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NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

IN THE MATTER OF:

MEETING OF THE

ACRS SUBCOMMITTEE ON METAL COMPONENTS

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

Monday, 5 November 1979

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

MEETING OF THE

ACRS SUBCOMMITTEE ON METAL COMPONENTS

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Room 1167
1717 H Street, N. W.
Washington, D. C.

Monday, 5 November 1979

The ACRS Subcommittee on Metal Components met, pursuant to notice, at 8:30 a.m.

PRESENT:

DR. PAUL G. SHEWMON, Chairman of the Subcommittee

MR. MYER BENDER, Member

DR. J. CARSON MARK, Member

DR. D. DILLON, Consultant

DR. H. CORTEN, Consultant

DR. W. BERRY. Consultant

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P R O C E E D I N G S

DR. SHEWMON: The meeting will come to order. It is a continuation of the meeting of the Advisory Committee on Reactor Safeguards -- it's not a continuation; it is a meeting of the subcommittee on metal components of the ACRS. I am Paul Shewmon, subcommittee chairman. The other members present today: Dr. Carson Mark, on my right. In attendance as consultants, we have Drs. Berry and Dillon. The purpose of the meeting is to hear from the BWR owners group on the matter of BWR pipe cracking, in partial response to the August 14, '79 ACRS letter on this topic. Generic items on pipe cracking in-service inspection and other topics will also be discussed.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act and the Government in the Sunshine Act. Al Igne, on my left, is the designated federal employee for the meeting. Rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register. A transcript of the meeting is being kept of the open portions of the meeting and will be made available, as stated in the Federal Register notice.

It is requested that each speaker first identify himself and speak with sufficient clarity and volume so he can be readily heard.

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

We will proceed with the meeting and -- I wondered if wanted to wait for the rest of the staff; they are here. I will call on Dave Rossin, chairman of the technical advisory committee of the BWR owners group.

MR. ROSSIN: We appreciate this opportunity as representatives of the BWR owners to present a program which is now in place and in operation, one which we feel it is important that the ACRS is acquainted with, and the opportunity we have this morning we will try to use as efficiently as possible. We want a couple of things in the process: not only do we want to tell you what we are doing, what our objectives are and how it came about, but we are very interested in feedback from the ACRS about the scope of our program, about where it is headed and about how it deals with the problems.

As you will see in the presentation this morning, while this program is very well laid out at this point, we have the authority and the flexibility to make changes. We will make those changes if it is clear that there are things which ought to be done that we are not doing, and vice versa.

Part of the reason for this meeting was the August

16th letter. Am I right?

MR. IGNE: Yes

MR. ROSSIN: From the ACRS to the NRC, indicating its concern about "increased incidence of pipe crack." As BWR owners we are deeply concerned about the availability of cracks in pipes, and we have taken a rather unusual action as an industry to try to deal with this. This started back in 1974 and '5, when cracks were discovered in Dresden and some other boiling water reactors. We formed an owners group at that time, and that group advised the early EPRI planning with regard to work in this area, but this was really a technical advisory group, and interestingly enough we set it up as a subcommittee of the task force on systems and materials of EPRI. So that there was a group of BWR owner companies with their technical representatives working as a subcommittee to advise the task force on how the research in that area should be structured.

When the Duane Arnold experience became available and some of the foreign experience became clear to us, as it did to the commission and the ACRS, it was important to do substantially more work in the future, not because we didn't know anything or hadn't learned anything in the past couple of years, because I think we had come a long way in our understanding of this phemonenon and our ability to deal with it, but with the recognition that this phemonenon was going to be with us, and if we possibly developed different characteristics, maybe in larger types, maybe incidents of cracking would occur that we couldn't explain with the theories we had developed, and we better be prepared for it.

In addition, it became obvious that there was a lot of work to be done in nondestructive examination and in developing repair concepts and proving them, qualifying them, that needed more money than the normal EPRI budget could stand.

As a result, we got the owners together, and we asked them to particpate in a program of research and development work would extend over a four-year period and which would be funded at the level of $30 million over that period.

Week before last, October 24, we held a meeting of the senior representatives of these utilities. We developed a charter and a research agreement and required -- we developed a per-share basis for funding this. Two-thirds of the potential shares were signed and in hand that the owners group would become a legal reality. We needed 48 shares to reach that goal. We now have 56-1/2 shares under signed contract. So, we are funded fully in operation. We hope to get all, or at least almost all, of the other companies signed up in the near future.

The budget for this year, calendar year 1980 coming up, from the owners group will be $9.2 million and an additional $740,000 for operating expenses, coming close to a $10 million figure for one year. This budget is tied in with money coming from EPRI operations, and you will see this in a few minutes.

The point is there are two pots of money. There is one integrated research program. There are not owners groups projects and EPRI projects; there is one research program. And while we may designate some of these for budgetary purposes, the key to this whole operation is that there is one program and it all hangs together.

There are two sources of funding but one program. The reason I repeat this over and over again is because we have had ample confusion about this subject over the months with our owner companies and with EPRI and with contractors and everybody else. We will be glad to answer further questions on that.

In order to monitor this program, we have the EPRI task force already in existence, but we have set up the technical advisory committee of the owners and the representatives here in the room of about nine to 10 companies are members of this technical advisory committee. Each of these groups has to approve the overall program and the specific projects. In fact, we divided our owners groups technical advisory committee into subgroups to correspond with the major categories of work that the EPRI people will present to you in a few minutes.

It is our overriding concern that we understand what is going on, that we develop ways to deal with it, that we are able to keep this phemonenon from creating safety problems, and that we are able to be effective in minimizing the penalty on plant availability that pipe cracking is liable to make. There is no guarantee that pipe cracking won't continue to occur. We know enough to know that now. There will be more cracks. They will be detected. They will be repaired. And in some cases, it may be costly. But we feel that with every year, we are getting closer and closer to an understanding of what is going on.

Finally, if we have time today, we hope to discuss with you your observations on what is happening. We are prepared to give examples from individual experience of what companies have done.

I must make one very important point. There are lots of utilities that own lots of BWRs. What each utility is doing to cope with pipe cracking phenomenon may not be the same as what another utility is doing. The utility has the ultimate responsibility for their plant, and they try and make the best decisions they can for their plant, considering the design, the history, and everything else. There is going to be diversity in these decisions. We think this is not only prudent, but extremely valuable, because we don't know all of the answers. We don't have an overriding safety problem, and so there is real merit, we believe, in different groups making the best decisions they can. And if some of these decisions are different but acceptable, then we are going to learn something more as time goes along. We don't see that there is a great risk in this.

One thing we are concerned about is at this stage of knowledge we have now some kind of uniform fix being edicted, because we really don't feel that is appropriate under the circumstances. We feel it is safe and prudent for a diversity of decisions and diversity of fixes to be used. I think it will become evident when we talk about differences between older operating plants, newer operating plants, plants under construction, and plants in the design stage. There are various things that can be done, and I think there is a diversity of decision which is of benefit to all of us.

DR. MARK: I have a question related to what you are saying. It is not really on the pipe crack topic. I understand your point that you would feel concerned about an edict: this fix will be applied under circumstances where there may be several things which need to be compared, for instance. How about the reverse? Is there any mechanism through EPRI, through owners groups, apart from just pv BWH

jawboning, if some utility says, "I am not going to pay attention to this," or "I am going to do something which the rest of the group feels is really wrong and could expose the whole group to public obliquy." Is there any measure to exert influence, or what is the mechanism on somebody who should do something and says, "I am not going to"?

MR. ROSSIN: Formally, p ps not. But in practice, this group of technical representatives meets four times a year, and one of the things we do is repair and report to each other what we are doing, what works and what doesn't, and what the problems are. I think, within the technical community, there are very good mechanisms for getting this communication across. And since we really do have the same objective, it is my feeling that this communication has been and will be effective.

But there is a key part of this. If there is a safety problem, we have a different situation than the problem on availability. If it is an availability problem, I think, in the ultimate, the individual utility can make its decision and stick with it. If there is a safety problem, it is a whole different ballgame.

DR. MARK: It is that I was concerned with.

MR. ROSSIN: If it is a safety problem, it is much different than the technical advisory group, because it affects Part 21, it affects the license, and we are dealing with the Nuclear Regulatory Commission. It is clear that if this group recognized there was a safety problem in existence, it would full knowledge to the NRC, because otherwise it would be in violation of Part 21.

I think the overriding concerns for the industry would show through very quickly. We are not going to vary a safety problem

On availability decisions, I think all we can do is advise a particular utility, "We don't think you are doing the right thing, and we are having better luck with this. But we tried this, and this experience gets fed back."

DR. MARK: I am not suggesting that there are people who take this offbeat indefensible position.

DR. SHEWMON: If you don't, I will.

(Laughter.)

DR. SHEWMON: What percentage of the BWR owners will belong to your -- do belong to your group? And of those who do not, do they still get the information?

MR. ROSSIN: Our share formula is very simple. Each utility is in for one share plus one share for each plant, a half share for plants that will come on line after 1982. That is the formula. We have 56-1/2 shares out of 71-1/2. And what this really means is that we have got, of the 29 companies, we now have 21 in the fold. And I have no pp BWH

turndowns yet. There are other companies who advised me they are still debating it within their company about whether to join or not. So, until we get a turndown from one company, I can still say that we have unanimous participation.

I might say that all of the large companies that have more than one plant in operation are in now. The companies that are still considering things are mostly those that have plants in the least stages of construction, and in a couple of them whose only BWR is still in the construction permit stage they say they are interested in joining but they haven't made the decision.

DR. SHEWMON: You talked about edicts. One of the things which is kicking around in the staff someplace is a reg guide which would speak to limiting chlorine or chloride contents in BWR water, as I recall it. It did not speak to oxygen content. Next time it comes up, I suspect it will. I have no particular feeling on when that will come out, but when you talked about annunciata or whatever your word was, I trust you were only requesting that you be allowed some discussion capabilities with regard to what reg guides would be or things of this sort?

MR. ROSSIN: I thought that was the practice, anyway. I would hope it remains the practice.

DR. SHEWMON: Fine.

MR. ROSSIN: We will discuss the oxygen question in the course of our presentation, and in some depth according to how deeply you want to go into it. I think the jury is still out on the potential gain from vacuum degassing, venting, and so on. There is an intense interest, and some companies have made a decision to adopt procedures and hardware; others have not. The consensus of the group is that that is appropriate at this stage of the game.

DR. SHEWMON: The final point I have is with regard to cracking of pipes, you are being shouldered around by the PWR people these days who haven't got such big pipes yet that are outdoing you in numbers currently. So, later in the day, while we still have the staff here, we will get into that topic, and if any of your group are interested and care in staying on, they are welcome.

MR. ROSSIN: One comment on that. Within the systems and materials task force of EPRI, we have got both BWR and PWR concerns. At this stage of the game, we have considered whether to broaden this group and this program to take -- to spread over into the area of the recent PWR cracks. We don't see that as appropriate at this point, and it probably isn't appropriate under the structure. But we do have another way to go at this.

The programs that EPRI funds are determined by this subcommittee of the systems and materials task force, and there are a number of PWR owners there. It is our feeling right now that if there is research necessary in this area, that it can be handled out of existing EPRI budget and that we don't have to form a new owners group to deal with it. This owners group has enough dealing with BWR problems. If another group has to be set up some day far down the line, we will do it. We don't see that with the kinds of problems that we see on BWRs.

DR. SHEWMON: It is not clear that the feedwater pipe cracking would be directly related, but at least from what I have heard of the stagnant line borated lines, that may well be. But we will get into that later.

MR. ROSSIN: Fine. Now what we would like to do, I would like to turn this program over to Karl Stahlkopf and his group from EPRI.

Let me explain one more thing. The owners have elected to have EPRI manage this entire program, just as they manage the EPRI work that they do for the utilities in general, and once these projects are under way, the project management in EPRI works on them just as they would if it was a normal EPRI job. They are going to present the whole program, and, once again, I must emphasize it is one integrated program and EPRI is managing the whole thing.

DR. SHEWMON: All right.

MR. STAHLKOPF: We would like to present now the technical program that has been put together both under the EPRI based funding and the augmented BWR owners group funding to deal with the problem of integrating their stress corrosion cracking in BWRs. For the members of the Committee, we have prepared a small handout which covers all of the viewgraphs which will be shown by the EPRI staff today, and additional copies of that will be made available if necessary.

(Slide.)

I would like to make my introductory remarks relatively short so we can get to the technical details of the program which will be covered by other members of the staff.

I think it would be perhaps worthwhile to put the the owners group program and the EPRI program in perspective by briefly taking a look at the incidence of pipe cracking, and see how we arrived at where we presently are.

(Slide.)

I think we are all familiar with these incidents. I think we are all familiar with these incidents. In '65, there was the first incident at Dresden I. At the time, people seemed to think it was a unique materials condition.

In '75, there were eight BWR plants in the United States which showed cracking. The assessment at that time was that we were dealing with a rare pile-up of stresses.

By '78 we were beginning to see some larger lines cracking in both Germany and the United States, and really, the assessment then changed to, one, then, no unusual conditions were reported relating in either materials or stress -- stresses relating to these incidents.

And if we take a look at the frequencies of cracking incidents -- This represents foreign as well as the United States plants -- in '75 we had '62 incidents of cracking, and this is both as determined by ultrasonic examination and actually leakers.

In '78 we were looking at 132 incidents, and this being updated, in October '79 there had been a total of 191 incidents.

DR. MARK: This gives the appearance that there was nothing between '75 and '78.

MR. STAHLKOPF: No. There certainly were, and it is a linear --

DR. SHEWMON: How many reactors were involved in the six of the foreign?

MR. STAHLKOPF: One, the KWRB, six pipes dealing with the feedwater inlet nozzles, and also the -- as I remember the inlet and outlet nozzles to the steam generators. It is a Dresden I type. It is a BWR, and there were incidents of cracking on both the heat-affected zone sides of the welds and also crackings in furnace-sensitized -- both in the --

DR. SHEWMON: I was curious as to how you counted.

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That is one reactor, not six reactors; six different pipes?

MR. STAHLKOPF: Six different pipes in one reactor. Each one of these incidents of cracking refers to a specific crack.

(Slide.)

I think from the number of cracking instances we have seen, certainly the perspective on IGSCC is the factors that cause it can no longer be considered to be rare. We think we understand a little bit more of why things are happening, but certainly, we can explain it in terms of susceptible materials, high-carbon materials, which are contained in the present plants.

You can expect the stresses on the levels which we have seen to cause cracking in them. Both oxygen and normal passage of time are going to lead to the type of incidents that we have seen.

(Slide.)

The question is what to do about it. Because of the history that I have laid out, the utility industry has become concerned with the potential availability and reliability problems surrounding pipe cracking, and the owners group, along with EPRI, has put together a program that in the next four years will pump over $40 million into research surrounding how to mitigate the effects of stress corrosion cracking in BWRs. Last year's budget in this area was about $10.9 million, which was augmented from a special EPRI fund in anticipation of setting up the BWR owners group; and in actual fact, EPRI has had an ongoing BWR pipe cracking effort for the last five years, so it is not a new program that we are starting. It is simply the augmentation of an ongoing EPRI program to treat the problem.

MR. ROSSIN: Before you leave there, that slide, there is one thing that maybe needs explanation. You notice in 1979, the existing EPRI program is $10.9 million. From '80 on the EPRI part is about $3 million and the owners' group about nine, or $4.9, and so forth.

What we did in 1979 was, recognizing it was going to take time to get the owners group together and the money, the Board of Directors of EPRI approved a one-time, one-year, big upgrading of the amount of money that EPRI would put in in this pipe-crack area. They did that so that we would have a large enough program going to meet the needs of the owners; but they did it on the promise that the owners would organize this group and get the funds together so that by 1980, they would be able to pick up a large share of that.

The normal EPRI budget on this kind of program would have been a maximum of $3 or $4 or $5 million, if it weren't for the promise of the owners group.

MR. STAHLKOPF: Our normal budgetary constraints in this area would be about $3 million. We got an excess of the

$7 million "kitty," as I stated before, in anticipation of the owners group being set up.

