACRS report. I will go over this briefly as it is nothing new.

And even as far back as the rule making, our intent was to put in place a new regulatory framework that has these features that are in bold. That is, that it is performance based, and it establishes performance criteria for ensuring tube integrity and leaking integrity under normal and accident conditions.

So I am going to elaborate a little bit more on that later when I get into a brief discussion of performance criteria. Performance criteria are in terms of parameters that are measurable and tolerable.

The framework is supposed to be flexible, in that the methods for meeting the performance criteria are up to the licensee. It should be adaptable to changing mechanisms and technology which a prescriptive framework would not be.

And it is risk-informed to ensure that no -- that there is no significant increase in risk associated with operational steam generators.

CHAIRMAN FORD: If you could just go back to that last slide.

MR. SULLIVAN: Sure.

CHAIRMAN FORD: Industrial parlance, would you say that this is a stretch goal given the fact that you no longer -- that you don't currently have Pis, forced steam generators as I understand for reasons that were just enunciated.

So this is really a wish list, and if I look at the timing on your latest action plan, the one that takes into account the NUREG 17.40 recommendations, you are looking several years out. You are looking 2, 3, 4 years out --

MR. SULLIVAN: Well, in terms of the framework --

CHAIRMAN FORD: before you can have this.

MR. SULLIVAN: In terms of the framework, not exactly. I will try and capture the time frame that we have in mind. In terms of the framework itself, we are -- and as I will discuss a little bit later, we are probably not going to completely capture the performance-based element.

We will incorporate it, but it won't be strictly non-prescriptive. We still have to work this through with NEI, and that is -- our current target date for completion is April, and that is probably optimistic.

CHAIRMAN FORD: After discussing it with NEI?

MR. SULLIVAN: Well, our target date for reaching resolution of NEI 97-06 is April, and I am saying that may be optimistic. After we reach resolution, which will entail some things that I am going to talk about later having to do with issuing a generic safety evaluation and so forth, the individual plants have to send in tech spec amendments to put this in place.

The tech spec amendment process could take up to an additional year. So just that alone could potentially take a year-and-a-half to two years. In terms of the risk issues, I don't think we will consider that we fully understand or more completely understand risk until the other issues associated with what I refer to as the 3.X items in the action plan are completed.

And the action plan has 1.X, and 2.X, and 3.X items. The 1.X are steam generator related, and the issues that came out of the lessons learned report.

The 2.X items are the non-steam generator related items that came out of the report; and the 3.X items are the ones that basically relate to the ACRS report on the DPL. So I am not sure if I have confused things by that answer.

CHAIRMAN FORD: And I am sure it is because of my lack of understanding of this whole process. But standing back, as I understand it, we have got a whole lot of reactors out there with steam generators that are demonstratively cracking.

We are not too sure how to quantify the progress of this cracking because of monitoring discrepancies or restrictions, et cetera, and modeling restrictions all go into this NUREG 17.40.

We don't have any Pis to tell us right now on an ROP basis as to how we are doing. And what you are just saying is that this is the wish list of where you want to go, but it is going to be the middle of next year before we have got the NEI thing reviewed, and 97-06 reviewed, and signed off.

And the information for this is not going to be around and approved without being used legally if you like until another 5 or 6 years. So what happens in the meantime? What is our backup plan?

MR. SULLIVAN: The intent is to put into

place a new regulatory framework which I am going to cover in subsequent slides and describe in subsequent slides.

CHAIRMAN FORD: I'm jumping in. Sorry.

MR. SULLIVAN: And the intent is to get that in place for every PWR within about a year-and-a-half, assuming -- and that schedule is contingent on reaching resolution of the outstanding issues with NEI and the industry. I noticed Jim Riley from NEI is interested in adding to what I have been saying.

MR. RILEY: Hi, I am Jim Riley from NEI, and I am NEI's project manager for steam generator issues. I think a real important aspect of what we are doing here is Ted's illusion to an NEI initiative that is set in place.

So even though the regulatory framework isn't there right now, and we are all working towards it, the fact is that the plants are inspecting their steam generators to a performance based program based on NEI 97-06, which involves basically all these things that Ted is talking about, the differences, and we don't have the tech specs in place yet that give the regulatory aspects of what we are doing some substance.

But in fact the plants are all committed, all the PWRs, to implementing NEI 97-06 and its guidelines that are associated with it.

DR. POWERS: And Indian Point-2 was one of those plants that followed this 97-06?

MR. RILEY: That's correct. I would like to point out though that at the time that Indian Point-2 did their inspection previous to their problem was 1997, and at that point in time they had not implemented 97-06 because it wasn't in place at that time.

CHAIRMAN FORD: Could I ask my colleagues have we seen 97-06?

DR. POWERS: Yes.

DR. SHACK: Yes.

DR. SIEBER: Before you take that slide down, on the second bullet there, how does one determine whether the value of some parameter is tolerable or not tolerable?

MR. SULLIVAN: The basic concept there is that we have in place concepts -- and as Jim said, in NEI 97-06, of being implemented -- related to specific performance criteria.

For example, the structural integrity performance criteria is that there should be a factor of safety of three times normal operating pressure against burst, and 1.4 times main steam line break pressure.

In terms of measuring, the basic concept is that you have a qualified NEI sizing technique, you assess -- and with suitable uncertainties, you assess the condition of the tubes against that criteria.

If you don't believe that you have a sufficient understanding of NDE uncertainties, the approach is to prioritize the tubes that are most damaged by this degradation mechanism and do institute testing against those factors of safety, and determine whether or not the performance criteria are being satisfied.

In terms of tolerable, the basic concept there is to set the performance criteria such that there is some leeway that if the performance criteria aren't satisfied, you are not falling off a cliff in terms of safety.

And in terms of leading to spontaneous tube ruptures or being vulnerable to main steam line break. Do you want to add to that?

MR. MURPHY: Yes, I can add to that. This is Emmit Murphy from the Materials and Chemical Engineer Branch of NRR. I might also add that when considering appropriate performance criteria, we did consider the available information on risk.

And we considered some of the findings in NUREG 15-70 pertaining to risk, and which also included an early look at tube rupture accident sequences and their impact on risk.

And the conclusion based on the information available at the time was that for plants maintaining margins at the performance criteria that were being proposed that there was not a significant risk issue at that point.

So whether you were just slightly below the performance criteria, or you were right at the performance criteria, there is not going to be -- you don't cross a critical risk threshold.

DR. SIEBER: Thank you.

MR. SULLIVAN: I think one of the major elements of the NEI 97-06 generic change package is the revision to the text spec that is being proposed, and we have worked quite a bit with industry to sort of get on the same page on this issue, and on this part of the change package we are all in agreement on.

And that is that it would contain basically three new elements that I have outlined on this view graph. The first is to revise the existing operational leakage tech spec downward from this standard of 500 gpd, which is in the improved standard, to 150 gpd, which a lot of plants already have in their tech specs.

And then secondly there would be a new limiting condition for operation, entitled, "Steam Generator Tube Integrity," and that would have a surveillance requirement to verify that the structural integrity and accident leakage integrity performance criteria are met in accordance with the steam generator program.

And then a new administrative text spec called "The Steam Generator Program," which I am going to talk about on the next view graph. The new administrative tech spec basically has four elements, or maybe five, but over five different elements.

It starts out by saying that a steam generator program shall be established and implemented to ensure tube integrity and performance criteria are maintained. It goes on to require that condition monitoring assessments of the as found condition of tubes be performed to verify that the tube performance criteria that I mentioned previously, the structural integrity and the accident leakage integrity performance criteria, are being maintained.

Then it goes on to say that licensees have to use NRC approved performance criteria, even though those performance criteria are located in the industry steam generator program, they have to be ones that are reviewed and approved by the NRC, either generically or plant specifically.

And in a similar fashion, the tech spec goes on to say that licensees can only use approved tube repair criteria, and NRC approved repair methods, whether they are again approved generically or plant specifically.

And the last section of this tech spec deals with tube inspection reports, and that is not on the view graph, and that has to do with when reports have to be submitted, and what triggers their submission, and what they are to contain.

As I mentioned, the details of a steam generator program would be located outside of the tech specs. The tech specs basically say what I just went through.

As Jim Riley indicated, licensees -- well, actually this isn't what Jim indicated. This is something different. As part of submitting the generic change package, licensees will commit to developing the steam generator program in accordance with NEI 97-06 guidelines.

The difference here between this and what Jim Riley said is that this is a commitment to us, as opposed to an internal industry commitment. The top tier of 97-06 guideline document provides general guidance for a performance based programmatic strategy for ensuring tube integrity.

And it includes the elements that I have towards the bottom of the view graph. It includes performance criteria, tube integrity assessment, in-service inspection elements, tube repair limits and repair methods, and leakage monitoring.

Not the details, but a description of those elements of a program, and it is our intent to review NEI 97-06 for endorsement as part of the NEI 97-06 generic change package.

CHAIRMAN FORD: And all of these, the sub-bulleted performance criteria and in-service inspection, the metrics for all of those come out of the latest action plan that we have got, the integrated NRR for such programs?

MR. SULLIVAN: No.

CHAIRMAN FORD: Where do the metrics come forth? For instance, in the in-service inspection or leak monitoring? Well, specific data and specific numbers?

MR. SULLIVAN: The specific approaches are in guideline documents that I am going to talk about on the next page. In terms of inspection, for example, since you mentioned that, there is a guideline document that contains details on matters such as what sort of degradation to look for, what sort of probes to use.

CHAIRMAN FORD: All right.

MR. SULLIVAN: What type of qualifications the inspectors need to have. In terms of limits, limits are in the performance criteria that the inspection program will develop the information to apply through integrity assessments to determine whether or not the performance criteria are being satisfied.

Actual limits are in the guidelines with respect to primary to secondary leakage monitoring and the actions that need to be taken.

CHAIRMAN FORD: I understand.

MR. SULLIVAN: So I mentioned NEI 97-06 as a top tier guideline, but here are subtiered guidelines that are on this view graph, and I thought I would give you a little bit of a flavor of the age of those documents, because they do vary quite a bit.

The steam generator examination

guidelines, and examination being another word for inspection, currently licensees are using Rev. 5, which came out in 1997, and Rev. 6 is being developed. And I am going to talk about Rev. 6 a couple of view graphs hence.

I believe those guidelines first came out in the '80s. They have been around quite a lot time. The tube integrity assessment guideline is the most recent, and I believe that came out in February of 2000. So that is only a little over six months old, in terms of it actually being issued to licensees.

The in-situ pressure test guidelines has been around about a year longer than that. The guidelines for monitoring primary to secondary leakage came out I believe in the early '90s. I think they are up to Rev. 2 of that.

The water chemistry guidelines we believe came out or first came out in the late 1970s. And the EPRI sleeve and plug assessment guidelines have been around for 4 or 5 years.

DR. BONACA: I have a question. Going back to actually slide seven, when you talk about performance criteria in '97 or '96, and this is more for information, could you give me a feeling for what is involved in that performance criteria?

Is it just simply the number of tubes, or leakage, or is it also for example the prediction or the ability to predict?

MR. SULLIVAN: There are three performance criteria. The operational leaking is probably the easiest because that already exists. The structural integrity criterion says that no tube should have -- I don't know if this is literal in this, but this is actually something that we need to discuss further with NEI.

But the gist of it is that no tube should have less than a margin of three against bursts, and the margin of three is against normal operating pressure, and 1.4 against main stream line break.

The accident leakage integrity criterion is again something that you have to calculate, and the idea of it is that under accident conditions the total primary to secondary leakage under accident conditions should not exceed one gallon per minute. Does that answer your question?

DR. BONACA: Yes. I guess what I am looking for is there some element that measures the ability of the inspections to predict, for example, the growth of the number of defects, as well as the severity of the indications?

Is there anything, any element, that does that in this program?

MR. SULLIVAN: Well, I think I can address that, and if I can't, maybe Emmit can add to it. I am trying to figure out where this comes up or whether I have already covered it.

I think I already covered it when I talked about in-situ, and talked about the administrative tech spec requires that licensees perform condition monitoring of as found condition of the tubes.

In a similar fashion, while it is not embedded in the administrative tech spec itself, the bases as it is currently written in draft in NEI 97-06 talks about the basic understanding that licensees perform what is called operational assessments.

And I had talked about that previously in the context of risk 2022, where licensees do predictions through calculational techniques, which would involve things like growth of degradation, to determine how far out in time they can operate and still maintain those safety margins.

DR. BONACA: Well, the reason that I am asking the question is that to me that is an element of performance that I don't measure in leaking, but I have a statement on the part of the utility that performs these inspections that says based on what we do, we predicted that we will not have more than X-number of additional tubes, nor more than this number of severe laceration.

Now, if I get to the next cycle and I find that these predictions are good, it gives me confidence in the process. I could say that that is a good performance element in their program if conversely they come back and they are totally off, and there is a much faster growth, and they cannot predict, and I would expect that I would measure that as an element of performance in their ability to support programmatically the steam generators.

Do you see where I am going? I am trying to understand how that --

MR. SULLIVAN: One of the reporting requirements that I didn't mention is that when licensees don't satisfy their performance criteria, they have to report that to us on a pretty short schedule. I am not sure exactly what the timing is.

And our intent if that were to occur would be to devote additional resources over what we planned to understand what is going on with that particular plant, and to work with the licensees.

They may not express it exactly the same way, but to work with the licensees to make sure that we agree with what their plans are for the next operating interval.

In the case of ANO-2, we had observed that they didn't satisfy performance criteria on a number of occasions going back as far as, I think, 1992. And ANO-2 had been on several occasions between then and when they replaced their steam generators last October, I believe, had done a number of mid-cycle inspections.

They had planned to only do one mid-cycle inspection in their last operating interval, and basically because of disagreements that we had with the licensee, they agreed to do two mid-cycle inspections.

So it is not formalized in terms of some sort of performance indicator or performance monitor, but it is where we devote our resources when we observe that licensees are having problems.

DR. BONACA: I still feel that performance criteria here focuses -- or I thought, focused specifically on the performance of the steam generator. I think that I would like to look at elements of the steam generator program, and among those there is also this ability of predicting the future leakage and somewhere they must be, and I am sure that NEI --

DR. SHACK: But you do that, right, because he has to do the performance assessment which sort of predicts where he is going to be. And then he does the condition monitoring to find out how well his prediction worked.

I was curious that when he misses that prediction, there is a discussion of why he missed it, and the result is a change in his assessment procedures, or the mid-cycle inspection, or that is a kind of an ad hoc thing that you go through when the two don't agree?

MR. SULLIVAN: Right. I mean, one way to put it is that we don't typically review operational assessments. That's not something that we do in detail, particularly in headquarters.

But if there is a missed performance criterion, we would at least review elements of the operational assessment, and maybe not take it under formal review, but in the sense that we would want to approve it.

But we would probably ask that it be submitted, and we would ask the licensees to give us briefings on what their understanding is of why they missed it, and what their corrective actions are.

DR. BONACA: It seems to me that if you really miss it -- I mean, what you are trying to do in this performance is to predict if you really meet in fact this criterion leakage, and accident leakage, and so on and so forth, all through the period of operation that they are allowed to go before inspection.

And if your predictive models are incorrect, then you are violating this criterion by definition, simply because they have no basis and no foundation.

So there has to be some -- and you are right. The real problem or has to be a fundamental element of performance, I think.

MR. RILEY: This is Jim Riley again of NEI. Let me see if I can explain how the whole process fits together. There is really three assessments associated with the steam generator inspection.

The first is called the degradation assessment, and that is done prior to the inspection. And the utility takes a look at what has transpired in their steam generator to this point, and evaluates what kinds of degradation they have going on, and where it is going on, and they plan their inspection.

They figure what they are going to see, and they plan what probes they are going to use, and what places in the steam generator they are going to look, et cetera.

And that's all based on previous history and anticipated degradation. They then do their condition monitoring, which is the actual inspection of the steam generator. They look at what they actually have in place.

If they find in their condition monitoring that things are going on that they did not predict in their degradation assessment, they revisit the degradation assessment during the inspection to see does this affect my inspection plans, and do I need to look in new places, and do I need to use different kinds of probes, and what do I need to do to account for this.

When they finish their condition monitoring, the last thing they do is an operational assessment, and that is a prediction forward. If they look at what they have got, and what growth they experience, and they predict as Ted indicated how far can I operate and still be able to ensure that I will meet my performance criteria when I next shut down and inspect.

And that process repeats itself the next time they shut down and do a degradation assessment. So there is a feedback mechanism that makes sure that they are accounting for what they are seeing with respect to what they are predicting, and influencing their inspection program accordingly.

MR. SULLIVAN: Okay. I am going to kind of shift focus in a sense for the rest of the presentation and start to try to give you some insights into what is currently going on with NEI 97-06 and some of the problems that we have been encountering.

At the time that we made the transition from the generic letter and fully understood where we were going with respect to setting up a regulatory framework that was based on an industry initiative, it had not been our intent to review and endorse the subtier guidelines that I put up a couple of view graphs ago, the detailed subtier guidelines.

Based on the guidelines that were available at that time, we expected significant enhancements to industry efforts to ensure tube integrity under this program.

The staff's expectation was that the

guidelines would be sufficiently well developed to lead to improved tube integrity performance under the new framework, bearing in mind that we didn't have all the guidelines. They had not all been issued at that time.

And we had expected, and continue to expect, that the guidelines will evolve over time in response to technology changes, lessons learned from operating experience, and results from various studies.

The staff developed a couple of concerns more recently though, and in just this past year, and I will try to lay out without getting into too much gory detail how they came about.

The first one is related to an action plan item having to do with conducting a steam generator workshop, which we did in February of this year. And in that workshop some of the industry representatives discussed draft revisions to the EPRI steam generator examination guidelines, Rev. 6 basically, to permit inspection intervals for steam generators with improved materials, which we didn't have an issue with in particular.

But we noticed that at least that draft has since been revised substantially, but the draft had inspection intervals that would go significantly beyond Rev. 5, as well as what is in the tech specs.

And bear in mind if this has not been clear that the approach under the new frame work would be to lift the maximum intervals between inspections that is in the tech specs, and rely on the performance based strategy instead.

In one scenario, as I have on that second bullet, it would have permitted inspection intervals ranging to 22 full power months. I am not trying to put that there as characterizing the proposals. I want to put out kind of one of the extremes that was in that proposal, at least that we considered an extreme.

We also began to have concerns about condition monitoring being implemented, and these grew out of questions that we were asking licensees in our outage phone calls about their bases for performing in-situ testing of tubes.

We had some concerns that at least in our view that in-situ testing wasn't being performed as routinely or under situations that we think they should have been performed, at least in some cases.

And I am not saying that they weren't being performed. Lot of utilities did institute tests last outage, but there were some plants that generated some concern in our minds who weren't performing any.

These concerns basically could be characterized as concerns whether or not the tube integrity performance criteria would continue to be met, and whether conditions not meeting the performance criteria would be detected.

DR. SHACK: What control do you have when they do a tube test that they pick the worst tube? I mean, I can always pass it by picking the right tube to test.

MR. SULLIVAN: Right. Well, if the key work is control, we don't have any. But we have I think some influence. Usually when it is evident -- well, first of all, we only pick the licensees for phone calls that we think have the most degradation, or that we are particularly curious about.

For example, we are going to have a phone call with Turkey Point-3 this season. They have got improved materials, but they have been operating for quite a long time.

We go over the results, and licensees generally characterize their worst tubes, and that gives us a sense for whether we agree or want to discuss further the in-situ testing that they are going to do.

They also frequently provide us with lists of any current measurements, bearing in mind that there is uncertainty, but they give us those measurements in tables that they are using themselves, and they tell us which tubes they are going to test.

We have had occasion, and one that comes clearly to mind --

DR. SHACK: But you see that list before they do the tests?

MR. SULLIVAN: Yes, generally before. Does that answer your question or should I elaborate?

DR. SHACK: That answers my question.

MR. SULLIVAN: We have had some influence in the past. And in the case of ANO-2, for example, in the '98 or '99 time frame, there were four tubes that we questioned why they weren't going to test.

They indicated that they thought they were unbrellaed by previous tests. We had given the uncertainties and we didn't agree with that. They subsequently ended up testing all four tubes, and discovered that one of them was at least questionable, or inclusive, regarding whether or not they could conclude that they had satisfied the performance criteria.

Okay. What I wanted to say that is that out of the latter concerns having to do with the in-situ tube testing, we took on kind of an initiative if you will to spend more time studying those portions of the EPRI guidelines dealing with condition monitoring, and generated a number of concerns.

Those concerns are developed in a letter that we sent to NEI. They knew that it was coming. We had had some discussions with them, and it is dated August 2nd.

My understanding is that you were provided with that many sometime last week. I'm sorry that we didn't get that to you sooner. The issues relate to industry practice that exist under the current regulatory framework.

But these are not brand new issues. They are concerns that we have recently generated in our own minds. But they are existing -- they would exist under the new framework, assuming that we were to go forward with the new framework, which is our intent.

These are not issues that we think we can settle in a real court time frame, and that's why I am talking about it in this kind of context. We don't think that the existence of these issues, particularly given the remarks that Emmit just last made, would reduce assurance of tube integrity or increase risk under a new framework, assuming that the inspection intervals don't increase relative to the current requirements.

And I am going to get into that in a little bit, as that is not quite as hard and fast as that may make it sound. In kind of a parallel fashion, at least in terms of the bottom line of this view graph, we have reviewed most of the industry responses to issues identified for the industry in the NRC IP-2 lessons learned study.

I am sure that you have glanced at that at least and noticed that there were quite a number of issues in there for industry, as well as for the NRC staff.

And likewise for the review that we have done, we included some write-ups on those industry sponsors in that same letter that I just mentioned of August 2nd.

These issues primarily relate to EPRI guidelines and some of the issues overlap what I have been discussing in terms of condition monitoring and inspection intervals. But some of them go beyond that.

A number of those issues still remain

unresolved, including the issues that extend beyond condition monitoring and inspection intervals. But likewise, those issues exist under the current framework and will likely continue to exist under a new framework.

And we don't think that the existence of those issues reduce assurance of tube integrity or increase risk under a new framework. Again, assuming inspection intervals don't increase relative to current requirements.

And again I will repeat that is pretty hard and fast, and I am going to explain that a little bit more in the last two view graphs. So, in terms of conclusions, pending resolution of these guideline issues, the staff has concluded preliminarily that it can proceed with review and approval of a generic change package provided that there are licensing restrictions on inspection intervals.

And what I mean by that is that we would have in mind that the generic change package incorporate agreements with industry on appropriate prescriptive intervals for inspections that would be tailored to the specific material in the tubing, Mill Annealed 600 thermally treated and Inconel 690 thermally treated.

And then the idea behind the words licensing restrictions would be that changes to those agreements would be likewise to performance criteria and repair methods, either generically or plant specifically, they would need to be approved by the NRC. That is the proposal that we are working on with industry right now.

DR. POWERS: I got a little confused. You said Mill Annealed, and then you said thermally treated. Did you mean just thermally treated?

MR. SULLIVAN: No, I meant three different materials. I'm sorry.

DR. POWERS: Oh, so three different things.

MR. SULLIVAN: The Mill Annealed 600, thermally treated 600, and the thermally treated 690. With this approach, we believe that the generic package -- I'm sorry. The generic change package would reduce the assurance of tube integrity only in cases where longer inspection intervals than currently permitted would be implemented without adequate justification.

That is just another way to say what I have just been saying. I think the rest of this, except for the last bullet, is kind of repeating what

I just said. I wanted to go on to a different concept to kind of tie a little bit of this together.

And to note that on the last bullet that we are working with industry to establish a protocol agreement resolving outstanding technical issues. It would formalize an approach for interactions between NRC and industry when resolving technical issues that exist and that will continue to arise.

This is not just something to settle NEI 97-06, but it would be a long term protocol. Examples of the types of issues that we currently would deal with under that protocol would be the lessons learned issues, and the condition monitoring issues that we have been talking about, the risk 2022 issues, and that sort of think, and any new issues that might come up over time.

DR. POWERS: Could I go back to the next to the last bullet.

MR. MURPHY: Yes.

DR. POWERS: And you say you were exploring alternatives with the industry, particularly for improved tube materials.

MR. SULLIVAN: I think what we mean there is that the proposal that we most recently have been discussing with industry would require that -- and correct me if I am wrong, Jim, but the Mill Annealed 600 tubing plants would basically have to inspect every refueling outage.

And longer intervals that follow a more elaborate scheme, depending in part on what the material is, and how long the plant has been operation, would have maximum intervals longer than that, up to three intervals between inspections, or three outages or three cycles of inspections.

DR. POWERS: This is what I am struggling with, is that -- well, it is very simple. People say 690 is a better material. As far as I can tell, that is what they thought about 600, too.

I mean, do we have any confidence that this material is really that much better, and that it is not going to start cracking?

MR. SULLIVAN: Well, I think that there is a lot of evidence in this country that 690, which has been in plants for close to 10 years, is performing much better than the Mill Annealed 600. But I am not sure if that is what you are driving at though.

DR. POWERS: Well, what I am going to say is that 10 years ago we probably could have said the same thing about 600. Well, maybe not. Maybe it had to be 20 years ago. But at some time we would have said that.

MR. SULLIVAN: We would have said that at the outset, but the Mill Annealed 600 tubing started performing badly from the very outset. I mean, plants were in their first inspection and performing their inspections after the first -- maybe you can elaborate on this more, Emmit. You were there at the time.

MR. MURPHY: Well, in fact -- this is Emmit Murphy again. In fact, plants developed leaks during the first operating cycle of operation just as an illustration of how quickly the problems developed.

DR. BONACA: Well, that was much to do with chemistry.

MR. MURPHY: Well, I can think of one case where the crack involved was primary water cracking that occurred in the first operating cycle.

DR. POWERS: I guess what I am driving at is how does one go about arguing that 690 allows you to go three operating cycles between inspections? Now, it seems to me that if you can say, well, it has operated for 10 years, and no problems. That's a pretty good argument for longer cycles.

I mean, if it is that empirically based, then it is pretty inarguable. The trouble that I see is the potential for it just suddenly starts leaking because of this long induction period it takes for cracks to suddenly show up on the detection device.

MR. MURPHY: This Emmit Murphy again, and I think we shared that concern, and I think that some of the operations that we are exploring with the industry here that would provide opportunities for materials, for plants with the newer tubing material to implement longer inspection intervals.

And that these prescriptive limits on cycle length would give us the level of assurance maintaining the tube integrity margins set that we have historically enjoyed, and certainly can do better than that hopefully by virtue of the expected and improved performance of these new materials.

MR. SULLIVAN: Another thing that I might add is that the plants -- you know, this is a little bit of an elaborate strategy, and we have not tried to get into particulars here.

But I think if you take some of the plants with Inconel 690 that have been operating the longest, the current proposal wouldn't allow them to go three cycles. The current proposal would allow them to go two cycles, which is basically what the current text specs already allows.

So it would only be -- I mean, the basic idea is that the licensees do a pre-service inspection at the first refueling outage, and they would have to do another inspection to monitor for things that -- you know, like wear.

That in loose parts, you can't just say, well, that is not going to happen. And then they would move on to a strategy of thee cycles. I think that it factors that in, as well as being based on some of the empirical observations that we have had.

MR. RILEY: If I could say something again. This is Jim Riley again from NEI. Another consideration that we have put into our guidelines again is this degradation assessment that I mentioned the last time.

The plants, even though they wouldn't have to inspect every outage under our scheme, would be required to do a degradation assessment every outage, and that degradation assessment needs to take a look at what has been happening at their plant, as well as what has been happening in other plants around the industry and around the world.

And if there are things going on in these other plants with Inconel 690 that wasn't anticipated, that has to be taken into account and it has to be taken into account from the perspective of how well it pertains to their design steam generators, their materials, their chemistry, et cetera.

But if they feel that this is challenging what otherwise would have been their inspection interval, they need to be reacting accordingly.

DR. POWERS: It is an encouraging thought, but what is discouraging is when I look at the assessments under the maintenance rule, one of the areas that the licensees found most challenging was the ability to take into account experience within the industry, and not at their own facility.

So, pardon me, but I would be just a little skeptical that they will -- that in the assessment that they won't be looking for ways to argue what is going on some place else just doesn't relate to my plant.

MR. RILEY: That's difficult to argue. I mean, obviously it depends on an individual plant, but I will say this. That there are plenty of information available to the licensees, in terms of what is going on elsewhere.

We have an industry organization that meets three times a year and shares operating experience. We have a steam generator degradation and steam generator database that EPRI maintains that keeps track of what is going on at different places, in terms of tube degradation, and tube pulls, and tube information, et cetera.