(Slide.)

I really don't think I will run through all of the formal presentation which is presented in your handout. That is because of limitation on time. I think it would be more appropriate to get directly into the technical details of the program.

One thing that I would like to leave you with in terms of philosophy of the EPRI program is that what we are trying to do, within this program, is to develop a series of on-the-shelf fixes; and these fixes can be applied to both existing plants and plants under construction.

Examples of these fixes will be given by each of the technical leaders as they go into the detailed discussions today. But I think we can see that already, some of the work from the EPRI existing program is now being implemented in the field: 24 plants presently are using solution heat treatment in their welded joints. Corrosion-resistant cladding has gone into 15 plants. Alternate materials, which is the low-carbon, nitrogen-strengthened 304 or 316 materials, are going into 18 plants which are presently under construction.

DR. SHEWMON: It is not clear to me whether those are retrofit or new plants, when you talk about 24 solution heat treatment.

MR. STAHLKOPF: I think both. As Dave so correctly said, each utility looks at its own specific problem. If they have had problems with leaking of target lines, then some plants have chosen either to go to solution heat treatment of welds in those lines, or to go to the replacement of those lines with the low-carbon material.

And so the numbers that are represented here represent both retrofits on the target lines and new plants which are under construction.

MR. ROSSIN: Paul, if we have time after the technical program has been presented, there are some utility representatives here. We could give you some examples of the specific things that various companies have done.

DR. SHEWMON: Item C on our agenda -- I am not sure you have been allowed to see this yet --

(Laughter.)

DR. SHEWMON: That allows the better part of an hour, here, for action taken by utilities.

MR. ROSSIN: Maybe we will get to it.

DR. SHEWMON: That is of particular interest to us.

MR. STAHLKOPF: Again, I think I would like to emphasize that our program, hopefully, is dealing with a variety of fixes which can be applied; and it is our purpose to ensure that all of these fixes be the alternate materials, corrosion-resistant cladding, different types of stress improvements which can come about through induction stress, really, through heat-sink welding, are all qualified, have been discussed with the appropriate committees and the appropriate NRC committees.

And we are developing what I would call on-the-shelf technology for utilization in BWRs to increase realiability of the piping systems. I would like to briefly show you what our program looks like.

(Slide.)

It is broken into three technical areas: plant resolution or plant problem resolution, which will be talked about by Robin Jones, dealing with determining the probability of the presence of cracking, how to deal with determining certain types of piping and talking about the consequences of cracking. Robin will be first up this morning. Remedy development, which will be discussed by Lou Martel; and remedy application, which will be discussed by Joe Danko -- I'm sorry. I have that turned around.

Danko will be discussing the applications -- Danko will be discussing the development and Martel the applications.

Because of the limitations of time, I would like to turn it over to Robin now to talk about the subsection of the program dealing with plant problem resolution.

MR. JONES: The resolution phase of the program is the part that contains the piping integrity analysis aspects. It applies to plants which are now in operation, and also plants approaching completion; that is to say, all plants which contain what you might call "off-the-shelf" grades of type 304 stainless steel, where there is a significant possibility of intergranular stress corrosion cracking developing.

We have three major objectives:

To provide the utilities with improved capabilities for predicting where cracks will form and for detecting them if they do form;

To provide models for predicting what will happen if the cracks do form, how they will grow, and what types of crack shapes and leaks are likely to develop; and, finally,

To evaluate the consequences of cracking from a system point of view: What kinds of leak rates we expect to get from intergranular stress corrosion cracks, how are they affected by loading.

I would basically like to spend about five minutes on each of these major objective topics, and tell you what the thrusts of our efforts are, and touch on the state of the art and how we hope to improve the state of the art.

(Slide.)

First of all, in the prediction and detection of cracking, we have three major thrust areas, shown here. We would like to develop improved methods of identifying vulnerable welds, mainly for the reason if you can identify the weldc that are going to give you trouble, that gives you the opportunity to do something about them before they give you any trouble. For example, you can apply one of the remedies that are being in the other parts of the program, such as redistribution of residual stress to reduce the probability of cracking. Or if it is a particularly critical line, you can do a replacement with a lower carbon material, or something of this sort.

The other two aspects of this part of the program are the development to improve crack detection capabilities -- We would like to increase the reliability and also the resolution of the techniques that are used in in-service inspection now.

And finally, we would like to develop improved leak detection capabilities to insure that if through-wall cracks are developed, they are detected in a timely fashion.

I would like to start with that last direction and talk about it very briefly, and then move back up to the other two.

Our perception of leak detection capability as a need is not so much for improved sensitivity of the detection system, but rather more for improved location of leaking cracks. The reason for that is that we believe the present in-containment detection systems have got plenty of resolution but they provide very little information about where the leak is in the piping system. And that means there is a considerable man-rem exposure in trying to find where the leak is.

We feel it would be a great step forward if we could improve the location capabilities of the leak detection systems. Our efforts in this area are really not past the planning stage yet.

We have looked at methods of locating leaks in complex systems and we have noted that in the United Kingdom submarine program they have had good success with acoustic techniques. As part of our program, about six months from now, we will be measuring leak rates, and at that time, we intend to use some acoustic work to assess the feasibility of leak location using acoustic methods.

If that looks promising, then we would get into the development of a prototype package, instrumentation package, which would then go to field trial. So we are talking about a fairly long lead time item here, probably several years, before we would have anything available.

DR. SHEWMON: Is this something that senses where the hiss is coming from in a room, or sits on the pipe and detects the direction or triangulates transmitting through the steel?

MR. JONES: It would be a triangulation type of system.

DR. SHEWMON: The noise would be transmitted through the steel, not the air?

MR. JONES: Right. I say that the first step has to be a feasibility one. You need to have some kind of "signature," if you like, for leaking pipes that would make it readily distinguishable from other plant noise. You also need to worry about how many transducers would you have to scatter around the system in order to give yourself a reasonable location fix. That is what we are going to look at first.

MR. MASCARO: Don't you expect a --

MR. STAHLKOPF: If you look at the success the British have had in terms of looking at the signature levels between two corresponding transducers and assuming that the transducers are all calibrated to the same sensitivity and knowing what pipe runs look like between the two transducers by looking at source levels in one transducer and another with a continuous signal, you can then determine how far you are from that source of one transducer.

MR. MASCARO: Based on time difference?

MR. STAHLKOPF: No. You are dealing with a continuous signal. You are strictly looking at a problem of acoustic impedance over the length of a pipe run, and back-calculating where the source must be to get this type of signal differential between the sources.

MR. JONES: In contrast to the leak detection capability, we are at the feasibility assessment stage right now, we are very much further along, in the crack detection capabilities area, as a result of several years of work.

We started at this four years ago. We have equipment becoming available which is already at the laboratory prototype stage and is ready to go into evaluation.

The first sorts of things we did were attempts, really to improve the resolution of conventional UT in-service inspection by improving the transducer designs. However, our evaluation led us to believe that that is not really what the problem is in detection of intergranular stress corrosion cracking.

There is plenty of detection capability there, but it is confused by the large number of geometric signals that you get in addition to the signal from the crack.

So a large part of our more recent efforts, then, had to do with the signal processing techniques, in particular using the adaptive learning network type of approach.

We are pursuing, really, two different kinds of systems and basically using the same kind of signal processing.

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(Slide.)

One is an automated system that gives you positioning information in addition to -- well, more accurate positioning information. This is the kind of system that I will be talking about again in a few minutes when I start talking about crack size capability.

We have also developed an instrument package that would essentially go along with a hand-held, conventional hand-held UTA examination, and the purpose here is to basically assist the operator or the inspector in making the decision whether or not there is a crack there. He sees the signal; he wants to have some assistance in making the decision, whether that signal is a crack or something else. We provide him with this package of equipment over here, which processes the signal, decides whether it looks like a crack signal, that it has already learned to recognize, and gives a substantial improvement in the accuracy of chords, at least in the laboratory.

MR. DILLON: Are these simulated cracks or actual cracks?

MR. JONES: They have been proved out in real intergranular stress corrosion cracks. We think it is important to do that.

(Slide.)

The kind of thing that one gets out of the signal

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processing is to take these kinds of signals, which look rather confusing to the eye, and make them into these kinds of signals where the indication of the crack becomes rather obvious.

In the -- we're also doing work in the area of portable equipment for high intensity X-ray generation, and that is at a similar stage to the UTA development. We have laboratory improved capability. We are moving into a field development stage. The time frame for the further development of these techniques is that we expect to conduct the field evaluation trials during 1980. We are anticipating that we will move into an implementation phase, where we start to make the equipment available generally, towards the end of 1980. And a large part of the effort, subsequently, will be through EPRI's NDE center, which will provide training and familiarization capabilities in the use of this new equipment.

DR. SHEWMON: Is there any manufacturer who will make it?

MR. STAHLKOPF: Yes, one of them, as I stated at the beginning of our presentation -- it is the philosophy of the EPRI program to provide off-the-shelf hardware for implementation in these programs. Presently the Adaptronics will be producing for sale the 4000 series, which is a signal processing unit which Robin has just described.

MR. SCHONBERG: Radiation, which is the company doing the development of the portable LINAC, will offer in their line for sale the LINAC to anyone who is interested in buying it. So all the programs we are going to be talking about today, we are making arrangements with the people who are doing the research or with subsidiary people, subsidiary manufactures, actual development for sale of all of the hardware fixes we are going to be talking about today.

MR. JONES: Moving back up the list we started with, the first item in the first objective area was how to identify the welds that are going to be vulnerable to cracking. There is already a technology for doing that, and it is based on formulation of two things, really, the stress rule developed several years ago by GE. This stress rule says that indication of severity of service of a particular weld -- it adds up to the stresses that the weld sees in this particular fashion (indicating).

It provides a magnitude of -- the index you finish up with provides an indication of how severe the service is. The original premise was that stress corrosion cracking won't occur if the stresses are maintained below the yield stress. That implies the index should be less than one. In combination with that, at least in recent assessment, there has been assessment of the carbon concentration of the high stress rule index welds. That provides an indication of susceptibility of the particular weld to cracking. If you have a combination of a high carbon concentration at a high stress rule, then you feel that there is some probability of cracking, and something should be done.

This particular approach has proven to be quite successful in defining the welds which will not crack. We have done quite nicely with saying that there are no cases of cracking where the stress rule index is less than one to date. We don't anticipate there will be in the future. Moreover, we have very few -- we know that the incidence of cracking in -- decrease sharply with decrease in carbon content. We can do a fairly good job of deciding which welds will not crack.

DR. SHEWMON: If you have one that will crack, how does that stress relatively to one, or the factor vary around the circumference of the crack, usually, the circumference of the pipe?

MR. JONES: The only terms that would vary from top to bottom would be the residual stresses, in some instances, and that is the largest single stress factor in the equation, and some of the thermal components.

DR. SHEWMON: Since they weld it all the way around the circumference, probably the stresses will be the same, or the residual stresses --

MR. ROSSIN: No, that is one of the keys to the whole subject. Actually, in applying the stress rule, some rules of thumb are used to give a conservative measure of the residual stress based on variations seen in other welds. So that really is kind of a limiting number in the stress rule.

DR. SHEWMON: Let me bring up something here that will interrupt this presentation, but bring a point in I would like to get on the record. When I first came into this job, I thought, "How silly and conservative can the NRC be. Everybody knows stainless steel is a very tough material, and how could you get a crack that would give you an instantaneous double-ended pipe break?"

As I grow a little bit older, I realize that cracks do sometimes develop around a 360 degree circumference, and that is probably the scariest part of Duane Arnold. One of the things I am particularly interested in here is, What are you doing? Or what are the chances of this thing developing into a crack which could come through -- around a fair amount of this, before you detect it?

MR. JONES: I am going to touch on that in just a couple of minutes, actually.

DR. SHEWMON: Fine.

MR. JONES: I think crack shape prediction is a

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very important part of our program, so you can look at this rule in its present state as being a necessary, but not sufficient, condition for cracking.

What we would like to do is develop something that gives us more sufficient criteria for cracking for all of the welds for this condition -- is not meant -- we would like to have some way of ranking the likelihood that they would undergo SSC in a bit more reliable way. We think we can do that by developing a second generation stress rule which includes some of the other variables that we know are important, like a number of stress cycles, the number of severity stress cycles and like the particular surface condition, what was done about grinding this weld, what was the final surface preparation, what about the welding conditions?

We have lots of information in the more basic programs that tell us the effects of some of these variables. What we need to do now is translate that knowledge into an engineering technique. The programs to do that are just now starting. They have been in place for only a few months. I really can't report to you any startling successes. I think the approach we are taking, of including more of the important factors, will certainly give us a better discrimination than we have now.

Another thing we are doing is making in-plant measurements to try to qualify what the ranges of some of these stresses actually are in-service. What kinds of real stresses are the welds seeing, as opposed to the design stress? What is the range of them? And the other aspect of it is, what variation and susceptibility do we get in typical welds? At the moment, they are being treated as being all the same.

Those things will provide the basis for a probabilistic approach of the type that is now used by the aerospace industry.

(Slide.)

The second major thrust area in the problem resolution phase of the work has to do with defining what happens if a crack does form. There are, again, three kinds of thrust areas. One of them is NDE improved crack sizing and surveillance technique. The other two are piping integrity types of things, prediction of crack growth and crack shape, and margin assessment, various considerations of cracks in loadings.

It is probably easiest to describe how these go together in terms of a structural integrity plan of this sort.

(Slide.)

This is probably familiar to all of you. It is our version, if you like, of the structural integrity plan that is in Section II of the Code. I will go rapidly around the loop here.

A crack is detected and sized, or else it is postulated. We do a crack growth analysis on that particular crack to decide how it will grow as a function of time. The inputs to that analysis, there is something about the crack growth in kinetics, and the loading that is driving the crack growth, and sort of analysis technique that is generally used is linear elastic type of analysis. This allows us to develop information on the crack size and shape as a function of time. That becomes an input to evaluation analysis, which says, What is my remaining safety margin?

The evaluation requires as an input the worst case accident loading that you care to postulate, plus information on the strength and ductility of the material. Based on the output of that margin assessment, one would tend to -- the Section II approach would be to decide, Is a repair necessary or can we continue operation? Perhaps with the addition of in-service inspection of ventation or a crack surveillance technique.

DR. SHEWMON: Does the Code speak -- I guess I will address to you, Warren, does the Code speak to what would be allowed to continue to operate there, and has the NRC signed off on what they would allow for pipe cracks in major pipings in BWRs? Or is this getting ready for that discussion, should it come?

MR. HAZELTON: I think Section II now primarily addresses fatigue cracks. Here, we have a different mechanism and I don't think we have the technology ready yet, but that is what I think he is getting to.

MR. JONES: Right now we don't have the technology to do this. There may well be cases when we have all of these boxes filled in where we could show, perhaps, continued operation would be justifiable. But that is not really the main thrust of this effort. The main thrust, or the reason for putting it into this kind of formalized arrangement, is to make sure that you address all of the proper issues and don't miss anything that is important. If you can do this kind of loop, then I think you can say that you can understand the cracking process and what it means to the piping system.

So, where do we stand on this? Well, we can do with improved methods of sizing, crack sizing information, as one of the inputs here to the crack growth analysis. That particular area is one which is just an extension of the crack detection work that I discussed a few moments ago. You need more exact positioning information. You have to integrate a large number of different methods to get accurate sizing information. We visualize more or less the same approach and with about a one year or so delay in time frame, compared with the crack detection equipment I told you about.

So we see the availability of improve cra sizing capabilities coming along in the, sort of '81-'82 time frame.

Coming around the loop here, the crack growth analysis, which I will come back to momentarily -- we have programs going on now to quantify what the rate of stress corrosion cracking is as a function of variables like loading and like number of cycles per unit, time, and oxygen concentration in the water and temperature, the kinds of things that you believe are important there for the service. We are also looking at the possibility that the crack growth characteristics might change as a function of time due to low temperature sensitization of the material, and the output from that is basically the capability to predict crack growth in test specimens.