We have organizations within the industry that do reviews of steam generator programs at various -- well, they rotate through all the plants, and do an evaluation of how well they are conducting their program with respect to what the requirements are in NEI 97-06 and other places.

And we have internal peer reviews that are done between organizations, and all these things are intending to look at how a particular utility is conducting its steam generator program with respect to the norm and the expectations.

And sharing with plant management cases where they feel that they are not meeting the industry standards on these issues.

MR. SULLIVAN: One thing that I might add for what it is worth is that over the years when a new degradation mechanism is identified, or not necessarily a mechanism, but a new location, and we learned about it in a phone call.

And we might be on the phone call at the same time, or the next day, or whatever, with a similar plant, and we would bring it up in the phone call, and I can't remember a single time that the licensees weren't already aware of it.

And I think as Jim indicated, the networking is pretty strong, and had modified their inspection plans to look for it if it was applicable, just in the "for what's it is worth department."

CHAIRMAN FORD: Can I just ask a question, more on a technical management aspect? Do I understand that right this instant, in terms of monitoring the performance of the steam generator tubing, that we are essentially using NEI 97-06 procedures, regardless of how they stand within the regulatory framework right now?

And that in very short order that you are going with this generic change package, which is based on NEI 97-06, but with modifications associated with its memo that you sent out on the 2nd of August?

And that would give some regulatory aspect to approval if you like. It may not have gone through all the sign-offs, et cetera, et cetera, that you may have to do. But essentially you have got regulatory approval for the NEI 97-06 procedures, et cetera, and that is in the short term.

MR. SULLIVAN: Yes.

CHAIRMAN FORD: And for the longer term,

as we go through the question of brisk assessment of the delta-LOCA and the delta-LERFs, and modifications to your current understanding of those parameters, and that will come out in later years as a result of this joint NRR research program. How I got the sequence of events right?

MR. SULLIVAN: I think that's correct, and then depending on what comes out of that, we may have to factor it back into our understanding, and/or our regulation of the steam generator programs.

CHAIRMAN FORD: Now, is it appropriate therefore in the short term, if you are going to have this model one of this generic change package in place, is it appropriate to have a presentation to this subcommittee -- and let's say in December -- so that we understand at least the technical pros and cons of this process?

MR. SULLIVAN: I think it is a good idea.

CHAIRMAN FORD: And I stress the technical aspects. For instance, what the pre-inspection assessment methodology is, and what is the uncertainties in it, et cetera, so that we understand the impacts on safety.

MR. SULLIVAN: I think coming back for another presentation is a good idea. The only thing that comes to mind is that we are also making a presentation to the Commission on December 4th. So we want to make sure that we don't have a conflict there.

CHAIRMAN FORD: I have no idea what the constraints of this particular aspect is --

MR. SULLIVAN: As a concept, I think it is a good idea, and we did anticipate that you want more technical details than what we are talking about today.

CHAIRMAN FORD: Okay.

MR. SULLIVAN: This is just kind of an introduction.

DR. DUDLEY: Just thoughts. Would it be more appropriate for an ACRS presentation before or after the presentation made to the Commission?

MR. SULLIVAN: Can I get back to you on that later? I would like to talk to my colleagues.

DR. DUDLEY: Yes, that is something that you need to work out.

CHAIRMAN FORD: But this is a joint NEI/NRR?

MR. SULLIVAN: Yes. Sure. We will have to coordinate with Jim, of course. I can't speak for them.

CHAIRMAN FORD: Excellent.

MR. SULLIVAN: But they have been willing in the past to come and make presentations like this.

MR. RILEY: Jim Riley again. We would be happy to join your presentation on the technical aspects of the program.

MR. SULLIVAN: Okay. I just have a couple of comments. I have kind of covered this, but I just wanted to make sure that it is clear that we do plan to develop a safety evaluation on this whole generic change package.

The vehicle for issuing it would be a regulatory issue summary, and the proposal would be to put it out for public comment before we finalize it. There are some specific reasons that we want to do that that we can get into now or in the next presentation.

Our target date had been the end of next month, and we clearly see that we are not going to make that. We are hoping that we can get this done in April of 2000, although I have to admit that was kind of an arbitrary projection that we could get it done within about six months.

We are still working with NEI on technical issues, as well as the regulatory issue having to do with regulatory controls. And so I am not sure just how optimistic or achievable the April date is.

And as I mentioned before, this same sort of data is contingent on coming to terms with this in the pretty near term, because there are a lot of steps that we need to go through, in terms of things like issuing a risk for public comment, and finishing the safety evaluation, and so forth. So that concludes my presentation.

CHAIRMAN FORD: Thank you very much. I would like to put this on hold for 15 minutes, and I'm sure that on hold isn't the right word, but we will take a tea break.

(Whereupon, the meeting was recessed at 10:08 p.m. and resumed at 10:25 p.m.)

CHAIRMAN FORD: Okay. We are back in session, and we are reversing the order. Ken is going first, and Joe is coming second. So, Ken will be talking about the South Texas project.

MR. KARWOSKI: I am going to stand during this, just because I need to point to some of the stuff on the view graph. My name is Ken Karwoski, and I am with the Materials and Chemical Engineering Branch in NRR.

My presentation is broken into two parts. The first part will be the overview of the South Texas steam generator operating experience, and the second part will get into the last part of the presentation, which is some of the issues on the -- with respect to the differing professional opinion.

So the slides are in the opposite order that I had anticipated. So we will skip the first two slides, and I will come back to those at the end of the presentation, and I will start with South Texas.

South Texas is a four loop pressurized water reactor. It has a model E-2 steam generators and there is about 4,900 tubes in each of those steam generators. They have Alloy 600 mill annealed tubing, with the exception that there is 15 tubes in one of the steam generators that is made of Alloy 600 thermally treated.

They did that, I believe, to test for whether or not this material would be any better. They have three-quarter inch diameter tubes, which is important for generic letter 95-05. The tubes are supported at various elevation by drilled holes stainless steel tube support plates.

That is a little different than most of the mill annealed plants. Actually, it is the only plant in the country that has drilled hole stainless steel tube support plates.

The bulk of the plants that use generic letter 95-05 have carbon steel drill holes tube support plates, and I will talk a little bit about that later on.

DR. POWERS: What is the potential difference between the stainless steel and the Alloy 600, the electrical-chemical potential differences?

DR. SHACK: There's not much.

DR. POWERS: But just about everything is though.

DR. SHACK: Well, it is certain less than carbon steel.

MR. KARWOSKI: But the key with the stainless steel, which I will get into, is that it is less corrosion resistant in a steam generator environment. So what you have with the carbon steel tube support plates is those tend to corrode and tend to fill the crevice with magnetite, which tends to impact the tubes, and actually cause corrosion-induced bending.

The stainless steels are less susceptible to corrosion in the steam generator environment, and you don't get that type of corrosion product build up in the crevice which could restrict leakage and can bend the tubes.

There have been other plants in the nuclear industry, particularly Doel 4 and Tihange 3, which ave these types of tube support plates. The steam generators at those plants have been replaced.

At South Texas the tubes have been hydraulically expanded into the tube sheet, and the expansion transitions were shortened to reduce susceptibility of corrosion.

R-1 and 2 of the steam generators went through a U-bent heat treatment to also reduce the suspectibility of corrosion of the R-1 and 2 U-bends. South Texas, coming on line later, implemented several enhancements to their steam generators in order to reduce the susceptibility of the tubes to --

DR. SHACK: Well, it is awful late for a Mill Annealed plant though?

MR. KARWOSKI: I think they started commercial operation in like '89, but when they ordered their steam generators and when they planned that, I don't have that information.

But, yes, in the overall sequence of events, if you look at some of the earlier replacements, they were thermally treated in the early '80s. And so I am speculating that they must have ordered them.

DR. SHACK: They must have decided that they didn't need to do that.

MR. KARWOSKI: Yes. Of particular interest here is that in their pre-heater area, they expanded several tubes as a result of a concern of tube wear that had been observed in Westinghouse Model D steam generators, and I would just point this out there because they have observed some corrosion there or some damage at that location.

And that is because of the cross-flow of velocity of the feed water entering the steam generator. South Texas has a T-hot of approximately 625 degrees fahrenheit, and that is one of the higher ones in the country, which just exacerbates some of the corrosion problems that they may be observing.

At the end of Cycle 8, which was in March of 2001, they had approximately nine effective full power years on their steam generators, which is not a lot of time.

The primary degradation mechanism is actually oriented outside diameter stress corrosion cracking at the tube support plates, the focus of Generic Letter 95-05.

I just briefly want to discuss some of the other degradation mechanisms that they have been observing. They have detected some free span outside diameter stress corrosion cracking, primarily associated with dings.

I use the term "dings" because instead of corrosion-induced denting, it is more damage as a result of fabrication.

DR. POWERS: What is the gap width for this drill hole plate in the tube wall roughly?

MR. KARWOSKI: I think the exact value is proprietary, but it is on the order of less than a tenth of an inch for the normal support plates. They have a flow distribution baffle, which I think is on the order of a tenth of an inch, which has an enlarged tube hole opening.

And that is the first support plate elevation, and in general they have not observed as much degradation at that location than they have at the higher locations, where the diametrical clearance is less.

DR. POWERS: What I am trying to understand is that because we don't have this included hole in the plate are we getting what would be crevice type chemistry changes in there, in that hole region?

MR. KARWOSKI: Can I answer that a little later on?

DR. POWERS: Sure.

MR. KARWOSKI: But that is one of the theories that might be happening with respect to the operational leakage. But I will touch upon that later on.

So they have had free spanaxial outside diameter stress corrosion cracking, and they have also detected some free span volumetric indications, and they have detected some of these over the course of the last cycle or the cycles prior to that.

CHAIRMAN FORD: I wonder if you could just mention -- and maybe you will mention it later on, but the question of the difference between the stainless steel and the carbon steel floor plates, the fact that there is generally less corrosion product, and therefore that would have an impact on leak rates.

MR. KARWOSKI: I will get to that in probably 3 or 4 more slides.

CHAIRMAN FORD: Okay. Good.

MR. KARWOSKI: New mechanisms that they observed during the March 2001 outage, they detected some indications that the hot leg expansion transition, that's not unusual for a plant with Alloy 600 Mill Annealed.

The indications were primarily OD. They

did find some ID indications of one ID indication. The licensee speculates that the shop cleaning may have been effective in reducing some of the ID cracking.

Some of the dings in their steam generator are basically separated by about three-quarters of an inch, which is the thickness of the tube support plate.

They believe that as they inserted the tubes into the steam generator that there was some bending moment that caused what they called paired dings. At one of those paired dings, they observed circumvential cracking at one location and axial cracking at the other.

They found a Row-1 new bend indication, which was outside diameter stress corrosion cracking. They also found cracking at the U-Bend transition, and they found a volumetric indication at the expansion transition of one of those tubes expanded in the pre-heater.

Most of these degradation mechanisms are common among plants with 600 Mill Annealed tubing. The licensee has currently plugged about 9 percent of the tubes. Their licensing basis limit, I believe, is 10 percent. The are scheduled to replace in December of 2002 at the end of the present cycle.

DR. SHACK: Do they sleeve or do they just plug every one?

MR. KARWOSKI: I think they just plug.

DR. SHACK: With respect to the voltage based repair criteria, I did mention that that is their primary degradation mechanism, and they first implemented Generic Letter 95-05 during Cycle 7, which was in the '98-'99 time frame.

They were approved for a one-volt repair criteria at that time. As a result of that amendment, they analyzed for 15.4 gallons per minute primary to secondary leakage during a steam line break to demonstrate that the off-site builds consequences where acceptable.

And during this review that the staff approved that limit. Cycle 8, the licensee also implemented the one volt repair criteria, and in Cycle 9, which is the cycle that they are presently operating in, they recommended a 3 volt repair criteria.

That repair criteria had been used at Braidwood and Bryon, and evasively what it involves is demonstrating that the motion for the tube support plants is limited such that the degradation at the support plate will not be exposed during a steam line break.

And which allows them to go to a larger voltage limit because the probability of burst will be less.

DR. SHACK: Now, I noticed that South Texas gets the benefit from IRB technology, as well as the three volt limit. Did Braidwood and Bryon get the IRB technology, or did they just live with 00 votes.

MR. KARWOSKI: By the IRB, the indications are that that methodology, although the value of what we assigned to those --

DR. SHACK: The probabilities, the 10 to the minus 5?

MR. KARWOSKI: Right. Both South Texas and Braidwood, and Bryon had to model URDs in their methodology to account for the potential that a tube attempts to burst, but can't because of the presence of the plate, and therefore the leakage could be higher. Braidwood and Bryon had to model that and South Texas also.

DR. SHACK: They got to use 10 to the minus 5th, first, and then two, as well as the three volts? When we say the three vote criterion, I never realized that you got a double-benefit.

MR. KARWOSKI: Okay. Let me take a step back. When you implement this methodology, essentially by locking the support plate in place, you have essentially -- for an axial crack, you basically prevented it from fully opening or fully achieving burst because of the diametrical clearances.

Because of that the probability of an axial rupture, that could be on the order of 10 to the minus 5th. I don't recall what the actual number is, but they basically modeled what the probability is for a burst given the amount of displacement of the plate.

In addition, they have a correlation which they say, okay, now that I can potentially go to higher limits, what is the probability that I tear this tube and get a circumvential break?

And that's how they would -- they would generate a limit for that. The industry would claim that that limit, that you could tolerate 10 volt indications, and the staff said 3 volts based on that correlation.

And so they also modeled the probability that you would get a circumvential failure of the tube at the location. So there is two parts of that methodology.

Now, the URDs, that is basically a leakage model aspect, and basically in the leaking correlation, basically they don't have indications which try to burst and actually leak excessively.

So as part of the three volt amendment, Braidwood and Bryon embarked on a testing program to figure out, okay, how that I have got these higher voltage limits, if this tube starts to open up how much will it leak given that the plate is there.

And that is what the URDs do, is that it is another leakage correlation that is tacked on above the normal free span leak rate correlation. So in Cycle 9, basically in February or March of this year, we approved this 3 volt criteria, and the licensee expanded tubes at tube support plates 2, 3, and 4 in order to limit the motion.

They only chose these lowe support plates because that is where most of the degradation is occurring. And I will talk a little bit more of how they actually implemented that repair criteria during this last outage.

During their past cycle, Cycle 8, prior to implementing this 3 volt repair criteria, the licensee was observing primary to secondary leakage in all four steam generators, for a total of about --

DR. SHACK: Excuse me, but can I just --

this IRB is confusing me again, because as I read this thing, when they do what I thought was a 95-05 methodology, which ignores the restricting from bursting, they exceed the 10 to the minus 2 probability of failure.

Then they have to go to the IRB thing, and that gets them down to 1 times 10 to the minus 3. So it is not an additive thing. They don't use the 3 volt criteria for the plates that are locked; is that the way that I am interpreting this?

MR. KARWOSKI: For the plates that are locked, basically they say how far will the plates move, or could they potentially move, and if I were to expose a crack of that length throughout that plate, and for all the plates in the steam generator which have applied that criteria, what is the probability of burst of that axial crack.

DR. SHACK: Okay. So that is saying that we understand the movement of this plate well enough that 10 to the minus 5th is the product of the probability that the tube will burst without the plate times the probability that it will be uncovered, right?

MR. KARWOSKI: It is more of just the materials issue. It is just that you have to understand how much the plate is going to move. So that aspect is in there.

You have to know how much of the crack will be exposed or could potentially be exposed, because we are postulating that the crack is at the tip of the support plate, and as the support plate moves it exposes the entire flaw over that length.

DR. SHACK: But they had to calculate that probability somehow from their fluid mechanics calculation.

DR. KRESS: They just assumed it happened.

MR. KARWOSKI: But they assume all -- they calculate the maximum displacement of the plates.

DR. KRESS: And then they assume it occurs.

MR. KARWOSKI: And then they assume it occurs over the entire plate, and so basically they are saying, okay, I have exposed -- I think in their case they postulated that -- or they determined that it would meet something on the order of .15 inches.

And so they said .15 inches for every tube at that plate. They didn't say that the plate is going to move .15 inches here, and .12 inches here, and .02 inches here. They just assumed that the maximum displacement for every intersection.

DR. KRESS: How did they make that determination? Do you know?

MR. KARWOSKI: The determination of how much it would move?

DR. KRESS: Yes.

MR. KARWOSKI: That is by thermal hydraulic modeling.

DR. KRESS: So you don't have a probability associated with that then?

MR. KARWOSKI: There is no probability associated with that.

DR. KRESS: So the probability of the materials isn't --

MR. KARWOSKI: Right.

DR. SHACK: So what you are saying then is that if I uncover a tenth of an inch, say, I can somehow calculate then the probability that he burst will be 10 to the minus 5?

MR. KARWOSKI: Yes. I think in general they say less than 10 to the minus 5.

DR. SHACK: And how do I do that?

MR. KARWOSKI: Well, basically you have a crack that extends outside the plate, and so the plate is constraining the crack, the bolt of the crack. Let's assume it is a three-quarter inch long crack for simplicity.

And I move the plate .15 inches, and so I have got 6/10ths of an inch crack within the plate, and .15 inches outside.

DR. SHACK: Do I do this on a mechanistic fracture mechanics basis rather than on a voltage basis?

MR. KARWOSKI: Yes. Yes. Basically, how much support does the plate give, and what the vendor would argue is that the plate basically -- that the length of the exposed crack is what is dominating the probability of burst.

So basically you can say, well, what is the probability of a .15 inch long flaw bursting. It is based on mechanistic and it is not voltage. It is not voltage.

CHAIRMAN FORD: So can I have just a time sanity check here? We are required to have a letter on the DPU issue at the next ACRS meeting. How long do you think at this current rate of progress do you think it will take? Can you be finished by 11 o'clock?

MR. KARWOSKI: Yes.

CHAIRMAN FORD: Provided that we don't ask too many more questions.

MR. KARWOSKI: Right.

CHAIRMAN FORD: Okay.

MR. KARWOSKI: Okay. So they were observing leakage in all four steam generators, and when they came into the outage, they did a secondary side pressure test, where they filled the secondary side up with water, and pressurized it to something on the order of 600 pounds.

And then they monitored for leakage on the primary side of the tubes, and looked for drippage from the tubes. What they found was that none of them were leaking excessively, but there were some tubes approximately that were damp.

The leakage was attributed to outside diameter stress, corrosion, cracking, at the support plates, and that is important because no other domestic plant has ever observed operating leakage as a result of cracking at the tube support plate locations.

And that gets back to various theories of why we haven't observed leakage, and one of the theories is that as the carbon steel support plates corrode, they form magnetite, and the magnetite gets into the crevices and impinges -- well, impinges isn't the word.

But it forms magnetite and the magnetite fills the crevice, and it will start denting the tube and basically or essentially would seal the crack. That is one theory.

So that the crack tries to leak, and it is not very porous, and it doesn't get out. That is one of the theories that has happened. And the stainless steel tube support plates situation in South Texas, you don't have that magnetite filling the crevice, and you have might scale on the outside of the tube, and still have a crevice.

And so you are still observing the corrosion, but in this case it is not impeding the flow of the crack. That is a theory. As I mentioned before, South Texas, too, is the only domestic plant with stainless steel tube support plates, drilled hole stainless steel support plates.

And Doel-4 and Tihange-3 had that. Doel-4 had exhibited leakage coming from the support plates during a similar secondary side pressure test in the early '90s.

Because of the concerns on operational leakage, although the licensee was authorized to implement a three vote repair criteria, they preventively plugged down to approximately 1-1/2 volts because of those concerns.

They did some depth-sizing of some of these flaws to determine which ones that they thought may have been most likely to leak, and they prevently plugged those.

After the outage and these results became available, the license submitted their 90 day report. It is basically a summary of inspection activities primarily related to Generic Letter 95-05.

The staff reviewed that report and we identified several issues that we asked the licensee to address. And the issues are on this view graph, and I would just like to illustrate them.

One of them is the ability to predict end of cycle conditions, which I believe was one of the concerns raised earlier this morning. There are two things that we look for during these reviews, and that is the number of indications predicted, reasonable, and is the severity, and in this case is the voltage of the indications reasonable.

What this table shows is that it shows the four steam generators and also the total, and it shows the three cycles where they implemented the voltage-based repair criteria.

For each one of these cycles, they show

the projected number of indications that they determined, and then the actual. In this first cycle, you will notice that they under-predicted the actual in one of the four steam generators, but in general they were conservative, with the exception of Steam Generator C.

DR. POWERS: And before I leap to that conclusion, I guess I would ask you how many indications were in these steam generators that they failed to detect?

MR. KARWOSKI: This actual number does not include any account for the probability of detection. So this number here and the assessments that they do is basically assuming that you are finding the more severe flaws.

And that the flaws that you are not detecting are not of structural leakage significance even now, and that they would not be of structural leakage significance at this point. This number does not account for that.

DR. POWERS: Okay. But if I take my probability of detection at .6, and they then do it for everything?

MR. KARWOSKI: Right. But this is more of a condition monitoring assessment. This number here would be -- would include the .6 from the prior cycle, but yes, you are right. The value of .6, remember, is to account for two things.

It is not only to account for indications which we missed during the inspection, but also for new indications which may develop or initiate over that cycle. So to adjust these by .6 in a condition monitoring system --

DR. POWERS: It is not quite fair, but to adjust it by some number is fair.

MR. KARWOSKI: Yes, but what we would argue is that what they missed is probably not --

DR. POWERS: I don't think you can do that. I mean, I think you have a database that says there are flaws of substantial size --

MR. KARWOSKI: That's true.

DR. POWERS: And you have a plant up in New York where that is definitely true.

MR. KARWOSKI: That is true. That is true. So this number does not include any -- it is basically what they found in the steam generator during that inspection, and it does not account for any improbability of detection.

CHAIRMAN FORD: All those numbers, the right or actual numbers, should be multiplied by 1.4

or whatever the number is?

DR. POWERS: I don't think it is quite fair to do it that way.

MR. KARWOSKI: No, no.

DR. POWERS: As he pointed out the .6 counts for other things. But there is some number that they should be multiplied by.

CHAIRMAN FORD: Correct.

MR. SULLIVAN: And that multiplication factor is used in the projections forward.

MR. KARWOSKI: Right. So to arrive at these projected numbers, what they did is they took the actual, and divided by .6, and subtracted off the number that they repaired, and that's how many they got.

The purpose of this is just to show the number of indications and the probability of detection, and you need both the numbers and the severity of the degradation.

DR. SHACK: So when we see these cases where the actuals exceeded the projected that is extremely distressing

MR. KARWOSKI: Let me phrase it this way. In general, for Generic Letter 95-05, one of the criticisms that the industry has always said is the

POD of .6 is excessively conservative, excessively conservative.

So when you typically look at these 90 day reports, you typically see numbers like that. In the case of South Texas --

DR. POWERS: You see numbers like C.

MR. KARWOSKI: Right. And if you just look at the total numbers, you start saying that things are getting pretty close, and if you look at the last cycle, they under-predicted the number of indications in two of the four steam generators.

Now, that may not be bad in and of itself, because if I am just finding a bunch of low voltage or indications which have no structural or leakage significance, that may not be a problem.

But this is just one piece of the puzzle. Next, the next graph addresses the severity of the indications, and basically it is a similar table to the previous one.

It shows the steam generators, and as voltage goes up the severity of the indication increases and we compare it projected to actual. And in general if you just look at the totals, in this case they under-predicted the number of larger voltage indications in the first cycle, but the number was minimal.

The second time they also under-predicted and the same thing for this third cycle. As a result of this, we are pursuing discussions with the licensee to ask them to address it.

And in the interest of time, this last view graph just shows that the average growth rate, that if you look at Cycles 6, 7 and 8, the growth rate has been increasing the average growth rate, and that pretty much is supported by the previous table.

There are some other issues that we have asked the licensee to address regarding leakage observations. During the inspections, they had done some in-situ pressure testing, where they insert a device inside the tube, and pressurize it to determine whether or not it is going to leak and/or burst.

And they observed some leakage during those tests, and given that the in-situ tests are typically done on the worst tubes, from the information that we were provided, it doesn't seem like those results indicate or could account for all the operational leakage that they observed.

And so we have asked them to take a look at that. So basically the last view graph, here the next step is that we post these issues to the licensees, and they are monitoring for operational leakage.

And there has not been any observed presently and the licensee plans to replace their steam generators at the end of the current cycle.

DR. BONACA: Well, you started to say something about after you looked at the severity of indication, because of this, we asked the licensee -- and then you didn't complete the phrase.

MR. KARWOSKI: We have asked the licensee that in light of these results, basically tell us why the methodology is working for your plant. What confidence do you have that we will be able to actually project what is going to be on this steam generator at the end of the next cycle.

DR. BONACA: Well, it seems to me that they are under-predicting both, in terms of severity.

MR. KARWOSKI: That's true, and in some cases that may not be a concern. If I am calculating leakage of a 10th of a gallon per minute during accident conditions, and I have under-predicted the number of severity, that may not be a problem in and of itself.

But in this case, they are, and in one of their generators they are projecting leakage which is approaching that 15.4 gallon per minute.

DR. BONACA: Plus, there are a number of indications that are going so fast and that is really what we are transmitting. And at that point you begin to wonder about when do you get to that point where you have a critical change in the leakage, for example.

MR. KARWOSKI: Right.

DR. SHACK: Now, when they do the operational assessment what will they use for the average growth rate? Will they project that increasing curve, or will they use the observed --

MR. KARWOSKI: They will use the methodology that is called for them to use, and the most conservative over the last two cycles, which I am assuming was the last cycles, and so they will use the observed.

And the reason for showing you the tables of the -- of what I will call the increase in growth rate is that that is certainly one of the issues that the staff would like addressed, which is, is the methodology working.

And that is basically the reason or could be a reason why they have under-predicted the severity of some of those indications. At this point, I would like to move to the second part of the presentation, which basically addresses two of the ACRS' recommendations on the differing professional opinion.

The two recommendations that I want to discuss are the seven-eighths inch diameter leak rate database, and the recommendation with respect to flaw growth.

With respect to the seven-eighth inch diameter leakage database, the ACRS indicated that the database needs to be greatly improved to be useful, and that the staff should consider requiring a near term expansion of that database.

The staff agrees that the seven-eighth inch database does not exhibit as strong a correlation as the three-quarter inch. To refresh everybody's memory the three-quarter inch database has approximately 50 pull tubes, and about half of which come from pull tubes.

The seven-eighths inch database on the other hand only has approximately 30 data points, of which only around 25 percent, or seven or eight data points are from pull tubes.

So the staff agrees that this seven-eighths database has a weaker correlation. With respect to whether or not the expansion of the database will actually improve the correlation, as part of getting ready for this presentation, I tried to do that assessment by looking that as they added data over the course of several years, and what has happened in general.

And based on a very simplistic evaluation, which I did, it looks like the correlation is staying the same, or maybe getting slightly worse. So even though they added data, it has not necessarily made the correlation better.

But the correlation in 95-05 does address how to handle it if the correlation -- you know, if there is a correlation or if there isn't any correlations.

With respect to adding more tubes, the staff recognized when they issued Generic Letter 95-05 that the limited data then -- and it is still recognized as it is now, that the results as part of the methodology that licensees committed to a tube pull program, either the one that is in the generic letter, or an industry developed the tube pull program.

And with this protocol the utilities periodically pull tubes, and the focus of those pulled tubes is for seven-eighth inch diameter tubes is the leakage database. They need more data and the industry recognizes that.

With respect to -- with the exception of this commitment, there is really no other regulatory vehicle and the methodology to require removal of additional tubes. But the staff will continue to monitor the effects of additional data as more data is added as a result of these tube pulls.

The next recommendation that I want to talk about is flaw growth. The recommendation was that the staff should establish a program to monitor the predictions of flaw growth for systematic deviations from expectations, and that the staff should develop a database on predictions, and observe voltage distributions.

As part of Generic Letter 95-05, we asked the licensees to submit the data to the NRC to permit putting together -- or to permit the staff to do these comparisons of predicted and observed voltage.

And I think that the South Texas example that I just went through is one of those cases where we do look at that when we do those reviews to determine whether or not there is something that we need to follow up on.

So we have and we will continue to review the 90 day reports with that recommendation in mind. That was the reason for requesting that information to be provided to the licensees.

We recognize that it is an empirical approach and we need to continually assess how well we are doing with respect to our predictions. The staff is formalizing the review of inspection summary reports, which the 90 day reports are a subset of, in conjunction with the steam generator action plan, Item 1.10.