We want to predict crack growth in pipes, and that requires a couple of more steps to be taken into account, one of them being the influence of residual stress distributions, which give you steeply varying driving forces as a function of distance through the wall, and the other being composition changes that you can get as the crack comes up and intersects the weld, as opposed to going through the base metal. Those are also being studied.

We plan basically, then, to try to use the base line information together with models of these other effects to predict the behavior in cracked pipes, which will then be used as a verification experiment. I said we are trying to use linear elastic models for the crack growth analysis. We think that is justifiable because the plasticity which occurs, although stresses c ι be up near the stress locally, plasticity is well contained because usually local stress near the yield stress is accompanied by local stress somewhere else.

We can also do quite a little of analysis. We may not have enough data to finish the model, but we can do analysis. We find that the residual stress distribution is the real big factor in the crack growth analysis.

(Slide.)

This is a plot of the driving force in terms of stress intensity factor, as a function of distance through the wall, for a 28-inch circulation recirc line, considering residual stresses, using distributions which we have measured previously in normal operating stress of about 10 ksi, which would be typical for a particular weld joint in the main recirc line. And the result one sees is that the driving force varies almost exactly the same as the residual stress distribution; in other words, the residual stress is dominating all of the other components in the driving force -- remembering that negative stress intensity factors have no physical meaning.

What this says to you is that as the crack propagates through, if there was essentially no resistance to crack growth in the material, the crack should stop at about this point here (indicating). This raises the possibility that certain kinds of residual stress distributions could lead to arrested cracks. And contrasted to this, a four-inch diameter line, the residual stress distribution can be tensile all the way through the wall at some location, and the corresponding curve would be one that rises rapidly with increasing crack depth.

In those cases, we would expect rapid propagation. And we have done some calculations that confirm that is what should happen.

(Slide.)

This is a comparison of the probability that a leaking crack will develop after cracking has initiated, through a four-inch and 26-inch line, in the absence of residual stresses. The probability is pretty much the same. After the residual stress distribution we have a tremendous factor of difference in the essential life prediction for these two lines.

DR. SHEWMON: Why is it you predict such a difference in residual stresses?

MR. JONES: Because of the nature of the residual stress, it is different in the large diameter. The large number of passes produces an axisymmetric residual stress distribution, which has a compressive zone near to the inside surface of the pipe. That is not true in the number of passes in a four-inch line. In that case you can get some aximuths around the circumference. And then you have compressing all the way through the wall, that has very important ramifications to crack growth and crack shape, which has to be taken into account.

We are then looking at residual stress distributions, measuring them in representative pipe sizes, and trying to develop techniques that would allow us to do that in the field, and that, together will the base line crack growth information, should provide us with the capibility of predicting crack growth shape.

(Slide.)

The evaluation of the end-of-life flaw -- or perhaps it is not end-of-life, but the flaw size that you got at the next refueling outage, what is required here -- this is a ductile fracture problem. We have a very ductile material here, and the linear elastic approach is simply incorrect for treating the fracture of stainless steel. We had been doing work for several years on the development of ductile fracture methodology, and we have arrived at, in conjunction with General Electric, a rather simple conservative nalysis that allows you to quantify the failure margin for cracks of various sizes.

(Slide.)

This is a function of the loading. This is now a statically loaded case. We look at this one up here for the moment (indicating). The case one is an idealized crack. What we have plotted here is the fraction of -- the fraction of curve circumference, that is the crack size kind of plot.

And the boundary indicates the point at which ductile fracture could initiate. This is now a conservative analysis. We are not going to take advantage of what happens after initiation. This is the initiation-based analysis.

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This approach has been both analytically and experimentally verified for initiation of failure. And the one real remaining thing that has to be done is to decide how to use the dynamic loading, as opposed to static loading. We are looking at that now.

This would be how do you use this kind of approach, which is basically for static loading? Would you apply it to earthquake loading situations?

(Slide.)

You can do other sorts of geometries and get different kinds of data plot depending on what kind of geometry you are considering. This is a similar kind of diagram with different axes for the Duane Arnold-shape crack. This one was the one that was leaking, and this is the -- this is the margin for initiation of ductile fracture, again in the normal loading.

DR. SHEWMON: What does that mean, the initiaion of ductile fracture?

MR. JONES: That you could not start the ductile tearing fracture process until you are on this side of that line.

DR. SHEWMON: It doesn't say anything about whether you have a 100-inch crack or a complete break?

MR. JONES: That's right. So far we haven't addressed the problem of what happens if you do exceed that

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line. That is part of last area, which I will get to, that is the consequence evaluation.

(Slide.)

Basically, in this area we are concerned with three sorts of things. One of them is the one that Dr. Shewmon just alluded to: What happens if you exceed the fracture, and the ductile practure process starts? What will be the consequence of that? Will we get a leaking pipe? What kind of a leaking pipe?

And that is the second area here, where we are going to attempt to quantify leak rates for pipes with certain straight cracks subject to certain loadings.

There are other possible system consequences of cracking, too. We would like to look at them a little bit further downstream. The kinds of things we are talking about there are the possibility of multiple breaks. If you get one large loading impulse, what is the probability that more than one pipe could break? Is there any probability that failure of one pipe would trigger failures in others that had part-through cracks in them?

The problem of leak before break really comes down to ductile material, like stainless steel type 304, to determining whether crack extension is a stable or unstable ductile fracture process. This has been addressed recently by an analytical approach, where it was treated -- they treated simulation of safe ends cracks in Duane Arnold and came to the conclusion that there was considerable remaining margin, if you like, to initiation of unstable crack growth.

We are extending that particular approach and also validating, if you like, with numerical approaches that don't have to make quite as many assumptions as the analytical approach.

DR. SHEWMON: Where was this published?

MR. JONES: Tada -- NUREG -- there is a reference to it in the study group report. It is the Washington University analysis. That particular area I think is well in hand, and I think the present results suggest that the likelihood of getting an unstable ductile fracture in piping systems with the sort of designs we have in recirculation piping is very remote indeed.

That brings attention to what kinds of leak rates could we expect then from stable cracks subjected to various types of loadings? And that means that we have to do two things: We have to be able to predict crack shape. This is the kind of sequence of crack shapes you get in the stainless steel, the crack extension going on with a great deal of widening. The sort of scale here is of the order of an inch at this stage, the crack separation having started up at this crack.

If you want to predict leak rates, you have to be able to predict this kind of behavior. And using the ductile fracture mechanics that is being developed at EPRI, you can come pretty close already. This is the crack configuration with everything normalized, normalized stress against open area of crack. These are the data from the previous slide, and this is the prediction for the elastic fracture mechanics.

It is slightly conservative. It overpredicts the crack opening area.

(Slide.)

We are going through some additional work in this area. Having predicted the area, now you have to predict how fast will the plume come out through it. That is relatively straightforward for blowdown analyses for large orifices. But if one does calculations for through-wall cracks in the sensible types of loads, you don't have very large orifices. In fact, you have crack-like defects, as opposed to actually symmetric things that are treated in blowdown analysis. That has not been treated in the past, the relatively tight cracks.

We are treating them two ways. We have a small analytical effort to try to see how to adapt blowdown models to that particular case, and we have somewhat larger experimental efforts which will be measuring leak rates as a function of crack configuration to provide the experimental basis for a predictive model.

In summary, in this area we have three main thrusts:

One of them is the prediction and detection of cracking.

The next is the development of the technology to predict what happens if cracking does initiate.

And the third is the assessment of what the consequences of intergranular stress corrosion-cracking might be in terms of leakage rates and for a variety of postulated loads.

Thank you.

DR. SHEWMON: Thank you.

Any other questions?

MR. DANKO: My name is Joseph C. Danko. I'm with the Electric Power Research Institute, and the subject of my presentation is the pipe remedy development.

(Slide.)

The objective of the pipe remedy development activities is to develop and evaluate pipe remedies for application to the BWR recirculation piping system and to demonstrate the fact of improvement of these pipe remedies over a reference or as welded 304 stainless steel pipes.

The technical approach really is based on an understanding of the mechanism of stress corrosion cracking. At this point in time, I feel that we have a very good understanding of what is going on. It is related to three critical factors:

One, a sensitized microstructure is required. This is produced in the welding of normal 304 stainless steel. There is a need for a stress intensity or strain time factor, and of course a need for an environment, superimposed such that they have coincidence in one area. And this can give rise to the intragranular stress corrosion cracking that has been observed in the stainless steel piping in the BWRs.

Based on this model, we can select pipe remedies that would provide a solution to the stress corrosion cracking. And you can take individual items, or combination of these three critical factors, in selecting remedies to eliminate or to avoid the problem.

Obviously, if you take one of these factors and completely break it away from the coincidence, you would essentially have immunity to intergranular stress corrosion cracking.

Obviously, if you work on two factors, it is quite possible to minimize this area here, which really, in a simplistic way, can be looked as a probability area. By significantly reducing this, you can essentially avoid stress corrosion cracking over the lifetime of the plant, jlBWH

which is considered at this point to be 40 years.

So given this information, we have selected a number of pipe remedies for evaluation and to verify that they will provide factors of improvement required for plant operation.

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What I would like to do is cover some of these pipe remedies and also to indicate what specific area, based on the Ballantine circles that we were attacking.

Solution heat treatment; the intent here is to take the shop welds, solution heat them, and in doing so you obviously eliminate the weld sensation and also eliminate the weld residual stresses associated with that weld. The application would be for shop welds, and it can be applied for plants under construction, and for several pieces for repair of existing plants.

The area of the corrosion-resistant clad; the objective is to attack the sensitization problem, to place on a weld deposit from 308L weld metal with a controlled delta ferrite. And based on laboratory test and field operation, if you get the delta ferrite content high enough, it will prevent stress corrosion cracking. And, typically, we are looking at levels on the delta ferrite. In the weld deposit, this corrosision-resistant clad is placed on the ID such that the butt well is complete protected. So the heat-affected zone does not see the environment, and it has eliminated the sensitization factor of the Ballantine circles.

The application here would be for shop welds, and it has application for plants under construction and for repair activities.

The corrosion-resistant clad, as deposited; this is a case where you just take the 308 weld metal depoit on the ID pipe, as opposed to the CRC with the solution heat treatment.

And in the case of the solution heat treatment, you avoid any possibility of desensitization, that transition from the CRC to the base material. The CRC, as deposited, has field application and would cover plants under construction and for repairs.

The heat sink welding is an approach where after you make the route pass on the weld you introduce flowing water or a very active spray water on the subsequent weld passes; and in doing so, you provide a state of residual stresses in the heat sink weld that results in a compressive residual stress pattern on the ID. So this would be attacking the stress factor of the Ballantine circles. And this approach has application for field welds, pipes under construction, and for repairs.

The induction heating stress improvement, which is a technique that was developed in Japan, is applied to welded pipes. You take the OD of the pipe with an induction coil, heat it up to approximately 500 to 550 degrees C. for a short period of time. While you do this, you have water flowing on the inside of the pipe, and you end up with a complete redistribution of residual stresses in the weld area, such that there are compressive residual stresses on the ID resulting from this process.

Again, the thrust here would be to look at the stress factor that contributes to the stress corrosion cracking. Application would be to field welds and plants under contruction and for repairs.

The alternate pipe alloy; this is to eliminate sensitization with the weld heat-affected zone. And the alternate alloys would be applicable for plant under construction as well as for pieces for repair activities.

So these currently are the major pipe remedies that are under development, under evaluation. And there are additional concepts emerging as we continue the development activities.

For example, you may have heard of the crown weld passing. This has come up as a concept based on the residual stress analysis, the idea being to take a pipe that has already been welded and just have a fusion pass on the crown weld, water flowing on the inside; and, in effect, it changes the residual stress pattern of the pipe. It would be similar to the heat sink, except the application would be on a pipe that has already been welded.

Another concept that has emerged is to reduce the stresses on the pipe by applying a back leg or a weld deposit over a large portion of the OD of the pipe. Again, you can do this with water flowing on the inside, or it can be done without it. The intent is to reduce the stress level on the heat-affected zone of the pipe.

MR. BENDER: Are you going to say anything about what size piping goes with what methods, or do they apply to all sizes?

MR. DANKO: I will touch that.

MR. BENDER: All right.

(Slide.)

MR. DANKO: If we have these pipe remedies, one of the real questions is: How do we verify that these remedies will actually work on hardware that has been failing?

In the past, testing has been pretty much confined to small specimens. This is a way the stress corrosion cracking testing has been done.

The limitations of that testing technique were recognized by General Electric a number of years ago. At that time they felt it was important to get to the actual hardware testing, so the pipe remedy verification is really based on testing full-size, welded pipes, which utilize as well the 304 stainless steel, which is the reference base to make the comparison with the pipe remedies. And then you can statistically evaluate the data and come up with a factor of improvement for the pipe remedies.

The field data were analyzed and statistically a factor of 20 was required as margin of improvement over the referenced 304 stainless steel to demonstrate that the pipe remedy would be capable of running for 40 years or the plant lifetime. So this factor improvement over reference 304 stainless steel is important to remember as we talk about the pipe remedies and the verification of these pipe remedies.

Now, the test on the full-size welded pipes have been pretty much limited to four-inch diameter pipes. A few tests are planned which will extend all the way up to 16 inches in diameter. The tests are performed under accelerated test conditions to promote or enhance stress corrosion cracking. The temperatures typically are 288 degrees C., which is the approximate operating temperature of the pipes in the circulation system.

Stress levels have been taken to be above yield, namely 136 percent of the yield stress on the base materials at the temperature. The cyclic rate is used of .67 cycles per hour. This is found to also be a powerful accelerant to the stress corrosion cracking. And in the environment there is introduced in the high purity water 8 parts per million of dissolved oxygen. This is a powerful accelerant.

DR. DILLON: Could I interrupt just a moment? It is conventional to accelerate the environment with oxygen. I appreciate that, but I've always had an uneasy feeling about the unspecified effect of cholorine -- chloride, I should say, particularly as it might be involved in the film formation process, whether that has any significance to the actual environment in which we are dealing with the problem.

MR. DANKO: The particular environmental conditions that we depicted here were based on the specifications for a BWR. And a number of years ago there was a series of tests performed at GE examining the question of chloride additions. They covered a range of chloride and, at least for the small laboratory test group, it demonstrated that within the specifications there were no detrimental effects associated with it.

MR. DILLON: I am thinking back to the old Savannah River problem. Remember their nozzle problems, where the problem was eventually related to significant chloride involvement in the oxide deposit on the nozzle, even though the water was maintained at negligible chloride levels? I am just curious as to whether or not this has ever been looked into as a major factor?

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MR. DANKO: As far as I know, that particular problem has not been examined as far as the chloride formation and the breakdown of film; we have a tight control of the water chemistry.

DR. SHEWMON: What is the typical chloride content in an operating BWR?

MR. DANKO: We have a stack on that. I think it is rather complicated. There is a period of time when you can tolerate a certain level and then if it exceeds that, you have to shut down. I am not sure of the exact number.

MR. HAZELTON: It varies with temperature.

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MR. ANGLE: Our spec is one ppm for 24 hours.

DR. SHEWMON: So part of his question is: Do you think you would get different results if you operated with typical BWR water instead of this?

MR. DANKO: And I addressed that question by stating that a lot of laboratory tests were performed many years ago addressing the question on the water chemistry specifications with respect to chlorides.

DR. DILLON: My point is a little more complex than that. I am concerned about the actual chloride content incorporated into the oxide film itself, which could be the result of a long-term exposure or it could be an accumulation on transients of various sorts.

MR. DANKO: The particular program here on the pwa-2A

verification does not address transients chemistry, but in the alternate pipe material program, there are some tests planned where transient chemistries will be examined.

MR. MARTEL: This is related to the presence of aluminum? That is an additional factor, besides the average chlorine in the water, that it is combined with the chloride and then it is selected with the deposit with the weld.

In order to translate that experience to BWRs, you have to at least address the comparability of the presence of aluminum.

DR. DILLON: I am not going to draw a one-to-one comparison. I am simply concerned with the possible incorporation of oxide in the weld part, and I want to understand what you mean by "acceleration due to cyclic rate." It doesn't accelerate it beyond anything. It would simply reduce.