And there have been instances where the predictions have been non-conservative, and South Texas is one of them.

DR. POWERS: As part of this formalization, you are going to explain how to use a probability of detection to adjust the numbers that are sent to you, right? I mean, you have got to deal with the probability of detection issue don't you?

MR. KARWOSKI: Right.

DR. POWERS: Okay. One of the ways of dealing with it is to say that I am not going to deal with it, but I think that would be fairly unsatisfactory.

MR. KARWOSKI: We can definitely look at it as -- and whether or not it gets into formal review

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UNITED STATES NUCLEAR REGULATORY COMMISSION'S
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SEPTEMBER 26, 2001

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or whether or not that is more detailed guidance --

DR. POWERS: Well, how do you handle it?

MR. KARWOSKI: Yes, we need to realize that there are some indications which you can miss.

DR. POWERS: I think Westinghouse put together a pretty nice story on what the probability of detection is for what we needed in this context, and which strictly is a probability of detection.

CHAIRMAN FORD: There is a question of probability of detection, but the efforts that you are doing in this area is combined in our own research, and is in the 3.6 of the NUREG program. That's in addition to this one isn't it?

MR. KARWOSKI: I am not -- with respect to the database, the database is basically a regulatory issue; whether or not research plans that I am doing additional testing under these model boiler or laboratory produced specimens that could supplement the database, if they develop any of that type of data, would gladly include in the correlation if it is applicable.

With respect to the flaw growth, I don't know if research is going anything on this issue. The recommendation was more looking at how the predictions, compared to what we observed in the field. And so it gets more into how well is my operational assessment performing.

CHAIRMAN FORD: I am not surprised that you are not firming up on your correlation, and just adding more uncontrolled data or bad data is not going to improve your correlation plan.

MR. KARWOSKI: Right. But that's --

CHAIRMAN FORD: You can have as many bad data points as you like, but that is not going to help you.

DR. POWERS: I think they made a case for the pulling and that it wasn't doing too much to it, and a case gets made when you say, gee, the three-quarter inch data gets pulled just the same way, and it doesn't look all that bad.

What is there so unusual about the seven-eighths, and it is kind of hard to imagine that there is something different about pulling one.

CHAIRMAN FORD: So as we go down this path, and then you realize that you are not going to improve the correlation factors, what is your fall back?

MR. KARWOSKI: I don't necessarily want to say that we won't improve the correlations, but --

CHAIRMAN FORD: I guess at this point that you had better recognize it that you probably won't. So what is your fall back?

MR. KARWOSKI: Well, if the statistical criteria are not met to demonstrate that there is a correlation, the Generic Letter 95-05 methodology says that if you can't demonstrate that, then you need to calculate your leak rates in accordance with the following procedure, which basically says that the leakage is independent of the voltage observed.

So there is a methodology that already accounts for that, because back then when we were doing the 95-05, some of these databases didn't have a correlation, and so we had to deal with that back then. So there is a fall back in the methodology.

CHAIRMAN FORD: And thank you very much indeed. At this point, is that your presentation?

MR. KARWOSKI: That's it.

CHAIRMAN FORD: Thank you very much. Mario has to leave at 11:30, and the next talk is by Joe, and who should be talking about some of the further DPO issues and the new research program. Mario, before you go, would you like to make any comments on what you have heard so far?

One of the issues that we have to address is what is the next action as far as this subcommittee is concerned, and we are going to write DPO a letter for the next ACRS meeting, and we have suggested that in the November-December time frame that we have a presentation by NEI/NRR on the 97-06.

Do you have any comments on what you have heard so far?

DR. BONACA: The only one that I mentioned before regarding performance, and the issue of prediction that has already been discussed now. That is the only point that I think we want to stress is important.

And also this consideration of what do you include in the predictions. I mean, what should you consider a multiplier to that.

CHAIRMAN FORD: Thanks so much. And you like the idea of having a meeting in the November-December time frame?

DR. BONACA: Yes. I would like to see if and when we have a new presentation that there would also be more focus on the objectives of this integrated plan.

I mean, one thing that I was left with was that I think I understood the objectives of the NEI program, and while clearly stated, for the integrated plan I heard that the objective was to integrate the activities.

And still I think it would be nice to have a statement somewhere of what is the purpose of reintegrating all these activities. We understand it generally, but often times if you state what the objectives are, then it focuses better on the plan itself.

And I would have liked to have seen that in a statement at the beginning of the presentation.

DR. KRESS: Our obligation is just to have a letter on the DOP issues?

DR. BONACA: Yes, for right now.

DR. KRESS: And some of the other things that he is talking about would be just a briefing?

CHAIRMAN FORD: A briefing to this subcommittee in November or December.

DR. BONACA: That's right. That is just a suggestion for the briefing, yes.

DR. DUDLEY: I would like to think that if we did do a review of the 97-06 letter that the committee would comment back to the staff on it in the letter in December.

DR. KRESS: Combine in the same letter as the one on the DOP issues?

CHAIRMAN FORD: We are going to do that

next week.

DR. KRESS: Oh, you are going to do that next week?

CHAIRMAN FORD: Yes, if we have enough information, and if we don't have enough information, we can't comment.

DR. KRESS: Okay.

CHAIRMAN FORD: Okay. Thanks very much.

MR. MUSCARA: Thank you, Peter. My name is Joe Muscara, and in June of this year the EDO sent a letter to the ACRS transmitting the action plan that included DPO issues.

That plan is updated monthly and is available to you. So the status is really available within that plan. So what we thought we would do for this meeting was to more or less concentrate on the near term milestones.

So we will try and cover some of the work that has completed in the past year, and address work that will be going on for about the next year. In the presentation, I will start off discussing some of the issues related to materials, engineering, and inspection.

And then Charlie Tinkler will give us an overview of the severe accidents and thermal hydraulics work; and Steve Bajorek will discuss some thermal hydraulics calculations for predicting the loads during a steam line break.

And Chris Boy will provide us some input on some CFD calculations that have been conducted recently. Under 3.1 of the action plan, the history of crack propagation in steam generator tubes under a steam line break condition, and we have planned some work in this area to essentially start in the new calendar year, 2002.

What we will be doing there initially is to obtain some loads, including cyclic loads, during the MSLB from thermal-hydraulic calculations, and this will be covered in a bit more detail later.

At the same time there has been an analysis conducted, and we have submittals in this area, and so we will also plan on reviewing those submittals, and try to obtain some of the loads form those.

We will put together what we think will be the bonding loads experienced by the tubes during the MSLB, and based on that we will calculate the crack growth, if any, for a range of crack types and sizes using the loads as determined above.

CHAIRMAN FORD: The crack growth is just

tearing, and not sub-critical crack growth?

MR. MUSCARA: That's right. We will assume that we have some existing cracks, and then we have the accident, and then we will determine whether these cracks propagate or not.

As far as the ranges of crack sizes, clearly we would like to look at initially at a crack that is stable under normal operating conditions. But it would be unstable under the steam line.

So with this largest crack, we can one that will still not propagate a leak. And then we will take that crack size and determine whether that would propagate under the steam line break conditions. But we will look at a range of crack sizes.

CHAIRMAN FORD: Will we be coming back to discuss some of the details? For instance, what -- as I understand it, calculating the delta-Ps by some of the existing hydraulic codes is not necessarily an easy thing.

MR. MUSCARA: Right.

CHAIRMAN FORD: So will we be discussing some of the technical challenges and back up if we can't meet those challenges?

MR. MUSCARA: Right. The discussion that follows will address that issue.

CHAIRMAN FORD: Okay. Good.

MR. MUSCARA: Another approach that we will take is to also estimate the loads that are required to propagate existing cracks. And based on that we can determine some margins, and what is the margin over the MSLB loads.

In fact, if we find that we have large margins, then we really don't feel that we need to refine the thermal-hydraulic calculations. If in fact the margins are not so large, then we have to refine the calculations again, and that will be discussed later.

And having conducted these analyses, and we will be using existing procedure for evaluating the burst and leakage, and mostly burst in this case, we will then conduct some tests to validate these analyses.

So then the tests will then take into account not only the pressure stress, but also the bending loads and the cyclic loads, and that work will be done at the beginning of '03.

CHAIRMAN FORD: Again, the question of the movement of the plates and things of this nature. This is again a fairly -- in calculating these loads, it is not a trivial exercise at all?

MR. MUSCARA: Right, and so again what we are doing there is we will do some of our own calculations, and the thermal-hydraulics will be described, and we will look at what the industry has provided us.

And we will come up with some upper bound estimates, and then we will use those loads to determine what happens to cracks. And if we find that we have small margins, then we will need to do additional work to refine the analysis.

And another item that is covered in the operating plan, and also of course addressed in the ACRS report was damage progression by jet impingement, and this is jet impingement both under severe accident conditions and jet impingement from a steam line break.

Last year, in October, about this time of the year, we presented some information on the jet impingement work under severe accident conditions to the ACRS, and at that time we were more or less agreed that jet impingement from severe accidents from the aerosols are not really a problem. There is very little erosion that goes on.

And the ACRS suggested that we may want to look at a somewhat longer term test. Our initial tests were 10 minutes, and we have conducted some additional tests based on the recommendation.

DR. BONACA: Let me just ask a simple question. Going to page four, you have or you mentioned that starting in 2003 that you will have a test on the tubes under pressure and axial bending. Why are you waiting so long?

I mean, wouldn't you want to have results as you do calculations, and that mostly likely, especially in doing hydraulic calculations, you raise a question insofar as the modeling, and whether or not certain effects are being properly modeled.

MR. MUSCARA: Well, the test that I am talking about is mechanical tests to validate our analysis. The analytical methods have been developed and proven over many years. So we don't believe that the validation tests are going to give us a different result.

Our main emphasis is going to be using the procedures already developed, and in most cases it will be a flow stress model for essentially the failure criterion. We will also be using some fundamental analysis on the structural side.

DR. BONACA: It is only a test, and it going to be purely --

MR. MUSCARA: It is a validation test just to confirm that the analysis was proved.

DR. BONACA: And that is dealing with tubes and some force applied to.

MR. MUSCARA: Right. The tests that we have conducted so far in the models that we have developed have been mostly pressure stress. So we want to add to those pressure stresses some of the bending loads.

And with the bending loads and axial loads one might see with the support plates moving what the tubes are doing in terms of support plates.

DR. BONACA: And you said that this analytical method or models that you are going to use already are credible for this kind of test?

MR. MUSCARA: Yes. We conducted back in the '80s 800 tests with different types and sizes of flaws to predict failure of these tubes.

DR. BONACA: And so you are talking about the analysis now, and I am talking about the analysis.

MR. MUSCARA: Yes. Well, based on those tests, we developed analytical procedures and those have been validated. And tests have been conducted in other parts of the world that confirm those methods.

DR. BONACA: And these are analyses as you mentioned are computer codes that you are going to use to perform these analyses?

MR. MUSCARA: Most of the analysis will be under stresses, and the evaluation of MSLB, which is a parameter that describes the stress on the ligament of the crack.

DR. BONACA: I guess I am asking because I am kind of surprised, and I just didn't know that you already had all this information, and models available, and they were not being used to address this issue of main steam line break.

MR. MUSCARA: Frankly, if you consider axial flaws, for example, and we think that this might propagate under steam line break conditions, I don't believe that is credible.

I mean, these tubes have got so much toughness, and it would need to have so much pull to propagate those flaws that the tube would fail as if the flaw wasn't there, and it would take a great load.

Now, the other conditions are when we would have circumvential cracks, and in those conditions it would be somewhat a little bit different. I still believe that based on the work that we have done that it is going to take a great load to open up these cracks enough to cause a major failure.

For example, we find that cracks that are 270 degrees around the tube all the way through still will not open up and give you a large leakage. So I guess that part of the reason that we haven't done these tests is because that we have felt from an engineering feeling that the steam line break loads will not propagate these kinds of cracks.

And with respect to cyclic loads, yes, we have some cyclic loads, but how long are these loads going to be on there. Again, I don't think we have enough cycles to affect the growth of existing cracks. But we will do the work and see where we are.

On the jet impingement work as I mentioned, we have work that is ongoing on both the aerosol impingement and from a steam line break. The work on the aerosols was conducted at the University of Cincinnati with Professor Tabakoff, and the jet erosion tests have been conducted at Argonne National Lab.

And I think I mentioned that the rest of the items we have conducted tests now of up to 30 minutes for the aerosols. Dr. Ford, if we are stressed for time, I could skip the view graph here.

DR. POWERS: My feeling is that you can

skip over the erosion results.

MR. MUSCARA: Well, I guess the final outcome of that is that the 30 minute test did not provide us any different data. We still have very low rates, about 2 mils per hour with just nickel, and about 5 mils per hours with nickel, plus aluminum. And these are much more severe conditions than the actual aerosols.

DR. POWERS: And I kind of assumed that was the results that you were going to get.

MR. MUSCARA: In fact, the data was really indistinguishable from the prior data. All right. And some results that we haven't shown are test results on the jet impingement and steam line break conditions.

Here essentially we have run some tests with the different sized holes, but concentrating on the 1/32nd inch hole. There is a specimen spot weld to the leaking tube, with a stand-off distance of about a quarter-of-an-inch. So the leaking tube impinges on this group.

We conducted tests as a function of temperature, and we find that the most degradation is obtained at about 280 degrees centigrade, which is about the cold leg temperature, and where you don't expect to see cracks.

And then the amount of erosion decreases as the super heat goes up, and so as the temperature goes up. So we are getting some flashing and not as much penetration.

The greatest amount of penetration we had was about 25 percent of the wall over a two hour test period. And we will move now on to some comments on the NDE. There was a comment in the ACRS report that using a constant POD may not be the best thing.

We have been doing work in this area for a number of years, and last year again I described work on a mock-up. We have now some results, and I think I will go into showing some of the results from the round-robin analysis of the mock-up.

CHAIRMAN FORD: Joe, I asked the question to Ken Karwoski about the interrelationship between the work being done by research on this item, and it being transitioned into use. Can you make a comment on that?

MR. MUSCARA: Well, let me give a little bit of background. We issued this work about 5 or 6 years ago, and at that time I was looking for a physically based model that we could use for doing the operational assessments.

The big concern was that we were using for the voltage based criterion, and it is empirically based, that there is no physical reason why it should give us good correlations.

Voltage does not relate to crack size. Therefore, it cannot relate to crack growth, and crack growth cannot relate to burst pressures. Generally as the voltage goes up, the crack size goes up, but there is a general correlation.

What is not true is that for low voltage that it is not just small cracks. We are going to have big cracks that have a low voltage. So in my mind what was needed was something that was more robust and more physically based.

So at that time we conducted an operational assessment. We needed to know the probability detection so that we can take into account the flaws that were missed during inspection, and we needed to know something about cracking issues and what happens during the cycle.

And of course we needed to know crack growth grade, and not based on voltage, but based on some physical parameters. And so at that time we set up work to learn more about these items.

And one of the key areas of work then was the probability of detection. So by the time the ACRS had their comment, we already had done a considerable amount of work trying to develop POD as a function of different parameters.

And also this data is available. It is available for us, and it is available for the industry, and it can be used as people see fit. We tried to conduct these tests in a realistic way. We are using procedures that are used in the field, and we tried to limit the entire inspection processes conducted in the field.

We have done the degradation assessment, and we have the right techniques, and qualified techniques, and qualified people doing the inspections.

We have a five-person team that has done the inspections, and so we have tried to reproduce as much as possible the process that goes on in the field. With respect to the tubes and the division itself, the same thing.

We developed a fairly comprehensive mock-up with different conditions of dents, and corrosion products, and transitions, and realistic flaws, developed in the lab with realistic flaws from the point of view of signal, and so we believe that we have a reasonable test.

And we do have now some results that may be POD to some other factors besides the --

CHAIRMAN FORD: Am I missing something? That although you have this data, it is not being used?

MR. MUSCARA: Well, this data is just evolving. In research, the main emphasis is to develop also a code that can be made available to the NRC staff so they can do their own independent operational assessments. POD is one input to this code, and precision crack code would be another code.

So that code is under development and the data is becoming available, and our first topical report will be published before the end of this year providing these results.

And of course the results have been made available, and we have reviewed the draft reports, and so we are aware of the information.

CHAIRMAN FORD: So we are ahead of the ball game here on this particular result?

MR. MUSCARA: Yes, I think so.

DR. POWERS: The ad hoc committee -- I think you have to understand that the NRR staff has a different set of problems. They need to detect and then they need to predict, and they need to predict what kinds of things show up in between the two.

What the ad hoc committee was concerned was about was using a constant POD with respect to carbon stone was that as the technology for sampling, for inspecting tubes improved, and as the technical understanding improved, you wouldn't be able to correct things, and take into account, and it is a draconian thing.

So when we moved to something that was more easily corrected, and that is all that this research is doing, and it was basically an endorsement of this research.

MR. MUSCARA: In fact, the Generic Letter 95-05 made some comments at that time, and they in fact did say that they felt that the voltage raised criterion is acceptable for now, but we should be moving towards more physically based criterion.

And the ACRS said that, and so based on that also we felt a need to develop this kind of data. The results were that the upper left figure shows the POD is a function of depth, and for flaws at the tube support plate, both for the OD and the ID.

Quickly, we noticed that the ID flaws are more easily detected if the POD is higher, and that is reasonable because we get in general larger signals from the ID than from the OD. There is not as much penetration of the ID currents.

In the next view graph we are showing a similar plot, but with respect to voltage, and we see here that the role is reversed. What I need to mention is that once the voltage gets considerably high, all the POD get to be about the same.

But for lower voltages, we are getting a better correlation with the OD flaws. At one point, for the ID flaws, we also had the dents. So many of the flaws at the support plate that were originally from the ID also had a dent.

That means that we had a signal which was not very clean. Now, because the inspector looks at the signal rise on the plane to a vertical position for calling it a crack, and because there is a dent signal, and because ID flaws only have a small range of phase angle shift, the signal does not rise very much, and can also be buried in the noise.

So in this case the ID flaws showed a lower POD than the ID flaws. But this shows in general that we can plot that POD is a function of the depth of the flaw, and POD is a function of the voltage.

And the bottom graph essentially shows POD for the tube sheet section, where we have a couple of tube sheet flaws also with the tube transition, the role transition being present that complicates the signal.

Besides looking at the flaw size, flaw size and voltage by itself, a very useful parameter to plot the PODs as a function of MLSB, and again MLSB describes the stress at the ligament of the flaw. It directly relates to the burst pressure.

So here we can relate POD as a function of a structural integrity parameter, and we noticed that the POD gets to be reasonably high if LIDSCC parameter of greater than 2.3 would correspondence to a flaw that would fail at 3 delta-P. So the POD for cracks that are at 3 delta-P can be fairly high.

And just to show it from the view graph and to make an other point that even though our results are qualified, what we noticed for certain conditions, such as the tube sheet, and the top two graphs, we are plotting the results on a team-by-team basis. The others were combined results.

And we noticed that the teams more or less cluster fairly close together for those two examples, but in other cases -- for example, the free span, where the teams are not use to looking at the flaws of the free span, they find lots of flaws on top of the tube sheet and support plates, and not so much at the free span.

And also for the support plate for the LIDSCCs, there is quite a bit of scatter in the team performance. The good team is quite good, and the number of teams right there is sort of an average.

But there is always a team that does not perform as well, and again I would like to stress that these are teams that are commercial teams, and they are qualified, and they are conducted in inspections in a manner that is similar to what they do in the field.

And if anything of course they know that they are under test conditions, and so this is under best performance.

CHAIRMAN FORD: And the lines on these grants -- I'm sorry, but what are they?

MR. MUSCARA: They are just a different team. The assembles are a team and also the line is also a team. So we had 11 teams participating in this round robin.

CHAIRMAN FORD: Oh, I see.

DR. POWERS: The best team and the worst

team had to change lines, and everybody else --

MR. MUSCARA: And it is just a logistic thing. So we are showing you essentially the variance between the best and the worst team. I mean, this is very useful data when we are doing probablistic analysis.

So I think more or less we have addressed the issue for ACRS as to other methods may be useful, and we already have data in this area. There is one item that I would like to cover --

CHAIRMAN FORD: I'm sorry, but I am violating my own principle of not asking questions, but if you would go back to the bottom right-hand slide, the IDSCC tube support plate and the biggest scatter. Is that purely because the cracks are on the ID and the eddy can't pick those up for some reason or other?

MR. MUSCARA: No, because one thing is they are doing quite well if you look at the green light.

CHAIRMAN FORD: Yes, but the scatter.

MR. MUSCARA: Well, yes, the scatter, but what is the complicating factor of course with these flaws is that there is a role transition, and that role transition provides a fairly large signal.

CHAIRMAN FORD: Oh, so you have a float between the --

MR. MUSCARA: It is a complicated signal, although --

DR. SHACK: But this is the tube support plate there though?

MR. MUSCARA: I'm sorry? Oh, yes, this is the ID with the dent. So you do have considerable noise, and some things do better than others. I think here again that it is a matter of -- there may be a signal there as a matter of calling it a crack.

And because the signal is more and doesn't have a large shift-in phase, and there is a complicated noise signal, it still is difficult for the inspector to notice it to call it a crack. They may confuse it as being part of the noise signal. But the good inspectors do quite well.

And this next view graph is not really at all to do with materials. I see that Jack Hays is in the back of the room and he can answer any questions on this.

This is the item on the item spiking. We have conducted an assessment of the ADAMS and Atwood, and Adams and Sattison spiking data this summer, and I understand that this review has been completed.

And the plant having a response to the ACRS comments by December, and our evaluation of this will be published for public comment around February, and then based on the public comment, there is a final position that will be put together.

I understand that after we evaluate our position on this issue that we could be willing an able to provide a presentation to the ACRS on that position before it goes out for public comment.

So I think this is something that is up to you if you want to hear about this or not after we have assembled a position on it.

DR. POWERS: Comments are always the same. That is more work than it would take to solve the problem completely. Do it the way that you want to, but that is an awful lot of work for a problem that I think is susceptible to a technical resolution.

MR. MUSCARA: Jack, do you want to respond? No? Okay. Well, I am almost finished, because the next view graph is milestones and is fairly far into the future, but there will be work going on next year in this area, and I know that Peter will be interested in this.

So I decided to discuss this a little bit. Now, we are planning on conducting some tests to better understand the crack initiation and crack growth. And we are taking the comments from the ACRS to heart. We want to conduct tests under realistic conditions of stresses, temperatures, and environment.

That means that we need to evaluate better what goes on in crevices. As far as the tests themselves, they are not defined yet, but we may be using model boilers so that we can reproduce the thermal hydraulic conditions and the crevice conditions, and therefore, have the appropriate crevice chemistry.

We may have to measure the crevice chemistry, and we may just run tests and evaluate the cracking behavior, and then measure the crevice chemistry at the end when we are not at operating conditions anymore. But it is very difficult to instrument these crevices.

So there are a number of ideas that we are considering. The work is not defined, but we will be looking at crack initiation, and crack growth, and using tubular specimens, along with other types of specimens.

And hopefully under realistic fuel conditions, and the idea here again is not necessarily to develop the mechanisms, but to develop data that will be useful for our code for doing the assessments, the operational assessments. And we need crack initiation data and crack code data.

DR. POWERS: A couple of questions, Joe. As people move to 690 are you going to be testing 690?

MR. MUSCARA: Yes, thank you. We will be testing 690, along with the 600. The idea here is that we have a great deal of information on the behavior of 600 in the field.

So we will be conducting tests with 600 mill anneal, and 690 thermally treated, so that at least we know the behavior in the laboratory; and then knowing the behavior of 600 in the field, hopefully we can extrapolate the behavior of 690.

It may be well that on 690 to just make a couple of comments. Now, 690 is susceptible to cracking in different environments. It has cracked in the laboratory, and cracks in environments that are not overly aggressive. It cracks in neutral solutions and sulfates, and in copper, and in lead.

So what we want to do is with respect to 690 to evaluate the range of conditions under which this material is susceptible so that we can get a better idea about its behavior in the field.

In addition to this, we have had Professor

Staley working on crack initiation. This work was just started about a year ago, and he is modeling this. But we have also been looking at some of the field data.

When we look at the data for 600 mill anneal, and we consider the cracking that we are experiencing these days, and not necessarily the caustic cracking that we got in the early days.

We will consider cracking at the support plate and crevices. Well, 600 mill annealed has taken 10 years before it experiences this kind of cracking. So the fact that 690 has gone 10 years doesn't give me that much more comfort yet.

We know that in the laboratory that it behaves better, and I do believe that it will behave better, but I don't know whether it will last 40 years. But through this work hopefully we will get a better feeling for the behavior of 690, as compared to 600.

DR. POWERS: Another thing that I noticed -- and as you say, trying to instrument to understand what is going on in crevice corrosion -- and probably because it is small, and things just don't fit in there -- I noticed that within the corrosion community there are people -- I mean, crevice corrosion is not peculiar to nuclear plants. It is a lot of places.

But there are people who are trying to develop what they call scaling laws for crevice corrosion. In other words, to do experiments that are scaled where you can instrument, and then you try to find out how does that scale down to the real crevices. Are you paying any attention to that kind of work?

MR. MUSCARA: Well, actually there is work also going on related to steam generators. Jesse Lumpson at Rockwell Science Center is doing some work for EPRI, and he has been doing work for a number of years having a typical crevice.

And he has done quite a good number of studies himself, but also this crevice model has been taken to a plant in Japan, where they are conducting tests using the coolant from the plant.

So they are developing good model data, and we will take advantage of that. My feeling is that we will still need to run some model boiler tests, where we reproduce the crevice under thermal-hydraulic conditions, and see how the materials behave.

We will try to research it as much as possible. Some of the things that we can certainly get are temperature, and maybe potential, and maybe MPH. It would be interesting to be able to get chemical species, and that is a harder problem.

EPRI is working on it and they may in fact by the time we are ready to do something have some solutions on how to do that experimentally. But one thing that we can fall back on is what is in the crevice after we have shut down the system. That will give us a clue as to what was there in the operating conditions.

CHAIRMAN FORD: I have a couple of questions, Joe. On Task 3.8, that relates to the whole question of how can you correlate a bonding, a linear correlation of voltage of this type, with non-linear performance, time dependent performance, of the cracking phenomena?

That latter part would come out at 3.10, and how are you going to from a management point of view compelled in this information in 3.8?

MR. MUSCARA: From 3.10 and also from the inspection work. My belief truly is that the voltage does not track crack size or crack code. The linear literature is not with crack code, but with voltage code, which is meaningless.

So we happen to have a linear correlation.

We didn't try to make a scatter code really. There is quite a bit of scatter, and so I don't know whether it is linear or what it is.

But I think my point is that there should not be a correlation there with crack growth, but we will find a correlation with actual flaw sizes.

CHAIRMAN FORD: So as we look down the time, and if what you say is correct, which I think it is, should we not be looking for another spectrum methodology which is more related to the physics?

MR. MUSCARA: Yes, and I think in general that we are doing that in our program, and we have come up with some fairly good techniques for sizing flaws. I presented the slides here and some reports are being published on this.

But we have come up with a very good technique for characterizing flaws, and particularly the flaw profile. And from that we can get directly MSLB, and we have been able to predict the bursts of these tubes from the flaw profile and from the MSLB correlations.

EPRI is also working on different techniques for better characterization flaws, and the industry has moved towards other plugging criteria. For example, at the tube support plate crack and the idea with dents. This is an area where they are using the profile of the flaws.

They are getting away from voltage and using the actual profile to determine the burst pressures. And I believe that is a direction to go into, and I think we are moving in that direction.

CHAIRMAN FORD: And industry is responsive to these?

MR. MUSCARA: Well, that is what industry is proposing, and utilities have come in with an ultimate criterion.

CHAIRMAN FORD: Now what sort of time scale are we talking about for this more physically realistic inspection?

MR. MUSCARA: Well, I think the characterization methods that we have now -- in fact, EPRI is a member of our IC program, international cooperation. And they are aware of this process that we have developed for sizing flaws, and we are exchanging information, even to the point where we are going to turn over the algorithms.

CHAIRMAN FORD: Are we talking about six months, a year?

MR. MUSCARA: Again, right how this is a laboratory tool, and so in order to develop for the industry more work needs to be done to make it more user friendly.

And once it is in the hands of someone who wants to turn it into a field system, we are talking over a year or so. But again besides their own work, there are other things that are coming up. For example, this probe for doing better detection and probably better characterization of flaws.

We are evaluating that, and that is something that is almost industry ready. They have done a lot of work getting data from plants, and we are also incorporating them into our round robin exercises. So we are evaluating that advance in technology.