MR. DANKO: Time to failure. The intent here was when the first pipe tests were performed, they were done under the kinds of load conditions and the test times were going out further and further in time. And obviously, if you want a test that you can case and get results to apply to your plants, and there are a large number of plants under construction, you want a test that accelerates the time to failure. So the cyclic rate was found to accelerate the time to failure on the as-welded pipes. The particular cycle that was picked came about by some experimental work in the cyclic testing of pipes. Perhaps it is still not an optimum in terms of minimizing the times to failure of the pipes, but the test results are right at a point --

For example, typical 304 stainless steel pipe, with 05206 percent carbon content, under these test conditions, were failing in like 100 to 200 hours. If you did not cycle, you might be running out to 1000 hours.

MR. BENDER: Could you clarify this factor of 20 criterion? It sounds impressive. What does it refer to? Over what?

MR. DANKO: Typically, if you examine the failure histories of the pipes in all of the BWRs, the statistician examines the data and says, "Okay. If you really want to verify these pipe remedies will indeed operate for a 40-year plant lifetime, this is what you are going to have to do."

He took a look at the distribution curve on failures, and the times of the failures, and then he did the typical statistical analysis and said, "Okay. Here is a family of curves that we can use, with this number of welds and this number of pipe tests, and for these test times compared to the reference 304 stainless steel, you can get -- you will need a factor of 20 over the typical failure history of the 304 stainless steel."

This is a very conservative estimate. For example, if you take a look at the average failure time, the time that this was done, it was like five years. So you take a factor of 10 times that. It is 50 years; which is like the plant lifetime.

MR. BENDER: That doesn't mean very much. I think the question I am trying to get at is: Assuming I want to establish a factor of 20, what in the test program will tell me that I have established it?

MR. DANKO: What you have to do is to determine the distribution of failure of as-welded 304 stainless steel pipes of the same diameter, which has been done.

Taking that mean time to failure, you say, "okay; the mean time to failure says it is 200 hours." So a factor of 20, roughly speaking, would be 200 times the 20, or 4000 hours of testing.

So if you would take the pipe remedies in that same pipe configuration under the same test conditions, and if you went out to 4000 hours without a failure there, you have achieved the test criteria of a factor of 20.

MR. BENDER: You are telling me you are going to extrapolate the accelerated tests to the in-service performance; is that what you are telling me?

MR. DANKO: That's what we are doing, yes.

MR. BENDER: Is that a comparable basis?

MR. DANKO: Well, it is one that is based on the failure. It is one that we had to get some acceleration into the tests. So far as we can determine, the fact that we have added a lot of conservatism into the 20, I think basically people feel fairly comfortable with it.

We do need more testing. We have to extrapolate that into the bigger lines, and I think that there is still an additional factor that is going to fall out of this that says, "yes; it is extremely comfortable, using this test technique to verify."

DR. SHEWMON: It is a fair filter. Whether it is a best filter --

MR. ROSSIN: That is the key point. This isn't the only way to get a definitive figure of merit, but this is a very good way to get a screening so we know what techniques are worth pursuing further. We are not basing all of our conclusions about whether something is really going to work for the lifetime on this one test. It does enable us to cull out the ones that don't have promise.

DR. SHEWMON: I guess the one place I have heard where I didn't like the results of this was since you are going up to 136 percent of yield, if there are techniques that set up residual stresses, like the things you were talking about earlier, the in-service heat treatment, then this doesn't treat them very kindly, because it wipes out the residual stress in a few cycles. Is that a fair --

MR. DANKO: That is a good point. One of the things we are questioning right now is that on some of the pipe remedies, like heat sink welding, we will indeed -- The stress levels here, will they override the residual stresses placed into the pipe as a result of the process? Is it possible, then, to just wipe out those favorable residual stresses?

And there are tests underway to evaluate whether we are exceeding the conditions. We have tests planned at 110 percent of the base material yield stress at test temperatures. They are residual stress measurements being planned on pipes that have been processed by heat sink welding and IHSI.

They will be measured before and after to see if they are, during the testing, whether they are being shaken down. It is a good question and one that has been specifically addressed on the pipe remedies where you are looking at favorable stresses.

DR. CORTEN: Is that in a range, that 136, where you can control it? Or should you control that strain then?

MR. DANKO: It is another question that has been kicked around a number of times. A stress value was selected based on some actual early tests, where the pipes are

**? (inaudible).

So we actually measured the strain and calculated the stress value, and we are still evaluating whether we should be addressing stress or strain. But for the time being, these are the test conditions for the testing program.

I do want to make another point here. You will note by the bottom line here that we are not relying solely on these pipe test results. We are running a large number of stress corrosion tests. There are sensitization tests being performed on these pipe remedies. Electrical-chemical measurements are being performed, and all this data, then, will be analyzed along with the verification of pipe testing to make a proper engineering decision on these pipe remedies.

(Slide.)

Also, I mentioned earlier that a number of the pipe remedies, there are plans to test pipes up to 16 inches in diameter.

Then in the program that is planned for the next few years, we are going to extend that all the way up to pipe sizes of 26 to 28 i ıches in diameter, just to make sure there is no surprise. It is going to be costly, but it will add that extra engineering piece of information that, "yes, we have tested full size," and cover the entire range of pipes in the recirculation system.

(Slide.)

This particular table here presents the iatest test results on the verification of these pipe remedies. For example, on the solution heat treatment, we have factors of improvement ranging from 2.3 greater than 20. The reason there is a range of values here, we are testing three heats of material, and statistically, we didn't want to limit the test to one heat. And you pick these heats of material randomly, and some of them are extremely resistant to stress corrosion and cracking.

And since the factor of improvement is based on the failure point, the first failure point, we have not been able to fail some of these highly resistant materials; and hence, there is an improvement quite low.

Now, there is one heated material which was very susceptible. In fact, it was susceptible in the as-received condition; and that particular heat failed very rapidly. So we have gone well in excess of a factor of 20. The last figure was like a factor of 67 improvement; so it really demonstrates that the solution heat treatment of the shop welds is a viable remedy for the stress corrosion cracking.

Some of the other heats are out to times of 8000 hours with no failures, and the tests are continuing.

Unfortunately, the solution heat treatment is something that you can not apply to all welds. This is a shop practice, and at best, you might be able to get to 40 or 50 percent of all of the welds in the recirculation system.

The corrosion resistant clad: This is the field application, where you just apply the 308L weld metal on the ID and do not perform any subsequent heat treatment. Factors of improvement are 1.7 to 6.6.

In one heat I had mentioned, we had failures in this one heat at the transition between the corrosion-resistant clad and the base material. That is this factor here of 6.6. The other heats that are quite resistant are still on test, and those have experienced no failures out to test times of close to 7300 hours. These tests are continuing.

It does raise a thought here that if you want to apply this particular technique, and if you have a susceptible heating material to begin with, you want to be extremely careful on using this particular method.

On the shop application of the corrosion-resistant clad, again we have exceeded the factor of 20 improvement for this one heat that is very susceptible, and it is out to a factor of like 67 right now.

The low number here represents the heats that are very resistant, and those have shown no failures and the test times are up to 7600 hours.

The CRC shop application looks like a very viable pipe remedy on the heat sink welding specimens tested at 136 percent of the base material yield stress. We have factors ranging from 3.8 to 12. What we have found here is the surface condition in the heat sink welding, as well as other pipes, is extremely critical.

This range of factor of improvement is 3.8 to 12. The one set of pipe test specimens, the particular vendor did a very good finish on the heat-affected zones. In another case, there was a typical machine surface. And where we had the machine surface, we have a factor of improvement of 3.8. For the one that had a very nice finish on it, we had a factor of improvement of 12.

Then the question comes up which relates to your question, Paul: Were we really wiping out the benefits by testing these high stress levels? And we are going to evaluate that based on pre- and post-residual stress measurements, using qualitative checks on it.

It does show that there is a factor of improvement using the heat sink welds. Initially we felt that this would be primarily related to the distribution of the residual stresses. Some sensitization measurements made on these pipes recently failed, and they showed that the values of sensitization based on the electrical-chemical-kinetic reactivation technique, shows that the heat sink welding is actually providing a lower level of sensitization in as-welded pipes.

There are some benefits to the sensitization area and certainly there are major benefits in the weld residual stresses. On the 110 percent test, no failures. Maximum test times are out to 2500 hours, and the program manager at GE says they have had but one failure. That was at 3000 hours, and it is being analyzed.

The IHSI pipes are being prepared for test. There are a series of pipes that will be tested here, including both the 4-inch and going all the way up to the 16-inch diameter.

On the alternate pipe material, a number of remedial materials were originally tested in what we call the "screening test," 304 stainless steel, nuclear grade, and 316 nuclear grade. This is the GE designation, which is .02 carbon max, and .1 nitrogen max.

These have been selected from a large number that were originally in the screening test and they are being carried to what we call "qualification testing." These are in progress. They have exceeded 20, a factor of 20.

These represent many more heats of materials and will go up to pipe sizes of up to 16 inches and then eventually, to make sure there is no surprise effect, will go up to the 26, 28 inch pipe testing on these materials.

There is a great deal of testing continuing on these two which includes laboratory tests, of course; electrochemical stress corrosion tests, sensitization tests. But these two materials look very, very good as an alternate to the 304 stainless steel.

MR. BENDER: What was the old carbon spec on 304?

MR. DANKO: It is ASTME, which is a .08 carbon max.

MR. BENDER: Were you working to that previously?

MR. DANKO: It had been ordered to the ASTME spec, so it covered a range of up to .08 max. If it exceeded that, then it was in violation of the spec, and they had to reject the material.

MR. BENDER: For some reason or other, I thought that there was some reduced requirement, even for that material. Maybe my memory is poor.

MR. BERRY: Are you also looking at the long-term metallurgical stability of the nitrogen and low-carbon heats?

MR. DANKO: Yes. There are long-term tests in progress, and there are some fundamental studies going on to examine the nitrogen effects. And in fact, the preliminary data that have been generated in the General Electric Research Laboratory show that these low nitrogen levels, there seems to be a beneficial effect from nitrogen on retarding sensitization. It is not quite well understood why it is happening, but it does happen.

DR. CORTEN: When you specify, is that on the minimum as specified? Or is that actual yield?

MR. DANKO: These are the actual measured values of the pipe.

DR. SHEWMON: It is my understanding, is it, you feel you can get this nuclear grade in under the umbrella of the previously approved 304 with regard to ASME because it falls in the lower end of their range?

MR. DANKO: That is correct. It has been checked with the Subcommittee, Section 3, and they will accept that.

The key thing here is .1 nitrogen must not be exceeded. Then it puts you into the L classification. That is a little different classification.

If you maintain .1 nitrogen max, you will fall in with the conventional 304 chemistry specs.

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DR. SHEWMON: What was the nitrogen, the 07 carbon steel for the older plants?

MR. D'NKO: The specifications generally did not call for a nitrogen analysis. Typical mill search do not show nitrogen unless you do your own cross-check on the chemistry, which all of these pipe test results have been using.

MR. BENDER: What would you normally expect?

MR. DANKO: On those, 05, 06, in that ballpark.

I would like to move on to the status of the pipe remedies. Carl touched on this briefly in his introductory comments, but the solution heat treatment of the shock welds has been applied now to 15 boiling water reactors under construction using 304 stainless steel.

As I mentioned earlier, you can get about 40 to 50 percent of all of the ones in the recirculation system using the solution heat treatment of the shop welds. The corrosion resistant clad application has been used now at 15 plants under construction. Based on the results so far of the heat sink welding, GE has recommended that for field welding of 304 stainless steel, that heat sink welding should be considered and applied where possible.

The 316 nuclear grade -- there are 16 BWRs under construction now that have committed to using that in part or in the entire recirculation piping system. In fact, there have been some cases where the utilities have actually scrapped out the complete 304 stainless steel piping, a good decision on their part — expensive, on the other hand, but the 416 nuclear grade, based on all of the test results we have right now, certainly should meet the requirement of a 40-year plant lifetime without the stress corrosion cracking incidence.

This is a case where the utilities have seen the data, recognizing that it is a much better material than 304 stainless steel, and have shifted to the new nuclear grade composition.

On the IHSI, development is still in progress; but I would like to report that a number of plants in Japan have utilized it. They based their decision on a great amount of residual stress measurements, a great deal of laboratory testing; and the only thi.. that was not in their decision package was actual pipe test results. Those are currently in progress as part of this development program.

MR. BENDER: With regard to the solution heat treatment, what chances are there for that process to go wrong? Is that a foolproof process?

MR. DANKO: If the vendor follows the specifications, I would say it is essentially foolproof. And that is that -- there is a time-temperature relationship, and then there is a cooling rate that must be achieved to make sure that there is no precipitation on the carbides during the cooling. That means a very rapid quench with the thermocouples attached to verify that we have achieved that condition.

MR. BENDER: If I were to use that for in-service maintenance, is it a viable idea?

MR. DANKO: It is not applicable right now for utilization in existing plants, because you are faced with a situation of heating locally a weld up that temperature, and there will be a transition somewhere where you are facing with cutting through a sensitization regime which could put you into a very susceptible area for stress corrosion cracking.

MR. ROSSIN: What has been done in a couple of cases where a piece of pipe with certain welds has to be replaced, and that piece is of a suitable size so they can do the shop treatment, ship the whole thing in, and then you do have two field welds, and there is no way you can rot those. At least you've got the best quality of material you get in between the two.

MR. DANKO: What you can do in that case, and this is the reason for the corrosion resistant clad in the shop welds, you can put on the last weld that is going to be applied in the field, a corrosion resistant clad on the ID. And when you apply then the solution heat treatment, you

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e.iminate the zone that exists between the corrosion resistant clad and the base materials such that when you make your final field closure, at least that side of the weld is protected. Then the rest of the piping should be solution heat treated, as Dave pointed out, so all of the other joints would essentially have immunity to the stress corrosion cracking.

MR. BENDER: When I perform that operation in a shop, is there anything besides the heat treating will tell me that it is done right?

MR. DANKO: There is a certification required, which is part of the quality assurance program. And the documentation of the heat treating and the documentation of the cooling -- there have to be records for that, identification of the heats and --

MR. BENDER: But there are no property measurements?

MR. DANKO: Joe, you can help me out on this. Do you use the EPR on the solution heat-treated pipes from the shop procedure?

MR. LEMAIRE: I believe all of the material used in current specifications of the 304 variety do require either an ASTM or an EPRI type of screening test to be performed. That would be an additional check on heat solution treatments as well. That would tell you whether

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anything went wrong.

DR. SHEWMON: What is an EPRI test?

MR. LEMARIE: Electro-potentiokinetic. It is applied locally to the material.

MR. DANKO: It is a sensitive test for picking up the sensitization.

MR. ROSSIN: Before you go into your next topic, I just want to point out that the largest contractor of EPRI in this area, of course, is General Electric Company. Part of their facilities in San Jose include this pipe test laboratory, which is unique in this country. The amount of equipment that is there we have no way to duplicate. GE, being a major contractor, is also a cost sharer on this; and the EPRI contracts with GE involve participation through GEN.

This is extremely important, because it will move forward rapidly. But also I think it is due to the fact that GE was already moving in these areas and had a number of these laboratory facilities in existence or under construction back when we first got into this problem.

MR. BENDER: There are no independent activities?

MR. STAHLKOPF: We are setting up another pipe test laboratory at Battelle, specific, and we are engaged in negotiations with Battelle to do this. We look at the stock time frame between the nine to 12 month to have an

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additional facility in operation.

MR. ROSSIN: When EPRI does these contracts, part of the job is to monitor them and to see that there are appropriate checks so that we have confidence in the data that comes up. We are just not in this with the idea that somebody is going to cheat on the data. I think that has got to be made very clear. We are dependent on contractors, but we have independent checks to show that the data are verified and documented.

MR. BENDER: Heating is not what I had in mind. I hoped that that wasn't the interpretation, but there are variations in perspective, and there is often bias the technological interpretation that you can only eliminate by having somebody else that is outside of the existing testing approach look at the problem.

I think this thing has suffered from that for a long time.