So technology is advancing, and I think to the point where we can start making use of the actual parameters of the flaw. They should be profiled and length in depth, and then we can more accurately predict failure.

CHAIRMAN FORD: I have one more technical question, and then we should discuss the ACRS type actions that we have to take. On this one here, Joe, how do you take into account that we just don't know what is a good heat and what is a bad heat?

MR. MUSCARA: That's true, but what we

will probably do is catch bad heats, and work on the bad heats so that at least we will be conservative on what we find. If we get a good heat, we will be testing forever and get no data.

CHAIRMAN FORD: Yes, I understand that, and so your strategy on this is that we will go for the worst case scenario and just happens to have by chance some good heats?

MR. MUSCARA: Frankly, I have not thought too much about doing heat variability in this work. We will probably wind up doing several heats, but probably not a tremendous amount of heats.

And again the idea generally would be to find some susceptible heats, where we can do our work to evaluate different parameters on cracking.

CHAIRMAN FORD: Okay. Joe, thanks very much.

MR. MUSCARA: So I guess now we will have the discussion on thermal hydraulics.

MR. SULLIVAN: This is Ted Sullivan from the staff. I would like to make one additional comment. I think you started to touch on it when Joe was mentioning that this is a laboratory tool, and it is being made available to the industry.

But in terms of making a transition to

applying that to ODSCC as a substitute for the voltage, first of all, you have got to get industry -- I don't know who the you is, but industry has to be interested in basically making another proposal to the staff, and developing it to the point where it is a suitable substitute for the staff.

And it has to happen -- if something like that were going to happen one of two ways, either the industry has to take it up and make a proposal in the room, or the staff would have to make a safety case that this sort of thing needs to be done.

And I don't think it is our view that it would be easy to make any sort of safety case, but that sort of transition needs to be conducted.

CHAIRMAN FORD: Okay.

MR. TINKLER: Joe described for you some of the work being done by the Division of Engineering and Technology in the Office of Research. I am going to summarize the work that is being done in the Division of Systems Analysis Regulatory Effectiveness in the Office of Research that primarily addresses the issues related to severe accident and design basis thermal-hydraulic conditions that create at least in part some of the loading conditions on the steam generator tube.

Be advised that all three divisions in the Office of Research actually are contributing to this initiative. The Division of Risk Analysis and Applications is also heavily involved with NRR in integrating this analysis into our understanding of risk that are posed by steam generator tubes, both from the standpoint of initiating events on the design basis, as well as the risk from severe accidents.

Oh, and I am Charlie Tinkler, and I will be followed by Steve Bajorek, who will talk to you about our current thinking on the thermal hydraulics questions related to support and steam generator tube loads.

Chris Boyd will also describe in more detail some recent analysis that he has completed on the staff to address the details of mixing in the steam generator and the steam generator tube --

CHAIRMAN FORD: If I could just give you some guidance. WE have another meeting beginning at one o'clock, and I guess the members would really like some lunch. So if we can try and finish the whole thing by say, 20 by 12:00 at the latest, and bearing in mind that the information that we want to get a feeling for right now is whether the recommendation in NUREG 17-40 are being incorporated into this joint proposal.

MR. TINKLER: Okay. This is a list of the major recommendations of the ACRS Ad Hoc Subcommittee on the DPO. They are going to be addressed in this presentation and that are covered by the work in our division.

We want to develop a better understanding of the behavior of the steam generator tubes under severe accident conditions specifically addressed by Steam Generator Task 3.4.

The evaluation of the -- and ACRS also recognizes that we evaluate the potential for progressions of damage to steam generator tubes during the rapid depressurization caused by a main steam line rupture. That is the more traditional thermal-hydraulic issue, and that is specifically addressed in the action plan under Item 3.1.

To address the severe accident response of steam generator tubes, and general hydraulic boundary conditions in the reactor coolant system, and corresponding component behavior in the steam generator tubes, we have four basic parts to this research.

We have the system level code analysis, and the system using SCDAP/RELAP. That is where we model the core, the RCS, the steam generator tubes, and all the other related components.

We are relying in part now on computational fluid dynamics code analysis and modeling, principally the FLUENT code, to model the single phase natural circulation and mixing in the steam generator tube bundle.

It gives us a much better portrayal of the spacial dependencies and resolutions of temperatures within the system. We are assessing again the 1/7th scale test data.

These are the tests that were sponsored originally by EPRI in the 1980s, and later co-sponsored with the NRC as a mock-up of a steam generator -- of two steam generators and a reactor vessel.

The tests were designed and conducted primarily by Westinghouse personnel, and so occasionally you will hear them referred to as the Westinghouse 1/7th scale test.

We are also contemplating conducting some new experiments to investigate conditions that weren't addressed in those original 1/7th scale tests that have been raised in the DPO and raised by the ACRS, and I will talk about those briefly.

Under 3.4, we have a multitude of subtasks that address a lot of the technical issues related to severe accidents. These are some of those technical issues. Some of these have their own separate subtasks in the action plan.

Plant design differences. We have done the bulks of our calculations for the SERE (phonetic) design, which was the original basis for our tube integrity analysis for NRR.

We started looking at -- and we have done calculations for other plants, and we are now focusing our attention on the Zion-like geometry, and that has a number of advantages.

It is representative of a bigger group of plants, and it also allows for a little better comparison with some of the industry analysis, because the industry analysis more often is done for a Zion-like geometry.

And we have plant sequence variations, and we typically focus on station blackout type sequences, where one steam generator is also depressurized. The steam generators have all boil dried, and the core has become uncovered, and now we have super-heated steam circulating through the loops.

Now we have a counter-current flow that we are primarily concerned about because for most of our calculations we predict the loop seal for the red coolant pumps is filled.

So we get counter-current flow out through the hot leg, and through the steam generator, and to one-third to one-half of the steam generator tubes, and returning through the remaining portion of the tube bundle, and back along the bottom of the hot leg to the reactor vessel.

This task is to look at variations on that sequence, and to look at the effects of reactor coolant pump seal leaking, and to look at leakage from PRVs or safety valves to see if there are variations on the sequence that pose some unique challenge.

In response to past ACRS comments, we are conducting a more rigorous uncertainty analysis to look at the influence of mixing parameters and other phenomenological issues in this calculation as part of the system analysis.

The ACRS raised in its ad hoc subcommittee report, and we recognize the importance of loop seal clearing in this analysis. The effect of clearing the loop seals is to have unit-directional flow through the steam generator tube bundle,and not get the benefit of return mixing through the coolant portion of that flow.

So it typically predicts higher temperatures. It is normally associated with slightly depressurized sequences, and so we looking at those two effects combined. The effect of tube leakage on inlet plenum mixing --

DR. POWERS: Are you going to be able to resolve the issue of loop seal clearing just with analysis?

MR. TINKLER: We think so. We know that we have to present more analyses and our rationale to the committee on this matter, but we believe that is the case, and we understand the comments that have been raised, and we understand the concerns about small delta-P clearing loop seals.

We understand that, and we have work to do on that, but right now we expect to address that analytically. The effect of tube leakage on other plenum orientation, and this is the notion that if you have tube leakage up in the bundle that it will disrupt the mixing in the inlet plenum that was observed in the 1/7th scale test.

So you won't get quite as an efficient mixing and you get perhaps channel flow or tunnel flow up through the inlet plenum, and that can create a locally hotter plenum.

And hot leg/inlet plenum orientation. The 1/7th scale test looked at a proto-typic Westinghouse steam generator, where the hot lay comes in low on the inlet plenum. The CE designs have a hot leg orientation that comes in a little higher on the inlet plenum.

And so it is a little closer to the tube sheet, and so the argument there is that the mixing path lends a shorter -- you might not get effective mixing in the inlet plenum and the tubes will be exposed to higher temperatures.

These are areas that we expect -- that are well-suited to CFD calculation, but they also would benefit from additional testing, and we are considering that.

The things that we have to be mindful of are the scaling issues associated with these kinds of tests, and the need to run them with a denser fluid, like SF6, and that poses a problem in some facilities.

There are a host of instrumentation issues, as well as costs. Tube to tube variations. When we do air calculations with control volume codes, we have relative coarse nodalization of these volumes. And inlet plenum is basically three control volumes.

Now, that's okay if you are using the empirical models developed by the experimenters, but if you want to hope to model the response of tubes or clusters of tubes in a 3,000 tube bundle, you need finer resolution.

So we were looking to see if the analysis, as well as perhaps additional testing, to get more insights on that. And fissure pipe deposition. This relates to the risk impacts.

The ACRS has commented in the past that we might not be taking full credit for those severe accidents where tube leakage or tube rupture occurs. The fact that that tube bundle and the upper internals of steam generator will serve as a mechanism for deposition of aerosols. These radioactive aerosols wouldn't be transported off-site

Now, there is testing that is planned in the Artis facility in Switzerland, the Paul Shearer Institute is conducting tests where they have a mock-up of steam generator tube bundle, and they are looking at the deposition of aerosols under their severe accident conditions or a range of conditions.

Here is 3.4, the near items. We are doing system level analysis to look at sequence variations to look at the effect of reactor coolant pump seal leakage,and to look at issues associated with safety valve leakage, and to look at the effect of tube bundle leakage.

And we are looking at the effect of tube bundle leakage from a systems standpoint, and not a local CFD level. We are also looking at alternate steam generator depressurization. Typically, we do these calculations with the pressurizer loop steam generator being the one that is blown down and depressurized.

And we have calculations being done looking at the other three loops to see if it makes a difference, and we are also looking to see to the extent that we clear loop seals in some of these calculations.

We have done the calculations where we are halfway between a draft report and a final report, and so we are not quite ready to talk to you about these results, but we will in upcoming subcommittee open meetings.

Our next task is to reevaluate some of the SCDAP/RELAP modeling and simplifications of assumptions, things like radiation heat transfer and the hot leg; and some of the loop seal clearing issues we hope to address in this.

It might also give us a vehicle for looking at some of the comparative items between industry calculations and our calculations.

Subtask 3.4e.1, benchmark of the CFD methods. That is the FLUENT against the 1/7th test data, and this work was just recently completed on schedule in August. Chris Boyd will talk to you about it in more detail.

Lastly, design basis and thermal hydraulics. This was to address the issues in the DPO that were raised by the depressurization by blowing off a relief valve, or a main steam line break. That is just a cryptic summary of the kinds of loads.

Steve Bajorek will just describe to you a little more of our thinking at this point on how we are going to tackle that issue, and he is next.

MR. BAJOREK: Good morning, or good afternoon, I guess now. My name is Steve Bajorek, and I am also a member of the SMSA branch, and relatively new to that branch.

What I am going to talk about are some of the issues pertaining to generating the hydraulic loads that we are going to need to evaluate the blow down forces on the steam generator. The work that we are doing initiates from two different contentions.

I have listed them both here, and both arise due to the uncertainty in what are the hydraulic loads and forces that result across the tube sheet, and across the tubes during the break, and the rupture of the main steam line break, or potentially another relatively large pipe connected to the secondary side of the system.

By way of background, I think it is useful to think of the high pressure depressurization of a system into two overall segments. We can think of the first phase; that while this fluid is primarily subcooled, and while the depressurization waves propagate through the system at a sonic velocity,and then another phase of that depressurization once those waves have dissipated, and the system depressurizes primarily dependent upon the break flow and the size of the break.

This is an issue that is actually of fairly well-studied in the initial design of a reactor system from the point of view of the primary; whether you have rod drop or not, or whether you will have grid crushing within the core, is dependent on your design and how you evaluate the breaks to the primary system to take a look and track the depressurization waves as they move through the loops, and through the core, and potentially move the core barrel from one side of the downcomer to the other.

A good analysis of that type of event tracks the waves at sonic velocity, and incorporates a fluid structure interaction between the core barrel, which is the primary component of interest in that type of an analysis, and generates the delta-Ps from one side of the downcomer to the other side that we give to the structural analysis so that they can perform a structural analysis and tell us whether the rods are dropped, or whether the core barrel deflects.

We have a similar situation now that we need to address on the secondary side. Now, I think the reason why that has not received as much attention as the hydraulic forces that develop on the primary side has to do with the rate at which those waves move through the primary or through the various systems.

For the primary system Tcold -- and C stands here for the sonic velocity, and this is at about 550 degrees fahrenheit, at typical Tcold at pressure, moves through the system at a little bit greater than 1,000 meters per second.

If you think of the primary system full of sub-cooled liquid early in the transient, this wave is certainly capable of moving through the loops in the core on the order of a couple of dozen times, and interacting with waves which move throughout other parts of the primary system, generating fairly complex loading across the core barrel or the steam generator divider plate, and other things that need to be looked at.

And causing some of those components to move. And we need to start thinking about what that type of analysis or evaluation does now over on the second side. But it is important to keep in mind that the most important physical parameter which determines the velocity of that wave is its density.

And in the primary system, typical conditions are that we are seeing velocities a little bit later than a thousand meters per second. On the secondary side, the velocity that we might find in saturated liquid at about 900 psi, just a little bit less than what we would see on the primary system, the difference being the difference in the density.

However, in the vapor space, that velocity drops significantly to roughly half of its value. Now when you do a thermal-hydraulic evaluation of the primary system, that analysis to take a look at the interaction of the waves goes for on the order of milliseconds, because what happens is that as soon as we start to form some voids within the system, those waves are dissipated very rapidly.

And the interaction of the waves becomes a no, never mind, in the analysis. It is something that will probably help out the structural evaluation here on the steam generators secondary side. That is not to say that those loads are going to necessarily be small, because there will still be a fairly significant shock to the tube sheet and resulting motion.

Now, because the steam generator either has significant voids through the bundle region at a steady state, or has an interface at no load condition, the most significant pressure wave that is going to cause motion of the tube sheet and transient stresses on other components within the steam generator is going to be this initial wave that moves through the steam generator.

We won't have much in the way of reflection or interaction, with the exception of the fact that we have more voids on the interior of the steam generator, and sub-cooled fluid in the downcomer, and so conceivably we could see a wave moving down the steam generator downcomer, and reaching that portion of the tube sheet earlier than we would in the interior of the bundle.

So our initial approach -- and we have got to admit that we are in the very initial stages of developing a plan of attack at this point -- is to try to develop relatively conservative hydraulic loads that we can give to delta-P(t) for them to apply to their finite element model, and to determine the bending stresses and other stresses that they get out of that type of an analysis.