MR. ROSSIN: There is independent examination of the data, a lot of it. But the physical facilities are expensive, and we are not going to be able to duplicate it many times.

MR. STAHLKOPF: We do have alternate facilities which will be going in place at Battelle, and primarily dealing with larger diameter pipes than are presently being dealt with at the GE facility at San Jose, which is primarily dealing with the four-inch pipes.

MR. DANKO: There is a point to be made here, Carl. There have been constructed in Japan a number of the same of test facilities, and there was a round robbin setup with GE with Japan to make sure that the test results can be duplicated in other laboratories essentially using the same test procedures in similar facilities.

The round robbin did establish that for 304 stainless steel piping welded by GE, shipped to Japan, that they got similar time to failure on the specimens as GE was getting, so there is a cross-verification of the testing technique, that it is something that can be reproduced in other laboratories.

MR. MASCARO: The NRC is planning some independent research programs to evaluate these fixes and proposed solutions to the problem.

MR. BENDER: That is part of the reason for this discussion. We are trying to understand the relationship between what GE is doing and what the NRC might be doing. I guess we are also interested in what the Japanese might be doing and whether that is an independent test. I think the whole thing needs to be looked at.

(Slide.)

MR. DANKO: I would like move on to the question of BWR duration. We have a program which was just starting, and the objective is to determine if deaeration during reactor startup will reduce the propensity of intergranular stress corrosion cracking of the welded 304 stainless steel. There have been comments made that it will have a beneficial effect. To this point, it really isn't clear. So the intent is really to quantify if there are any benefits associated with deaeration during startup. This is to perform laboratory stress corrosion cracking tests on specimen 304 stainless steel that have been actually removed from a butt-welded joint, and preserving then the actual weld sensitization, and trying to keep the specimen as close to the ID surface as possible so that we can actually preserve that surface, which is critical in terms of initiation.

The test conditions -- I would like to point out that these have been based on in-reactor measurements, both water chemistry and electrochemical behavior. So when you see simulated startup oxygen and peroxide additions, that means in a laboratory we have to try to have these introduced in the makeup water, which is a very difficult experiment to achieve, and then to simulate the actual measurements we have for in-reactor, start-up conditions.

As a sort of a backup method, you can use the potentiostatic control to simulate electrochemcial potential during startup. We have measurements in the reactor of that, so we have two approaches t. examine then the actual start-up conditions. And we are going to use strain rates that actually simulate the conditions.

We talked to the GE people. They have values that have been calculated from the pipe design engineers to make sure that we are simulating the actual strains in those wells. The intent here is not to take the specimens to complete failure, but rather to interrupt tests at a strain value, a total strain value that is consistent with the start-up conditions; so that you cannot be mislead, that whether initiation is occurring or not, the specimens that will be removed from the pipes will be attempted to keep the ID surface preserved and will include the gauge length, weld heat-affected zone in the base material. So it is really important to how these test conditions are performed in order for us to really evaluate the question of deaeration.

DR. DILLON: Are you cycling them?

MR. DANKO: There will be some cycling tests involved. There will be fracture mechanic specimens involved to see if there is an effect on the AVT examination. We are going to interrupt the test at very low strains and really see if we can detect the initiation of stress corrosion cracking. The critical thing is the initiation process.

We have measurements to show that 200 ppb, which is the equilibrium oxygen concentration in the operating PWR that cracks will propagate. So we also have had discussions with the Swedish, and they use a special technique in their start-up which is a nitrogen blanketing process, and we actually have a program under negotiation with them to insert some specimens in one of the reactors and really determine whether the benefits that they report are associated with the nitrogen blanketing or in fact is it related to the close specification they have on their 304 stainless steel.

We also would plan on doing a limited number of pipe tests after we get these preliminary laboratory results in. The programs status, the test similulating the start-up conditions, both chemically and potentiostatically, are in process. The final negotiations are in progress with Asea-Atom for them to do some special tests in the reactor in Sweden. The scheduled completion date is shown here. We hope to finish the work in GE by the end of next year, and we will have results coming in from Asea-Atom to be completed in 1982.

This concludes my presentation.

MR. STAHLKOPF: Thank you, Joe.

MR. ROSSIN: Any further questions for Joe?

DR. SHEWMON. No. The only other one that comes to mind -- and you can answer it where you will, but the

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Germans apparently -- three to six months ago the Regulatory Commission set out an order requiring, as I understand it, a fair amount of piping in German BWRs to be changed.

MR. STAHLKOPF: That was a ferritic piping, primarily in the steam lines. The problem dealt with an oxygen pitting corrosion. The type of ferritic which was changed by the Germans is not typical of that presently used in United States plants. It seems to be the material-specific problem. And in talking with Carl Kussmaul from MPA, his feeling, in looking extensively at problems that were exhibited in Germany, was that it was a material-specific problem to the specific type of ferritic which was used. And we do not anticipate seeing that problem in the U.S.

MR. DANKO: To further amplify that, the current German practice with their BWRs -- and this is also something we found is a Swedish practice -- for the large diameter lines, dealing with 20-26" diameter lines, they use a special pipe which is a carbon steel, and it is clad with a special rate of 347 stainless steel. I think this is important to understand, because previously I think people were assuming that those large diameter pipes were 347 stainless steel, and they are not. They are carbon steel clad with 347.

DR. SHEWMON: Those are the recirc pipe, and they are changing up the steam pipe.

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MR. STAHLKOPF: He is talking about a different pipe. I am talking about the steam piping. That is the material changeout called for by the German regulatory authorities.

DR. SHEWMON: Fine. Thank you.

MR. STAHLKOPF: The third presentation this morning will be on remedy applications.

Mr. Lou Martel.

MR. MARTEL: I am from EPRI. I will be talking about the third major part of the BWR Owners Group program, called Remedy Applications.

The various programs absorb about one-third of the resources in the program, so I will be talking about an area that is some $10 to $15 million in the program.

As Carl mentioned, the intent of this particular program is to put these remedies on the shelf. And as Joe pointed out in his talk, sometimes these remedies -- the benefit you achieve from the remedy is dependent both on the quality of work done and also on the size of the piping that it is applied to.

So in order to bring this through to its completion, the program through to completion, we have got a part in here that involves actual demonstration of the remedies on full-size piping mockups. We are in the process of letting a contract for that work, which involves building a significant facility. We expect to have that done by about the middle of next year, and be operational about the end of next year.

Before I go any further, I will try to put this part of the program into context with the other two.

(Slide.)

The total program is really oriented toward utility needs, and it starts it out with that number question, really, is there a problem in the plant? And then a second point, what actions are required to address a concern if one existed?

Those two are really grouped under the plant problem resolution area that Robin talked about .

Then a third element is if there is a problem, what tools do I have to apply to it? And that is the remedy development area that Joe talked about.

And then the fourth one -- this one I am addressing -- is how do you use those tools in the plant?

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MR. MARTEL: This is a summary of the various remedies that are being developed. As Joe mentioned, you can categorize them under the areas of reducing stress, improving materials, or improving the environment. This particular remedy application is the application of stress improvement remedies or materials oriented remedies for BWR pipe cracks.

As you can see, this paticular -- this method and that method -- are dependent upon stress reduction. The stress reduction is dependent on pipe size. That is one of the reasons that you want to do that on a full-size piping system.

(Slide.)

This viewgraph describes the scope of the work, and it consists of these four areas -- first, to demonstrate remedies on full-size mockups, to evaluate the effectiveness of the remedies that are applied to those mockups under field conditions. That is an important element of this phase of the program -- to qualify personnel for applying those remedies in plants, and then to assist specific plants that may develop a problem, that have a need to correct it. Those are the major goals of that particular area -- the approaches that are being taken to gather all of the information that is being developed in the remedy

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development phase that Joe talked about, and prepare specifications and procedures and quality assurance plans that would be done with any particular remedy for a particular application. This would be demonstrated on full-size mockups, and those mockups would factor in radiation environemnt concerns and plant design constraints, mainly the physical constraints that would be experienced at plants at particular, specific joints that may have to be prepared.

After that work is done, the -- there would be measurements made of either the stress reduction or the -- whether or not you received the reduction susceptibility of the material. Those are the two major ingredients that Joe talked about that relate to lifetime of a joint. After that would be test verification of these full-size pipe sections in a facility that Karl talked about or at GE -- either Battelle Northwest or GE -- to verify that the product reduced under the simulated conditions, you realize the benefit that you expect. And then this qualification is to actually have people run through the process after it is finalized on each of the remedy techniques to incorporate all of the quality assurance provisions that need to be there, including the code requirements.

And then another part is to verify that the joints that are made are acceptable to the requirements necessary and to include the work planning that is involved with radiation considerations at the plant, because the main objective of it is to improve the availability, and there could be a large loss of availability that would affect some of these repairs in an operating plant.

The last part is to help a plant with the technology that has been developed, to apply the work to specific joints in a plant with the prepared guidelines from the generic specifications developed here for the specific conditions that may exist in a plant.

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This summarizes the things that I said. The purpose of the program is to put the remedy application of the shop for immediate availability by plants. The deliverables are documented and accepted technology for practical field application to establish training on the shop training programs and aids, aids being mockups which can be used by utilities to train crews on. We also plant to have a quick response service by that contractor to utilities that may have developed a problem and want some assistance in planning the types of approaches to solve that problem -- to have outage planning assistance, because again the length of the time can depend on the exact methods that are used to effect the remedy.

This Number Five tends to be an open item. It mecBWH

will be something we will be discussing today and tomorrow — the Utilities' Subcommittee on whether or not we ought to have a supply of piping available so that they don't -- the utility would not have to wait to get piping or fittings and also the equipment itself -- some of the equipment like the IHSI, the induction heating equipment is readily available. We think maybe we should have that particular type of thing available to the utilities.

DR. SHEWMON: Could you back up one step? And as you know better than I do, it's one thing to have these fine plans. It is another thing to have them manned.

You referred to a contractor. I would be interested in knowing about who does all these things or how you are going to implement. You can take any one of the previous ones if you wish or talk in general.

MR. STAHLKOPF: I think we can answer the question first broadly and then, perhaps, specifically.

Broadly, Lou touched on a facility which we are presently negotiating to build with J.A. Jon Construction Company which will —

DR. SHEWMON: It will come from NDE.

MR. STAHLKOPF: It would be attached to part of our NDE Center, and we plan on expanding the scope of the NDE Center to include a training center for welding. There will be welding mockups there, and in essence, to be able to

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do crew training and certification for the types of remedies we have talked about today.

When you look more specifically at the applications of the specific technologies like IHSI, there are presently two utilities that are presently negotiating with IHI in Japan to perform IHSI on th ir piping. So either through direct negotiations with contractors who already have this capability or through the utilization of the expanded NDE Center facilities, we will either make sure that we have training facilities available to train AEs and construction companies in the types of practices we are recommending here or will ensure that vendors are available to provide the services for the type of rememdy applications that we are talking about.

MR. MARTEL: This is a technology transfer in this area, simil to what is being considered in the NDE area. We are trying to pick a vendor that knows the plant and also staffs the facility with people who know the development and then marry.

MR. ROSSIN: We didn't attempt to go into this type of detail in our presentation, but in the last few pages of the Blue Book, where the individual projects are listed by number, the contractor is noted on all of the projects where a contractor is actually working on it. Where there is no contractor listed, it means it is a new project, and the contractor hasn't been chosen yet. So you can get a rough idea of the mix of contractors that are working on these projects. Right at the end of the book starting at the page right before the last page, there are about four horizontal pages --

DR. SHEWMON: Under the budget information?

MR. ROSSIN: Yes. And where there is a contractor, just the initials are noted there. There is a lot more detail available outside of the book, but we didn't really think that we could take the time to go into details like that this morning. But it is here.

DR. SHEWMON: But the technology transfer -- whatever name you want — getting people trained, apparently it is not your specialty. I'm sorry; apparently it is not their specialty. It may be your speciality, one of your specialties, and how it got done is of interest.

MR. ROSSIN: I think that particular area is a real challenge.

MR. BENDER: I had a little trouble digesting this when I looked at it before because dollars are hard to transfer into hardware, particularly when you are talking about full-scale hardware. Is there any way we can tell how many specimens of what size and what conditions you might be planning to do?

MR. ROSSIN: I think we will have to respond to

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specific questions because we find even out group, our technical group, can't keep up with this whole program if we all try to understand what is going on here, plus do our own jobs, so we have even had to subdivide this in order to keep track of it.

So, in any area where you want specific information, we have got it, but if we give you the whole bale we will never get through it.

MR. BENDER: I am not planning to ask for it here, but I think it is inexcusable that there isn't a collective set of information someplace.

MR. ROSSIN: There is, but it is there, not here.

MR. STAHLKOPF: There is, and we would be happy to sit down with you or your consultants or members of the NRC staff. As a matter of fact, we have on many occasions and discussed in more detail the specifics of the pipe test laboratory, what we plan on doing with the NDE Center, and the welding adjunct to the NDE Center. I would simply extend an open invitation to you or anyone that you designate to come out and spend as much or as little time as you like, and we would be very happy to provide you with these details.

MR. MARTEL: A lot of that information is in the program document that is already out, and we are in the process of developing a contract, and that will be written up in December in the type of detail you are asking about.

MR. BENDER: Is the NRC staff intimately familiar with what is going on?

MR. HAZLETON: We have been following it pretty closely.

MR. STAHLKOPF: As a matter of fact, we have a variety of formal organizations on which various members of both the ACRS, in terms of Paul Shewmon, or NRC, from Warren Hazleton or Joe Muscara, serve -- the Corrosion Advisory Committee which deals with the intergranular stress corrosion cracking aspects which we have discussed today, and there is a study group chaired by a former ACRS member, Spencer Bush, who also serves as a consultant to the ACRS, and that group talks about specific integrity problems and also speaks to the questions of non-destructive test data.

I feel we have a very open program, and if it is n necessary to expand the representation on either of these Committees, we would be more than happy to if you designate the people you would like to attend. We will make sure that the invitations are sent to them.

Are there any further questions before we go into the summary of the program?

DR. CORTEN: Can you turn the television thing around? I find my attention is watching the speaker instead of listening to him.

(Laughter.)

MR. STAHLKOPF: I would like to introduce Dr. Richard Smith. He will give a summary -- a conclusion of today's presentation. I would like to point out that Dr. Smith is serving as the coordinator for all of the BWR programs, and it is his responsibility to see that all of the plans that we talked about today are carried forward, and he is also responsible for the continuing evolution of the Energy Group program.

I would suggest in the future that if any questions come up concerning this program that Dr. Smith would be the appropriate person to contact first.

DR. SMITH: Thank you. You have heard a great deal of information this morning about a lot of specific projects and programs. I am not going to try to reiterate all of those programs. What I would like to do is to give you a summary and hopefully a flavor for the program as we see it and hopefully as described by the prior speakers.

(Slide.)

In order to do this, I will touch on three basic areas -- first of all, some of the highlights of the current status. One of the reasons I say "current status" is that this is an ongoing program. It is not a program that just started up this year; it has been going since 1975. There is work that was ongoing even before that program started

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at General Electric, and also we are not alone in this current program. There are many people working on the program, both in this country and abroad. In Japan, there is a very large program, in Sweden, in Germany, in Italy. Many of these people are doing activities that are quite complementary and, in fact, we have bilateral agreements with each of the parties in which we are sharing information and putting it together so that everyone doesn't have to bear the whole burden.

Secondly, I would like to give you a little bit about the program characteristics, at least as I see them, and then lastly, to reinforce the last area that you heard about on the technology transfer. We feel this is a key element of the program, and, in fact, it is the purpose toward which everything else just is running.

(Slide.)

One of the things that can out in the earlier presentation dealing with the phenomenon -- was that the phenomenon was pretty well understood. I think that is a fair assessment when we take a look at the data. There are some nuances that we might be looking at -- in fact, we will be looking at in terms of mechanisms, particularly as it relates to crevice behavior and also as it relates to surfaces.

By and large in trying to implement fixes or

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develop fixes for the problem, we have pretty much understood the phenomenon, and we know what to do about it.

Secondly, there are various remedies that have already been implemented. This means that we have already studied these things. I mentioned it was an ongoing program, and we have already -- we have a lot of water over the dam -- with these remedies.

The reason you see the difference in numbers between some of the speakers is that some of them had just domestic plants. These particular numbers include foreign plants as well. You can see that already people are doing something about the problem. There is -- lines are being addressed, various activities are being dealt with in new plants. It is not something people are ignoring.

In addition, we have some stress related remedies which we think are very important. Now the reason they are important is that you can address plants that are already built. We are looking at things like induction heating stress improvement, heat sink welding, and other techniques that don't perhaps require the bulkiness of equipment, as for example the IHSI, but would give you a similar benefit.

We are not trying to duplicate to give a whole list of things that you can do. Each one has a specific use, and they each will do the job.

In addition, we have heard a little bit about the environmental type studies. The environment of a BWR is -- there are certain conditions of that environment that we can't get rid of unless we go to an alternate water chemistry, and in fact there is work going on in this area, but not at EPRI. The particular environments -- we are interested in typing the environments. These are difficult to study, and we are looking into them. There are programs underway to deal with them, but right now we don't know all of the details about how much benefit we can actually obtain by some of the environmental related remedies.

The next thing in the way of NDE equipment -- Robin showed you a flavor for some of the types of devices that are being develop . Now he didn't intend that to be a comprehensive list of the things that are going on. In fact, he even has a speaker up here that did spend a whole day just talking about that one area. There are a lot of things that have already been developed. They are being implemented and used in the field today.

There are things that are under field evaluation right now. This is an area that we see as a very important area.

The last area I ha.e identified is the ductile fracture mechanics. We started on this several years ago because we knew that there were cases that had to be treated by this type of method as opposed to purely elastic methods.

Because they are available today, we can treat the problem that we have, and that is what we are doing with it in the projects that Robin Jones talked about.

MR. BENDER: Before you take that off, the second item up there, maybe I don't interpret that right. It says "Sensitization Related Remedies Qualified." What is meant by that?

DR. SMITH: These particular remedies deal with the material characterizations. These particular items have been qualified in the studies that we have done already. There is further work going on, looking at the variabilities that you might expect. But in terms of their being qualified for application, they are qualified today and being used today.

MR. BENDER: I listened to something that said that we are trying to establish a factor of 20 improvement as a criterion.

DR. SMITH: This has a factor of around 67 right now. This one has factors way in excess of 20, except for the one heated material on one field application of the CRC, and that was related to a material that was already sensitized to begin with, and you would have expected that.

In terms of the alternate materials, we have a very large test program that has been going on for two years, and, in fact, there is enough data to already qualify materials that we have here. We are looking at the variabilities that are involved in it now when you go to a large number of heats. We have looked at about three heats.

MR. BENDER: The size parameters that I think would be important in the qualification -- they are still open. Is that right?

DR. SMITH: In terms of these remedies, we wouldn't anticipate as many of the size parameters. But that is exactly the variability that I am talking about that we are looking into. As you might have different processing techniques, this would lead to perhaps the variability. We want to make sure we have addressed it adequately. That is why the program is continuing.

(Slide.)

Now, what are some of the characteristics of the program? These are fairly general words, but I think that they are important.

First of all, we have a number of needs that ought to be addressed, and we think the program is responding to those needs.

What are the needs? They are the needs that Lou Martel showed you regarding trying to resolve the problem. Do we have a problem? What can be done about it? How quickly can you do it? Do we have the tools in place to deal with it?

We feel the program is very responsive to that, and it is a very comprehensive program. We are not jumping off and grabbing one little item and forgetting about the rest. The program addresses a wide front of things that must be considered. So it is not a program that we feel will pick up on one particular remedy, forgetting other things that it might influence.

The third thing is that the program I mentioned earlier is a logical continuation to the program that has been running for some time. It is also a program that is integrated with activities that are going on by a large number of people in -- besides our own contractors. For example, the contractors that the NRC has worked with us and also the NRC people, the people abroad as well.

The next topic deals with application verification of reactor components.

The reason we think this is very important is that until we have bridged the gap and are able to put the information "on the shelf" in concept, if you will, then we have not been able to examine it under -- Let me start over:

When you apply these remedies to certain field situations, you are having to do it under conditions that are somewhat different than the laboratory setting. In order to be able to verify that you can, in fact, do the quality job that you are after in the field, you have to do it on those kinds of conditions and under the conditions you have on -- And then verify that they in fact work.

The next characteristic is that the program is designed to converge. We are talking of a four-year program, and it emphasizes the work during the first two years and then it follows up on loose ends the last two years.

The last part that is very important is that we pay particular attention to communication for the program. This is important as we work with other people and also as it relates to you people and others that are involved in the program, in the problem.

We have timely reporting that is required on every contract. We have seminars that are going on. In fact, if you have not heard about the one that is being done this

January, I have some brochures on it; this coming January. It is a time when we will be spending three complete days to discuss the problems and some of the advances that have been made. There are speakers here from all over the world, not just our country.

We have regular review meetings, and we also have the industry advisory committees that Dr. Stahlkopf mentioned a few moments ago.

(Slide.)

MR. ROSSIN: There will be a report on this at the NRC Safety Information Meeting. This is part of one of the sessions on Wednesday.

DR. SMITH: The last slide represents -- emphasizes the last important area, and that is transferring the technology that is developed to new hardware. We hope to bridge the gap to the applications.

We have discussed the "on the shelf" concept, and in order to get there, we deal with realistic mockups. We deal with equipment specifications that will be required to do a quality job. We have the procedures and remedies verified on actual hardware with the appropriate quality assurance and inspection. That is why we are tying this into one location.

In addition, we feel we will be presenting complete documentation and training people to implement it. They will be trained under conditions that are prototypic.

In summary, I think we have a program that is very comprehensive. We feel it addresses the needs of both our utility sponsors and it also addresses the needs of our country as we forge ahead for providing energy.

MR. STAHLKOPF: Thank you. I would like to reinforce what Dick said concerning the seminar that is coming up at EPRI. I would strongly suggest that anyone who is interested, please come. It is an open seminar. I will leave these brochures at the front of the room for anyone who is interested.

I would suggest that perhaps it might be appropriate to have members of this subcommittee, or your consultants as you see proper, attending that seminar.

DR. SHEWMON: You have done a good job of staying with your schedule. Let me mess it up, now, for a little bit. It is an impressive program. You have been quite open and frank, and we look forward to staying in touch with it, as we can, with the time available to us.

Let me change the subject tangentially, though, to the penultimate paragraph out of the August 16th letter:

"The presence of the large multiple cracks at Duane Arnold in sections of pipe in which no in-service inspection was required points to a need for a comprehensive reexamination of all safety-related piping systems for similar or equivalent design fabrication or construction flaws, as

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well as the adequacy of the NRC requirements for in-service inspection."

Now we will get on to the NRC's view of that this afternoon. I would be some interested in perhaps a comment on what the utilities see as their role in this, or what they have been doing as a result of Duane Arnold, and perhaps that could come up in their presentation after a break. I would like to see it at least mentioned in what we do in the rest of the morning. Let's take a 10-minute break.

(Brief recess.)

DR. SHEWMON: Back on the record. Could we begin, please?

MR. ROSSIN: This part of the program involves what the utilities are doing. What I would like to do is to introduce the utility representatives that are here, and make a couple of points about this.

We have, as I said, some 29 BWR owners. We have a technical advisory committee in which all of those owners are welcome to participate. Those who haven't paid their money can participate as observers.

One question I didn't answer before is, what happens to people who don't join? Do they still find out what we learn? I think in the real world, yes, they do; but we would prefer to have everybody in the fold, of course. Every one of the people who are here out of this group are spread very thin.

A lot of us are involved with line responsibilities with our own plants, and most of the people here are also kind of senior technical people within their companies on metallurgy and materials, nondestructive examination, or plant operations; so that their appearance here represents a cut out of the group, senior members of our group.

And I want to point out what they are doing now and point out that in my opinion, my personal opinion, one of the things we do have to contend with is a terrific workload on people in the industry because of the extremely heavy weight of the responses that are coming through day after day.

I don't argue with the importance of them, but I think we have got to realize that our talent resource is finite. It is being stretched.

Perhaps there is a basic problem. We should have two or three times as many talented people in every company, with the years of experience that some of the people in this room have; but the reality is there aren't that many people around. And one of my ground rules in setting up meetings of this kind is to try to minimize the amount of time and travel away from the job of people in this room.

We have some representatives here. I am going to ask the utility people, when they introduce themselves, to mention the names of the BWRs that they have, and operating or under construction.

I think that everybody is familiar with these, but I think it will save some times later on. I will start. I am Dave Rossin, Commonwealth Edison. We have the Dresden units and the Quad Cities units in operation, and the LaSalle units under construction.

I also have responsibility as chairman of the technical advisory committee, the owners group, and vice president of the Systems and Materials Task Force of the utilities that guide the EPRI programs.

MR. BATUM: Batum, Southern Company Services. We have the Hatch units for Georgia Power under operation. I am also a member of the BWR owners group task force and the Systems and Materials Subcommittee of EPRI.

MR. ROSSIN: I point out that we are having trouble ourselves, as a group, keeping track of the details of all of the projects within the EPRI program. We have split ourselves up into three subgroups, to conform to the subgroups that EPRI people present: the problem of identification, remedy development, remedy applications, and we set up a fourth one which is licensing implications.

MR. BATUM: I am also the vice chairman of the Steam Generator Owners Group technical advisory committee. Like he says, we are spread quite thin.

MR. HOFFMAN: Hoffman, Yankee Atomic, representing Vermont-Yankee.

MR. HANFORD: Hanford, Carolina Power and Light Company, technical advisor on the BWR owners group and also a member of the EPRI Systems and Materials Task Force.

MR. ROSSIN: You have the Brunswick units.

MR. HANFORD: I, and II, operational 1974 and 1976.

MR. ROSSIN: Ray heads the Remedy Development Sub-group of our owners group.

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MR. SCHNABEL: Schnabel, Public Service Group, Electric and Gas Company. We have the two Hope Creek units under construction. I am on the BWR technical advisory committee. I am on the Steam Generator Owners Group, also on the Systems and Materials Task Force for EPRI, and currently I am the chairman of the technical advisory committee for the Feedwater Cracking Owners Group, which is a feedwater nozzle cracking mentioned before.

MR. ROSSIN: We regarded George as the dean of utility metallurgists. If we took time to go through all of this committee work, I don't think we would have time to finish the discussion.

MR. RAJARAM: Rajaram; Fitzpatrick plant, BWR group. So far we have had no problems of any cracking indication. There is a bypass on the core spray.

MR. HARRIGAN: Harrigan, the Bailey I plant under construction.

MR. ZONG: Zong, Philadelphia Electric Company.

Two operating plants. Peach Bottom Unit II under construction, the Limerick units, and a member of the EPRI Systems and Materials Task Force; chairman of the EPRI subcommittee on nondestructive testing.

MR. PITZEL: Pitzel, Tennessee Valley Authority. We have three units, Browns Ferry, and we have operating units -- We have four units under construction; Hartsville, two units under construction.

I am on the EPRI Pressure Vessel Subcommittee. I am also involved with the ASME Section 11 on repair and replacements, in-service inspection primarily.

MR. DeBARBA: DeBarba, Northeast Utilities, Mill Stone; chairman of the problem definition of the BWRs.

MR. ANGLE: Angle, Dairyland Power, chairman of the remedy applications group of the EPRI BWR pipe cracking task force.

MR. HARRINGTON: Harrington; I am from Iowa Electric Light and Power, Duane Arnold.

MR. COMPASS (?): Compass, Northern States Power Company. We have one boiling water reactor at Monticello. I am on the owners group technical committee and the subcommittee for application remedies.

MR. McLAUGHLIN: McLaughlin, the Tennessee Valley Authority. Gary has previously covered the units, along with the Systems and Materials Task Force, also technical advisory committee for the BWR owners group, serving as a member of the remedy applications subgroup.

MR. TAYLOR: Taylor, Pennsylvania Power and Light Company. We have Susquehanna BWR units under construction. Technical advisory member for the BWR owners group. I am on the remedy development subcommittee and a member of the EPRI nuclear systems and materials task force and chairman of the materials and corrosion subcommittee.

MR. ROSSIN: This took a little extra time. One of the reasons I did this was so that we can address questions to specific representatives here; and if we have questions about other plants and representatives aren't here, then we can get you the answers.

In specific response to the paragraph that you read to us just before the break, I think there are some very important lessons here.

One of the things that is important to us is that we think the paragraph is one that deserves discussion, and I wish the discussion had taken place before the paragraph was written.

But I think the realities are that this does indicate an ACRS concern. The safe end areas at Duane Arnold reveal a problem different from the problems that this pipe crack group originally focused on. As such I think it opened up a new area of concern and one that we are dealing with now.

There were inspection requirements for the safe end area. The code requirements, as we recall, involved four times during the plant life, so that would be a 10-year cycle for inspecting those areas.

We are willing to discuss details on this, but I think that you are already fully aware of what happened and what was done. And I think there are a couple of points here:

The crevice corrosion phenomenon which played a part in Duane Arnold was extremely important, and it is now one of the areas of emphasis in our program. The stress rule, if applied to that particular location, gave a very high number, indicating that it should be a target area.

Most of the utilities represented here that have plants under construction have taken steps with regard to safe ends where the crevice geometry is there. We have replaced the safe ends in our LaSalle County unit under construction. We replaced them all with a newly-designed safe end to eliminate the crevice of the kind that we thought was one of the contributors at Duane Arnold.

I think the combination of the work at GE in developing their analysis of the crack histories, the stress rule, and the programs that followed that bear importantly on the factors in this paragraph.

We now have target lines and key areas that we feel are the ones that deserve the emphasis in inspection. We would like to be able to focus our inspection efforts on the radiation exposure that is involved within the areas that are susceptible.

We would like to not only pinpoint new areas where we see it is necessary, but try and be realistic about the amount of inspection required in those areas where the performance is very good. And maybe the inspection requirements are unduly repetitive; because every bit of manpower involved here is critical manpower.

I think we have got to look at both sides of the coin on this.

Our program, part of our program, is involved with developing improved inspection capability and more automated inspection c[illegible] the adaptive learning technique, the abili[illegible] tors mechanically, automatically, so that [illegible]'t standing there as much as he was before, a[illegible] really do have reproducibility of inspec[illegible].

I [illegible] it is crucial, and that is one of our big areas of emphasis. We can talk more about the nondestructive examinat[illegible] cts that a[illegible] underway in the MDE center, too

I[illegible] leak detection you heard a couple of com[illegible] it is an area that we feel is extremely important: Not just leak detection, but leak location identification, again, an area where manpower irradiation areas are involved, so there is a tremendous incentive to improve this.

But one point to look back at: I think our state of knowledge at this point provides continuing reinforcement. We are dealing with a material, stainless steel, which is a tough material. We reiterate that this concept of "leak before break" is an important one.

We don't take the concept to mean across the board you have nothing to worry about because you have leak before break. We do state that the fact that these materials are known to behave in this fashion means that there are things that are important in terms of leak detection. It means we can identify a problem area before it becomes a catastrophe.

I think it is important for the public to recognize as well us that there is a big difference between an availability problem and a catastrophe.

I personally have had a number of challenges from our critics in my territory who have made speeches and presentations in which the leak from a cracked pipe, or the detection of a crack, has been put forward as a catastrophe in itself; justification for shutting down every plant in the area, and so on.

It is a tough communication job, but I think we have to try to do it.

Our program also is directed, as you heard, toward improved techniques for repairs and in identifying those areas where action should be taken in advance. I mentioned the changing of safe ends. I think we can give you some examples here of efforts taken by the utilities to minimize the probability that the kinds of cracking, not just Duane Arnold phenomena, but the other kinds of cracking are much more unlikely to occur because of actions that have been taken at the plants in question.

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DR. SHEWMON: What is a target line?