Our approach is first going to try to use what I will call glorified hand calculations to determine, one, what is the initial time at which that depressurization wave reaches the tube sheet and various parts of the steam generator base, and augment that with track 3-D calculations to look at the later stages of the blow down of the steam generator secondary side.

Now, during that phase of the accident something like a TRAC or RELAP should give us a reasonable depressurization. I would not expect it to do a credible job during this very initial part, where you have to TRAC the sonic wave and the interactions that it has with the various components.

That's why our initial plans are to try to get something that is conservative with the hand calculation, and augment it with the TRAC-M calculations, and give that to the finite element.

And if you can come back and tell us whether we have lots of margin, or there is a little bit of margin on that. If the answer comes back that we have just a very small amount of margin, the next part of our evaluation would be to replace the hand calculation with something better.

That would not necessarily be TRAC-M. I think we have to look at that closer and make up our minds whether it could or could not do that. The tools that might be available to us to analyze this are the things like the multiplex code that is used by Westinghouse to evaluate the subcool blow down on the primary side.

The staff a number of years ago to my recollection did have access to a code, and I think it might have been called SLAM, to take a look at that type of a scenario on the primary side.

That might be a better starting point than trying to force the TRAC-M to give us that type of sonic wave depressurization. But we would go along that path if we were to find that we wouldn't have enough margin and structural analysis, and then make a decision on what would be a more appropriate tool.

If necessary, then look at some experimental testing to try to augment our code validation at that point. At that point, if we had such limited margin, that might also be a good time to go back to the vendors and use perhaps their tools to try to evaluate the same type.

CHAIRMAN FORD: Thanks very much indeed.

MR. TINKLER: Thank you.

MR. BAJOREK: I have more slides than eight minutes, but I am just going to go through them quickly. Charlie covered a lot. This Charlie described, and I am just going to show this as the thermal-hydraulics of interest that we are going to focus on in this small subtask that I am carrying on.

I want to make this point before I start, and that is that the SCDAP/RELAP code is what we are relying on to get our thermal-hydraulic results to pass on to the materials people.

The tube temperature predictions that the tubes are subjected to come out of that code, and they are influenced directly by mixing parameters. So I am making the point that we are going to use SCDAP/RELAP and that gives temperatures that are affected by mixing parameters, and these mixing parameters are fixed in the code, and they are determined from the

1/7th scale testing principally and other tests if possible.

So these mixing parameters are what I am going to focus on. The advantages of CFD. I just give this slide to show an example that we are about four orders of magnitude more cells, on the order of hundreds of thousands, to a million, versus 10 to a hundred.

Less expensive experiments as you pointed out, and we are going to have a direct resolution of mixing. We are not tuning the code. We are using the most appropriate turbulence models from an academic point of view, and then just letting the code go.

So again no fixed mixing parameters. We are extending the data with CDF, or we will to full-scale, full-pressure, full-temperature steam, and then we can look at this inlet geometry effects and tube leakage effects that Charlie mentioned.

DR. KRESS: Do we have options in the fluid code or for what turbulence parameter, different options for turbulence parameters?

MR. BOYD: We have different turbulence models, and several to choose from, and then within a turbulence model, you can then tune that to the data. We are not doing that type of tuning. We are kind of using industry standard coefficients.

We don't really have data to do that kind of tuning, and we are not tuning to get the answer we have from the 1/7th scale test. We are just letting it fly.

DR. KRESS: Are you choosing one option, or are you --

MR. BOYD: We chose several options just to look at the differences. In the end, they did not make a lot of difference. The one that we chose was the second order of Reynolds Stress Turbulence Model, which is for this type of flow, it is -- I guess on paper it would be the appropriate model, as opposed to a two equation K-epsilon model.

So in this type of flow field, I guess we chose the academically appropriate, and in all the selections that we made there wasn't a large difference. It did not affect these types of parameters.

This is a quick slide to show the CFD approach versus a lumped parameter. The top picture shows the hot leg, and I guess that is not really showing up, but what you see is a full counter-current flow profile, with velocity vectors and temperature profiles.

And on the right in a lump parameter code, SCDAP-RELAP, there is just two pipes with a single temperature, and you have mass flow and temperature. In the inlet plenum, this is the SCDAP-RELAP nodalization in the middle on the right, and you will see the three mixing volumes.

Flow comes in and based on the mixing fraction, it either goes to a mixing volume, or it passes up through to the tubes, to again a fixed number of tubes.

With the CFD predictions, we are going to calculate the mixing implicitly with the code, and then as far as the tubes go, this is something that we will add a benefit to our predictions.

In the SCDAP-RELAP predictions, you are going to get one temperature and a number of tubes and up-flow that is predetermined. And in the CFD predictions, we will get the number of tubes calculated implicitly, and then we will also get tube to tube variations.

So we will know not just the average temperature going into the tubes, but what the peak average ratio is.

DR. KRESS: On your counter-current flow, what do you do at the reactor end?

MR. BOYD: At the reactor end, initially I put the core in there, and I just had a heat source and let it go, and it picked up that counter-current flow. I had a lot of uncertainty in my core model obviously.

I was using a lot of core options, and I cut that off, and at this point I just put on the end of the hot leg a mass flow in.

DR. KRESS: You just put it at one end?

MR. BOYD: That's right.

DR. KRESS: And that stuff going out just disappeared?

MR. BOYD: It is called a fixed pressure boundary there.

DR. KRESS: A fixed pressure boundary?

MR. BOYD: Yes. And I did a lot of variations with different velocity profiles, and all sorts of things to match the mass flow given in the test results.

DR. KRESS: And you had to specify the profile specification?

MR. BOYD: That's right, and I found that my profile specification wasn't all that significant. By the time that it got to the steam generator end of the hot leg, it had dissipated anything that I had put in.

So, CFD is going to provide an improved understanding of the 1/7th scale data. We have got these tests, and obviously what went on in the tests was fine, but we have a limited view of the tests from the limited instrumentation.

So we can fill in some of the gaps with CFD, and then we can extend to full-scale. One of the big questions is does scale affect the mixing parameters, and that is something that we are looking to address right now.

At that point, when we have gone to full-scale, we have answered that question among others, and then we can start looking at the effect of tube leakage and how that affects these inlet plenum flows, and mixing parameters, and the effect of the inlet geometry variations, like the CE plants with the hot leg entrance closer to the tube sheet.

And again we will get implicitly out of this tube to tube variations that then would give some understanding of what the hottest tube really is.

The schedule. Validate the technique by looking at the 1/7th scale. That is our best available data set. That has been done and in general the answer is that the code picks up all the relevant physics and does a pretty good job.

At this point, we are sensitivity studies, and extending the predictions to full-scale, using a kind of best estimate conditions out of a SCDAP-RELAP analysis.

Again, what is the effect of scale, and then we are going to complete additional studies on tube leaking and inlet geometry variations, as well as other sensitivity studies.

And just to give a quick view. This is the mesh that we that was used for the 1/7th scale. It's a symmetry model, half of the hot leg in the plenum and tubes. All the tubes in that test, 216, were modeled individually.

We won't do that at full-scale, and we will come up with a model for the tubes. But that gives an idea of the resolution. There are several hundred-thousand cells just in the inlet plenum alone.

There are some qualitative results. This is the first thing that hits you when you -- well, all of the qualitative flows predictions are correct. In other words, a sloping interface in the hot leg, and a plume that rises and dissipates fairly quickly into the inlet plenum, and about a third to a half of the tubes in up-flow.

The temperature of the tubes reaching the given values in the test, and by the time it reached the top of the tubes. All these kinds of qualitative features were matched by the CFD predictions. This is quantitative data, but I'm just talking qualitatively there.

When we go to the actual mixing parameters of interest, this table shows some of the results. These are the tests of most interest. In general, what you saw was about a 10 percent deviation.

If you look at the Westinghouse data carefully, you will determine that the uncertainty in that data is around 10 percent or more. The one big variation was the number of hot tubes.

We were 23 tubes over, which is about 10 percent of the tube sheet, and we are currently doing some sensitivity studies to determine what boundary conditions or condition in our model might affect that to see if we may have a problem.

And all the hot average temperatures, and mass flows, and things like that, were all pretty close, and in this particular run we had a 15 percent difference in the recirculation ratio, which again I believe is in the uncertainty of the data.

So as a quick look, what I get out of this is that the code can do this type of analysis, and that the results are pretty close. This is the tube sheet flow, and this is the number that I mentioned, 10 percent over-predicted.

The dark region on the tube is from the data. There is two lines there because the data had an uncertainty, and not every tube was instrumented. So somewhere in that range is where the boundary between where up-flow and down-flow in the tube sheet occurred.

And then the outer dashed line represents the FLUENT predictions. On the right, I give the peak temperatures. The peak thermal-couple in the data read 59 degrees celsius in this case. These again are cold tests done with SF6.

The maximum predicted value from FLUENT was 61.5 degrees, and that was on the center line. The data did not have any center line thermal-couples. If you look off-center line, it would be more consistent with the data. I had a max prediction of 58.5, which was pretty close to the measured value.

So as a summary, the CFD predictions are generally within 10 percent of its 1/7th scale data, and that is generally within the experimental uncertainty. There was a fair amount of uncertainty.

There was no mass flows directly measured in the tests.

They had to infer that from energy balances, and some of these energy balances were inferred from small delta-Ts. So this added to the uncertainty.

The phenomena observed during the tests were all predicted by the CFD code in a qualitative sense, and so the general flow features are there, and work on full-scale predictions is proceeding now, and I think we have a high degree of confidence in our technique, and so when we go to full pressure, full temperature steam, there is not going to be as much uncertainty.

So this benchmarking exercise has been very valuable, and I think this is just a restatement of that. The CFE technique has been demonstrated to be applicable, especially for predicting these mixing parameters, which are kind of average values.

And this work provides this high degree of confidence, and we are going to go to full-scale analysis, and at full-scale, then we will spend our time doing the tube leakage and geometry variations, and our sensitivity studies. I am just a few minutes over.

CHAIRMAN FORD: Thank you very much indeed. I would ask for any comments from the members here. We have on our schedule for the next ACRS meeting next week -- we are charged with a letter relating to the DPO.

And essentially hopefully saying that the recommendations that were in 17.40 are being followed in the new NRR research plan. That is hopefully what the letter would say. Is that correct?

DR. KRESS: The intent is to address that, yes.

CHAIRMAN FORD: Okay. Could we have some comments to help the staff and research as to how they would appropriate their time for the 30 minute presentation that they would have in that one hour?

DR. KRESS: I would like the approach where they are listing what the ad hoc committees' recommendations were, and then to say how we are addressing them in the plan. That would work very well. I certainly would want to have the full committee see this CFD stuff, and that addresses some of the --

DR. SHACK: But we will never get through it in 8 minutes.

DR. KRESS: But that addresses some of the real issues that the staff may have.

DR. POWERS: The plans are sufficiently in the works, and I don't see why the subcommittee chairman can't just summarize it.

DR. KRESS: I think that is probably right there.

DR. POWERS: Well, all you are going to do is say the staff has plans to address this issue, this issue, this issue, and this issue.

DR. KRESS: And they look like good plans.

DR. POWERS: And in 9 out of 10 cases, they have great plans, and in one case, I haven't got a clue.

CHAIRMAN FORD: The one question I have got, Dana, because I know nothing at all about it, is the thermal-hydraulics codes. Are you all feeling that these are the right approaches?

DR. POWERS: The one thing I know is that if you put two thermal-hydraulicists in a room, the one thing they cannot arrive at is a conclusion. What I would say is why don't we have the subcommittee chairman draft a summary, and put it up for the rest of the committee, and say we are addressing the issues that have been raised, because there is no more content than really that that they are addressing.

I mean, most of these things are in the works, and they are working on it, and then allow the speakers on this CFD stuff and the counter-current flow, because that implies so many things other than the steam generator tube --

DR. KRESS: And Dr. Wallis hasn't heard that.

DR. POWERS: Well, more in the context of here is some research that is going on now, and here is where we stand, and more as an update of general interest than just a DPO issue.

CHAIRMAN FORD: And that you think will be enough sufficient information to allow George to sign his name to a letter saying essentially that the recommendations from the ad hoc committee, and therefore the ACRS, are being followed?

DR. POWERS: Are being addressed, yes. They are taking them into account. That is what we were asked, and they know them better than I do.

CHAIRMAN FORD: So the answer could be yes?

DR. POWERS: Yes.

CHAIRMAN FORD: Just one word.

DR. POWERS: Yes.

CHAIRMAN FORD: So you are asking me to

stand up in front of the ACRS committee and summarize what we have heard today, and then for general information to have the thermal-hydraulic guys specifically get up and talk?

DR. KRESS: As an alternative, if that is uncomfortable to you, you could ask one of these guys to summarize.

DR. DUDLEY: Just from a public holding, and a presentation in a public meeting, at a full committee meeting to write a letter from, I think it would be more appropriate if the staff presented a summary, and then it would also save the subcommittee chairman the effort of pulling that together.

DR. POWERS: But a summary presentation.

DR. KRESS: Yes, a summary presentation.

DR. POWERS: I think the committee as a whole is going to be very interested in what they are doing with this counter-current flow issue because it has been around since the dawn of time, and there has been lots of concern about it for a variety of things. And let that talk go on at length.

DR. SIEBER: And also the tube sheet --

DR. POWERS: Well, that one is interesting, but I think that we are fixing to work on this. I think we can hold that one off until they have got some more results.

CHAIRMAN FORD: Could I suggest the following? Who is going to stand up and say I am the project leader for this and this is a problem, and where you are going, and this action plan, the joint NRR/research plan, is feeding into that overall thrust.

Just one draft, and one slide saying this is where we are going in general, and I am quite ready to stand up and say this is in line to go alone with your line. Here is the action plan, and here are the actions in the NRR/research program, and these are the ones that we specifically recommended, et cetera. Does that sound fair?

DR. POWERS: Yes.

CHAIRMAN FORD: Is that clear?

DR. POWERS: All right.

CHAIRMAN FORD: All right. We are adjourned.

(Whereupon, at 12:30 p.m., the meeting was concluded.)

**CERTIFICATE**

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

Name of Proceeding: ACRS Advisory Subcommittee on Materials and Metallurgy

Docket Number: (Not Applicable)

Location: Rockville, Maryland

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

Paul Intravia
Official Reporter
Neal R. Gross & Co., Inc.