MR. ROSSIN: I think that originated from GE with the report that they produced early after the 1975 pipe cracking experience. They identified those lines at which cracking had occurred. They identified the areas where they thought cracking was more likely to occur than in other places, and they called those target lines. In fact, GE's service recommendations said that if you were going to take action with regard to minimizing a probability for pipe cracking, the first target lines to do something about are the recirc bypass line and in order of priority identified some other target lines.

DR. SHEWMON: Okay.

MR. BENDER: Is there anything in what you said that represents something more than is being done by EPRI?

MR. ROSSIN: I think so. I'm not sure I understand your question, Mike?

MR. BENDER: I am trying to make sure that I comprehend everything that is going on. I heard the EPRI program, and I think it is pretty comprehensive as I interpret it, but there may be some things that the utilities are doing separate from the things that EPRI is doing, and I couldn't discern them in that presentation. You probably intended to tell them to us.

MR. ROSSIN: That's why this part of the program.

There are a number of fixes and remedies that were talked about in this program which are really past the research stage. I think both Lou and Joe were pointing out that while we are testing a number of these areas, it is in order to determine what the variabilities are in some of the key variables.

But we also -- we already have these techniques qualified and being used. The number applies to corrosion resistant cladding and so on.

Now various utilities have adopted approaches and are either working with General Electric or other contractors to implement these changes. I think some are dramatic. Maybe I ought to call on somebody just to give you an example. Can I do that?

MR. BENDER: Sure. I am trying to get a better feeling for it. Let's take Susquehanna as an example. Would you summarize what you have done?

MR. TAYLOR: We became concerned early on Susquehanna because we were well along in construction when we began to view with some alarm the incident of stress corrosion cracking, and so we had to effect certain remedies for Susquehanna to be able to do them in a timely fashion so that we didn't have to wait and then rip out extensive sets of piping.

So based on literature, research of the data on stress corrosion cracking phenomena, based on the early research done by General Electric Company and by EPRI with which we had become involved in the beginning of 1974, we took an approach to eliminate as much of the high carbon 304 material as we possible could in a timely fashion.

We had found, upon investigating the chemical analyses in the piping that we had in our pipe, that much of the 304 stainless steel piping had carbon content in the .06 to .08 range. We felt that made that piping highly susceptible to the stress corrosion cracking.

So we took a phase type of approach. For lines four-inch and smaller, we switched to 304L to get the lower carbon content where it was permissible to do this without impacting on the design stress limits for a stress analysis that had already been run. For the larger materials or greater than four-inch sizes, with the exception of the main recirc headers and riser pipes, we changed to a carbon limited type 304 material and imposed a .030 carbon limit on the piping we procured to replace the high carbon material originally supplied.

We checked to see if this material with the carbon limitation met strength requirements for the design stress analysis and stress report. Those were major piping changes. As I say, we changed out all except the main recirc headers and riser pipes. We did change out material on the recirculation system four-inch bypass lines. We went to carbon limited pipe 304.

DR. SHEWMON: What dces that mean?

MR. TAYLOR: It has a supplemental limitation on the carbon .030 maximum.

DR. SHEWMON: It is not L?

MR. ROSSIN: Would you explain the difference?

MR. TAYLOR: 304L material has its own specification, has lower permissible design stress since the carbon limit can come down to very low levels.

DR. SHEWMON: .03 would normally meet the L designation, woudn't it?

MR. TAYLOR: It would fall into the L category but also within the type 304 range as well, and we had physical tests performed to ensure that the carbon limited material met the strength requirements for the 304 grade. Since the stress reports had been prepared on the basis of 304 material with its allowable strengths, we wanted to be careful not to change the material from that basic material specification used in the stress report.

MR. BENDER: Is .03 the lowest carbon 304 you can get the suppliers to give you nowadays?

MR. TAYLOR: You could get lower if you specified it. They woud have to pick and choose a little more carefully to find it at lower levels, but in looking at the available data that we had at hand, recalling now that this was the beginning of late 1974 and into 1975, we felt quite comfortable in limiting the carbon content to .03. We felt that the available data showed that the susceptiblity to stress corrosion cracking increased at .05. I think this is the limit the Swedes have imposed upon their nuclear grade material for their BWR plants.

For a little added margin of insurance, we specified .030. This seemed a reasonable limitation. It also allows us to meet the strengths of the type 304.

MR. BENDER: I heard a target level of .02.

MR. TAYLOR: That is with the new nuclear grades with the nitrogen enhancement.

MR. BENDER: I am trying to get some feeling for the relationship between that target material that GE thinks they ought to be using and what you are able to get right now in a hurry. Is there any way of trying to correlate how much better the .02 stuff is going to be than the .03 that you could buy commercially?

MR. TAYLOR: You have to keep in mind now that the new material for which the specifications have been developed is different in a number of aspects. It has the .02 max carbon level and also has nitrogen enhancement. I think there are some other controls that have been invoked for that material which were not commonly applied to the

304, 304L materials at the time to which I am referring, '75-'76.

I think we have learned a lot of things about materials, control of tramp elements, grain size determinations, a number of things. If we were starting new with a BWR design now, I suspect we would look very favorably on these nuclear grade materials with a lot closer material controls. Our attempt here was to do what appeared prudent. It was well based on classical literature in stress corrosion cracking and our understanding of the phenomena, the available data to us in 1975 and 1976.

I might point out that despite some dire predictions that this will be difficult material to obtain, we were able to obtain very readily and quickly the 304 material with the .030 max carbon. We paid no premium in price over the garden variety 304 material, and we could probably do that again. I don't think one would have that much difficulty in getting that material with that carbon limit.

DR. SHEWMON: If there is more AOD capacity, I am sure it will get -- I don't know, in '74 it may have been harder, but I think it will continue to be easier.

MR. ROSSIN: Our experience has been that the inspection costs are contributing substantially, the quality control and inspection costs, to the price -- not

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substantially but visible, for nuclear grade.

DR. SHEWMON: That is separate from just the carbon content?

MR. BENDER: The material properties.

MR. TAYLOR: We also had this material furnished in an annealed quench condition. We had the ASTME sensitization test performed on the material purchased as replacement. Other of the key lines, then, instrument tubing, I guess I had that on the four-inch inferentially, but on the smaller sizes, we changed to 304L. We early made the CRD return line, we cut off and capped that return line to the vessel.

Subsequently, then, on the recirc riser pipe, we had already installed them on the first unit. We caught Unit-2 before they were installed. We sent them out to be corrosion resistant clad on the upper and lower ends, had them solution annealed and quenched and sent back into the plant. And then in response to the problems at Duane Arnold with their Inconel safe-ends, we took a look at the designs we had, and while we didn't have as sharp a crevice as they did at Duane Arnold, we did have a crevice.

Because of the known susceptibility of Inconel to crevice corrosion, we went back to General Electric and procured 316L safe-ends of a modified design, the so-called tuning fork, which gives a knick rather than a crevice. The attachment weld for the thermal sleeve is on an extended clad, so that weld is off of the pressure boundary of the safe-end. So we have riser pipes that are solution annealed quenched corrosion resistant clad on the upper and lower ends, and replaced the safe-ends with 316L with the tuning fork design.

We have decided to use the mechanical deaeration system for possible mitigating effects in reducing susceptibility to stress corrosion cracking. We think the deaeration system is attractive for reduction of general corrosion of ferritic materials.

DR. SHEWMON: Do you think it will reduce crud buildup?

MR. TAYLOR: I think personally it will. Reduction of oxygen, I think, is one step toward reducing general corrosion and crud buildup as well. We like the idea.

I suppose if we were going back in time again, my background is in fossil plant design, and I would have loved to have seen a deaerating feedwater heater in that cycle. I would push hard for one now. That is beyond the realm of feasibility for Susquehanna, so we are doing what we think is the next best thing, and that is adding vacuum deaeration.

The last thing I would like to mention, Karl or Dave mentioned there are a couple of utilities pursuing the

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inductive heating stress improvement. We have had people from Japan about a year ago with some other utility representatives just recently in the past two weeks, and we and our architect engineer have had representatives discussing with IHI details that will hoprfully lead to performance IHSI of the main recirc piping, which we did not modify because at the point in time we found ourselves, we began to understand this phenomena.

We would like to do that. We would also, I think, at this time plan to look at some of the other lines to see whether there are some candidate welds even in the modified materials which might benefit from IHSI for reduction of residual stresses where we would possible be doing some screening of these candidate welds by the EPR sensitization testing as well.

That is a rather lengthy capsule view of what we are doing at Susquehanna. If there are any questions, I would try to answer them.

MR. BENDER: What have you done about enhancing the inspection?

MR. TAYLOR: We are looking at a number of things, and we are following very closely the developments that are being effected through EPRI -- the improved transducers to get better discrimination of flaws. We are looking at the adaptive learning network for what benefits it will get us in characterizing and sorting out real signals from geometric reflectors. I think we are looking at an enhanced inspection, and we are quite interested in the developments that are taking place that will give us reliable in-service, particularly in the ability to interpret what we really have when we get some kinds of indications that are anomalies.

MR. BENDER: Are you trying to orient the frequency of inspection to where the high stress areas are, where the wear and crevice corrosion might be a problem, rather than making stagnant water streams, things of that sort?

MR. TAYLOR: I have not been directly involved in the development of that program, but I have had some inputs with it and discussion with other people who are working with the ISI program. We recognize what are the target or candidate lines. I mentioned earlier that we are one of the plants who are retaining the recirc system bypass lines. We have gone to a modified material, but those will be lines that we would expect to examine fairly frequently as possibly as early warning lines. We think they have some benefits operationally, at least in our view.

We also think they provide readily accessible lines to examine to see whether we have some incipient problems with these modified materials. We would expect to look at those frequently rather closely.

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DR. SHEWMON: In a different vein, it was my impression that the particular crevice area in Duane Arnold was not one that would be inspected, because it was not a throughwall weld. When you were starting your presentation, you said something about inspection every ten years.

MR. ROSSIN: I am speaking secondhand.

MR. HARRINGTON: That would not have been required.

DR. SHEWMON: Fine.

MR. TAYLOR: The welds that were inspected were the safe-end to the nozzle and the safe-end to the extension to the risers?

MR. HARRINGTON: Do you want to look at it?

MR. TAYLOR: If there is an interest.

(Slide.)

MR. ROSSIN: I think it is important to identify why. Ken, you mentioned that there was a reason why that weld wasn't inspected before. I think the question of what kind of inspection plans there are for that in the future is pertinent here.

MR. TAYLOR: This weld, which is the safe-end of the nozzle, is one that is included in the ISI program. Also, the weld from the safe-end to the safe-end extension, which then ultimately is welded to the riser pipe. The weld, when the problem occurred, was the weld here for the attachment to the thermal sl ve to the safe-end. If anthing, I suppose, this thing moderates that real crevice geometry, doesn't it, Ken?

That crevice is probably a little sharper than this diagram would tend to indicate. It is a long, deep crevice. By the time the geometry changes here and then back to the root of the weld, it is a rather long and very close crevice.

MR. STAHLKOPF: It is important to point out that with the Duane Arnold cracking -- that is that it is a plant specific type of design. As I understand, there is only one other plant that has even a modification of this particular type of Inconel safe-end. You really need to keep the Duane Arnold instance in the context of a plant specific happening rather than the more generically based intergranualar stres corrosion cracking of 304 in boiling water reactors that we have been talking about today.

DR. SHEWMON: The problem that always comes up, though, is whether you are in a classical bathtub curve, and since we know about that one, we are that much smarter, and everything is better. But since we weren't bright enough to see that one, we are being too fat and happy and assuming that there aren't any others.

Now the other one, as I understand it, is at Brunswick, which must be one of the best inspected joints

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around these days.

MR. TAYLOR: This is Brunswick that is shown here.

DR. SHEWMON: I see.

MR. ROSSIN: Does Ray want to add anything?

MR. HANFORD: We have it under the inspection program. It has been inspected at every refueling outage. We have it coming up for another inspection next year. So far we see no significant indications and no changes in the past inspections we have already done. We are following it, and we have contingency plans to replace it with other materials if it shows some kind of indication.

MR. BENDER: I recently saw some kind of document in the NRC literature about the water chemistry problems at Brunswick. Do they have any influence on this problem here?

MR. HANFORD: I am not qualified to address that part of it. I really don't know.

DR. SHEWMON: There is a hand in the back.

MR. PITZEL: How is that weld being inspected? Which weld are you talking about? Are you talking about the thermal sleeve weld?

MR. HANFORD: The thermal sleeve weld, I am -- it is by ultrasonic, and we are also doing some radiography inspection.

MR. ROSSIN: One example of something we did not so long ago with regard to this induction heat sink technique, three members of -- three representatives of the utilities went to Japan to watch them do the job on one of the Japanese reactors that was already constructed. Ray Hanford was a part of a delegation, and a man from Mr. Taylor's company, a representative from Commonwealth Edison. They came back with a report, and among the things that we are in the process of doing is trying to see that this particular technique, for those that want to use it, becomes a qualified technique and is acceptable to NRC.

It really hasn't reached that stage in the United States yet, even though the Japanese have used it on a number of there plants. One of the projects under "Remedy Applications" is to qualify that technique, or to get the research done so that the full Committee can accept it and NRC can accept it. The research project doesn't get the acceptance; the research project is targeted to get the data base to make sure that we have the data necessary so that our code case can be taken.

DR. SHEWMON: I guess the thing that is kicking around in the back of my mind is what you do is to call up what you feel is the best practice which is coming in, and the NRC's job is to see that the worst practice isn't going to get us in serious trouble.

MR. ROSSIN: I wish it were that simple, Paul.

DR. SHEWMON: So do I. I think the other sort of a thing, though, is that you are talking about one end of the spectrum, and it is the other end of the spectrum which rises up and bites us.

The question turning over in my mind is how, by asking this question, ask about the other end of the spectrum. And maybe we get into that this afternoon. And if you -- there are a certain number of these good examples of the sort you are talking about. Then that would be a strong positive influence.

MR. ROSSIN: You see, there is a gate here which says that a technique may be developed and a company may want to do it, but they can't do it unless NRC is satisfied that it can be done. So it isn't just pick the best thing and go do it. It is find out what is good, not necessarily the best, but acceptable, and make sure it's acceptable and prudent under the circumstances. And then try to make sure you are going to be permitted to do it. In some cases, I think we ought to be looking for some kind of credit for doing something prudent, which will perhaps reduce in-service inspection or something else later on.

Let me give you an example of diversity. The original cracks were found in the four-inch recirc bypass lines. At Commonwealth Edison, we made an evaluation and ended up with diversification within the company. Quad Cities, the lines have been cut off and capped. At Dresden the lines were replaced with carbon-304. The bypass lines are there.

We feel there is no compromise on safety with these two approaches. Each of the superintendents of those stations made a convincing case as to why his approach was justifiable, both of them safe, and we elected to do different things at the two plants. Now we are ready, if we have any cracking detected at Dresden, we will eliminate the lines. But we would like to keep the lines as long as we think they are now welded in safely with a good quality of material. There may be some operational advantage of having them there over a period of time.

It is your ball again.

MR. BENDER: Dave, let me pursue. Having listened to Susquehanna's story, I was rather impressed by the fact that they are going ahead and trying to use technology, new technology, wherever they can. And I suspect the judgments are well-founded.

If I were to ask the other utility organizations how they are progressing along these lines, what kind of answers would I get?

MR. ROSSIN: Let's try it. Who do you want to hear from?

MR. BENDER: Well, let's try TVA, since they are about in the same boat as Susquehanna. Are they doing the same thing?

MR. MAC LAUGHLIN: TVA.

TVA is located in Mike Bender's home town. That is why he is interested in TVA.

(Laughter.)

MR. MAC LAUGHLIN: Our operating units, back in '72 or '73, when the first problem was identified, our vessels were under fabrication. At that time we chose to cut those safe ends off and replace them, with the exception of one vessel, which has two sensitized safe ends, but they are clad both on the OD and the ID. We have removed the bypass lines on all three operating units at Browns Ferry. We are replacing the core spray lines with carbon steel on a schedule basis. To date Unit 2 has been changed and Unit 3 is presently refueling and is changing them, and Unit 1 is scheduled to be changed out with the refueling outage coming up in January.

We have, as a result of the Duane Arnold -- we have inspected our safe ends to thermal sleeve attachment welds. Ours are slightly different than design in the Duane Arnold. We have very little, if any, crevice in our design. However, we are inspecting it. We have inspected 100 percent on Unit 1, 100 percent on Unit 3, 50 percent on Unit 2, and have found no indications.

We have rerouted our CRD return line, capped the CRD nozzle, and we are presently under contract with GE, which should be terminated shortly, for the stress rule in-depth calculations to indicate those areas where we should put more emphasis stress-wise.

Going from the operating units, then, to the four units at Hartsville and the two units at Phipps Bend, we have scrapped the recirculation loops, which were the normal

304 stainless steel in lieu of the new nuclear grade, either 304 or 316. It was whichever material would be available. So we would come in with the new material, and if I am not mistaken -- our design man can clarify this -- I think all stainless steel lines within the plants will also be of the nuclear grade 304 or 316.

I think TVA has also responded to this problem in those areas where we know there are fixes or fixes that would improve the operation of the plants.

MR. ROSSIN: This brings to mind another example. I mentioned the trip to Japan by some people to examine at first-hand what the Japanese are doing on the induction heat sink welding. Les Byrd from Commonwealth Edison was with Ray Hanford. We went back and looked at the situation for LaSalle County and said, should we try to get to go in and do IHSI before we start up LaSalle. And we made a study on that and came to the conclusion that we think, with what we have done, LaSalle is in good shape.

One of the reasons that we decided we didn't have to be the first to try it, along with everything else, was that the Japanese have done this on operating plants, on plants that have operated. And if we feel after a few years, after LaSalle finally operates, that there is benefit to be gained by IHSI, doing it to a plant that is already built and in operation, the option will be available by that time. It will already have been demonstrated and we'll be able to buy technology that is proven and available. Our judgment was to wait on LaSalle.

MR. BENDER: Dave, you made a point earlier that, I believe, the leak before break criterion is still something you want to depend on, but not wholly. To what degree are we depending on the leak before break as an inspection tool, and how much do we have to depend on it?

MR. ROSSIN: I think it is more than an inspection tool. I think it is part of the question of whether we are dealing with a safety problem or availability problem, just what we are looking at. What we are trying to do is make sure we have, in the first place, the quality of materials and quality of welding, so that the likelihood of the cracking is reduced.

Second, NDE methods and in-service inspection to try to find cracks before they grow significantly.

Leak before break is next in line. The idea of finding a leak and if there is a leak to be sure to find it, identify it and take action at that time -- it seems to me the key is whether or not you have a tough material. It is almost the same argument as you have with the pressure vessel. You have got to have a tough pressure vessel. If you have a tough pressure vessel material, that has certain implications. If the pressure vessels were built out of glass, it would be different.

I think we do have tough materials in these piping systems. They can tolerate a leak without a catastrophic break being the next step, which gives us the opportunity to detect it.

The whole idea is you don't want to just go happily along and say, we aren't going to do anything, because if it leaks then we will fix it. That attitude we just don't have.

MR. BENDER: I am reminded of the fact that there are some people that are concerned that we may have a a crack in a state of development, but not through, and it may break through as a result of some kind of loading that we hadn't originally expected before the next in-service inspection. And there are people that think that cracks that start that way may propagate fairly fast. I wonder how much attention is being given to that.

MR. STAHLKOPF: I think we can answer that by saying that, from looking at the large line data -- and I think Robin presented it earlier today -- we feel that the chance -- because of the compressive stresses from welding of your large lines, we feel that the propagation of a stress corrosion crack rapidly into compressive stresses, where you are well below the Kl SCC of the material, is extremely unlikely; whereas it is not necessarily true for the smaller lines.

In addition to that, we are taking both a theoretical and experimental look at questions of mouth opening area under a variety of loadings for 304 stainless steel in a variety of crack configurations. Certainly our first look at it from static as opposed to dynamic loading cases leads us to believe that it is extremely unlikely that we will get very large mouth opening areas with throughwall cracks, certainly under the static conditions, and probably not under the dynamic conditions, because the plastic hinge will form at the bottom and you get a certain amount of yawning.

That is our best estimate of it right now. We are proceeding with an experimental program at both GE and Battelle Columbus Laboratories to confirm our preliminary findings.

I don't know if that answers the question.

MR. BENDER: I think that is a good start. I think that is the kind of thing we ought to be thinking about. I didn't invent the question and I am not necessarily a proponent of it being a problem. But nevertheless, it is one that hangs around, still.

MR. STAHLKOPF: We feel very strongly that leak before break needs to be demonstrated with a variety of pipe sizes and crack configurations. We are proceeding to not only theoretically treat this, but experimentally treat it, so that we can let the doubting Thomases put their fingers in the wounds, so to speak.

DR. CORTEN: Are you anticipating problems with the dynamic as opposed to the static?

MR. STAHLKOPF: No. We feel in the dynamic case we will simply be dealing with the formation of a plastic hinge and a certain amount of yawning of pipe. We do not anticipate a problem at this time.

MR. ROSSIN: Are you suggesting that is an area that we ought to look into as possible research areas?

MR. BENDER: I think you need to put the question to bed. It hasn't been put to bed yet. Whether it is done by research or analysis or some combination, I don't know.

DR. SHEWMON: Let me clarify one point. You started this with a discussion, a question about leak before break as an inspection technique.

MR. BENDER: It is a rather complicated logic.

DR. SHEWMON: I am concerned about your chiding people, in spite of their inspection technique, how many leaks they find, when they indeed dribble out on somebody, or whether you are concerned about whether indeed it would be a stable small crack.

MR. BENDER: I will start back at the beginning. There is the potential for stress corrosion cracking to occur. I think the experience at Duane Arnold says it could go a long time before you found it. As a matter of fact, I guess there it could have been found by the leak before break approach.

MR. ROSSIN: It was.

MR. BENDER: We were comfortable with that answer, at least some people were.

MR. ROSSIN: It is a fact.

MR. BENDER: However, if those cracks had been there and you hadn't found it by that leak before break approach, and if some type of dynamic loading had occurred -- and I am not sure what they are, nor do I necessarily think that there are any that are a problem, then there is the question about whether that could have propagated into a serious opening in the system and held if the crack had propagated when it started. That is a question that has been raised by a number of people, and I think it needs to be answered in some form.

MR. STAHLKOPF: Just to recapsulize what I have said, we agree with you that this question needs to be put to bed, and that is why we are not only going to go through detailed theoretical analysis of both the static and dynamic cases, but will actually be doing some large-scale pipe testing, which we hope can sufficiently answer these questions.

MR. ROSSIN: We have some system work going on in other EPRI programs on dynamic loadings, pipe whip, water hammer, and so forth. I think one of the questions is to identify the kinds of stresses that we are talking about and see whether there is something that can be looked at in a step-wise logical way, or whether we have got a problem that we weren't really addressing before.

Let me be specific. We have looked to some extent at the kinds of loadings you can get from seismic events and from postulated shock waves, steam and water hammers. When you look at the kinds of loadings you get, you don't get catastrophic breaking if you have got this kind of configuration. Even with relatively standard stress analysis, I think it is important, if people are of the opinion that this is something which definitely goes from this point to this point to a catastrophe, that we get some quantitative measure of this.

We don't believe that the numbers really imply that. It is something we are looking at. The theoretical work is the first, the analytical work. We really don't have evidence that these kinds of loadings are going to cause the kind of breaks that we talk about in these materials.

MR. BENDER: I imagine Herb Corten agrees with you, but I imagine I can find a few people on the staff that don't.

MR. ROSSIN: I think it is important to explore this further. I think we ought to be apprised of the feelings of members of the staff to see if a formal research project -- as I said before you came in, Mike, one of the things we have here is a program with an Advisory Committee that can cut off a research program, start a new one, whenever we feel like it. We have got the funds and the program to do this, and if this is something that is a priority we will put the effort there and see if we can solve it.

MR. BENDER: I'm not trying to set priorities. I raised the question because we need to discuss this kind of thing.

MR. ROSSIN: We need your input for setting priorities. There is a message here we want to take into account.

DR. SHEWMON: Let me follow up on that. Vance, would you comment on what you feel is the state of communications of the staff's concerns with this group, and to what extent you have been involved with that kind of a dialogue?

MR. VOONAN: I feel that the staff's communication with the groups are pretty good. Warren Hazelton has been in close communication with a lot of the EPRI people, finding out what is going on. Both Dr. Weeks and Frank Almeter from my staff have been talking to various EPRI people. I personally have talked to Mr. Gridley from GE on a number of cases about this.

When Duane Arnold first came about, one of the first things we did do was take a look at the break, and we saw in there the worst crack, and applied various loads, both normal and accident loads, to see if we could theoretically postulate rupture to pipe. From our analysis, we could not. We said -- there were some classic cases where pipe whip would withstand, like given the seismic load. That gave us some comfort and the feeling on what we were doing as far as Brunswick and our ability to detect cracking in this particular area of Brunswick, because it is difficult to look at an area.

The in-service inspection programs that have been implemented on Duane Arnold and Brunswick, and I think the better techniques used, gives us comfort that if the crack develops, we will capture it at an early stage.

DR. SHEWMON: We will change the subject. One of the other ways, as has been alluded to here, is increasing -- I would like to talk about exposure to personnel, something you alluded to, instead of better materials. Could you say a little bit about what program -- or am I talking to the right group? -- about what happens there with regard to getting the source term down as distinct from better widgets, so that the guy doesn't have to stand around and wave it so long?

MR. ROSSIN: One of the major EPRI utility efforts is decontamination of Dresden 1, and while it isn't in the BWR pipe crack area, a number of the people here are familiar with what is going on. And of course, there is widespread utility interest in the results and what we are able to find.

It is very clear -- Joe Danko could add from his recent discussions with Europe -- that there are some substantial advantages, if you are going into the repair program, to possibly even decontaminate a local area, and this is going to be important if you have repairs to plants that have been in operation. So it is not a new area. After all, decontamination has gone on in all kinds of processing facilities and Navy programs and other places, and the technique is useable. We just have to enlarge our experience base.

DR. SHEWMON: Do you feel that on Dresden 1 the critical path is in your shop or in the NRC shop at this point?

MR. ROSSIN: Dresden 1?

DR. SHEWMON: Yes, in that decontamination. That has slipped several times.

MR. ROSSIN: Those are the problems of getting a job done. I don't think it is a regulatory problem. We are having the usual problems with project schedules. We are not immune to those.

MR. VOONAN: Later in our discussions, we talk about the staff presentation -- Ron Gamble from DSS will be talking about what we are doing in the area of piping and what type of research we are proposing.

DR. SHEWMON: Let me come back to an earlier question. You said that Warren talks regularly to these people, which I can believe, and that keeps your part of the forest informed. To what extent do you feel he has an appropriate sense of responsibility about representing Jim Knight's people or indeed the NRC? Are they going to be blind-sided some day because they didn't talk to somebody else?

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MR. NOONAN: Ron Gamble, who used to be a member of our staff is not part of Jim Knight's staff over at Materials. We are basically in daily commmunication on various problems, and also with Joe Collins from I&E and Muscara from Research.

We do talk quite a bit. There might be times when we fail to mention it immediate, but that is becuase they are pressurized, not necessarily because of -- not because we haven't told him. We do tell them.

DR. SHEWMON: There is a difference between taking care of one's own responsibility or interests and feeling a responsibility to represent an organization.

MR. HAZLETON: The other thing I might mention is that a lot of our contact in the past, once every six months or so, has been with General Electric, where they have given us essentially one-day or two-day seminars on all of the things that they were doing, including the stuff they were doing for EPRI. Whenever those seminars come up, the representation is intended to cover everybody, DSS, DOR, RES, I&E.

Sometimes the meeting comes up and somebody can't make it, but the intention is that we have the relevant representation from all of the NRC at these meetings. There have been fewer of those several-day seminars given by EPRI. I am happy to see one coming up. But, again, we would -- our general attitude in this area has been, "Hey, the appropriate people at the working level in each of the divisions of NRC should be there. We talk together." Really, we do.

MR. BENDER: Is there a position paper on this that says here is where we think the answers are? And is it signed off by Knight and his people?

MR. NOONAN: Speaking of position paper, I am not sure we have what we call a DSS, DOR memorandum system that is working --

MR. BENDER: There is a task action plan in this area.

MR. NOONAN: There is information feedback, and there is what we call an experience, operating experience feedback. Under the information feedback, it is just that. It is information fed through officially so that it gets to the appropriate people, the appropriate management people.

On the operating feedback, again, it is a piece of paper that is sent through, but it requires some action on [illegible]S's part to say what action it would take. And there is feedback the other way also -- that is, systems and operations.

DR. SHEWMON: I think we will adjourn for lunch unless someone has some more pressing business.

MR. ROSSIN: We appreciate it, Paul. Thank you j13WH

very much.

DR. SHEWMON: Thank you.

(Whereupon, at 12:29 p.m., the hearing was adjourned, to reconvene at 1:30 p.m., this same day.)

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AFTERNOON SESSION

(1:30 p.m.)

DR. SHEWMON: If I can find my agenda here, I will tell you who is next.

This afternoon we shift tangentally, or slightly, to generic matters.

And let me talk to the front table here in Executive Session. Mr. Igne is concerned about whether or not we have covered item D, as in dog, in that agenda.

Does anyone where have anything to do on program objectives and feedback to say to the utilities before we go on?

(No response.)

All right. Good.

Then we will go on to the presentation from the staff.

Vince.

MR. NOONAN: Good afternoon, gentlemen.

My name is Vincent Noonan, of the Engineering Branch of the Division of Operating Reactors.

Today we will talk about the generic matters concerning pipe breaks. I will have my staff -- in fact, there are about 10 people here from DOR and DSS, combined, to address various matters, to field questions as required from either the committee or from the floor.

Mr. Hazleton will be the first speaker, talking about status of PWR and BWR pipe cracks; to be followed by Dr. Cheng and Ron Gamble from D&S.

We will also get into some problems that we had recently on TMI, borated pipelines; and finally, on the feedwater pipe crack problems.

Dr. John Weeks and Dr. Almeter, from my staff, will talk about the technical specification on water chemistry, and of the final interest -- I wasn't quite sure -- I do have Jack Strosnider here from staff to give us a rundown on the latest steam generator problems, both in foreign reactors and the latest one at Prairie Island and Trojan, resulting from cracking in the pipes.

A couple of questions -- I would like to refer to a handout that we have on feedwater pipe cracking, and I apologize -- it is not a viewgraph, because it was made up to be part of a report, and it is in very fine print. We didn't think it would come out very well on a viewgraph. It does list all of the PWR pipe-cracking problems we have been having in the feedwater lines.

The only thing -- Mr. Hazleton will be addressing this generically and talking about all this -- the only thing I want to bring up is on Mill Stone.

In August, Mill Stone reported a series of cracks to us in their feedwater lines. They told us the cracks

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were about approximately from 60 to 90 mills, and some extending completely, 360 degrees circumferentially either on the safe end side or on the pipe side of the transition section of the weld.

All of these cracks appear to be well away from the heat-affected zone of the weld, but they are in an area where they have some stress concentration points.

In August, we let the utility go back to power, because in order to make the repair for this particular utility, it requires us to chip into the shield wall. It is about five feet thick.

We asked them to go back to power until the end of October, in that period of time to do two things: Number one, come up with a program on how they would make a repair if a repair would be required; and, secondly, to do an inspection at this outage or this shutdown to see whether or not the crack is growing.

My main concern was in the shield wall since it does require shipping a fair amount of concrete. I didn't think that problem was thought out too well.

We did do what we call a fracture mechanics analysis on the crack, and we felt it was safe to operate the plant until the end of October. The plant did shut down on the 31st.

They went in, and when you see under inspection results, we were going to reexamine. In the data we have back from my consultant this morning, it said the reexamination showed that, number one, we either missed the cracks in the original inspection, or that cracks have grown to such a depth that we no longer feel comfortable to allow that plant to continue operating without replacement of pipes.

Mill Stone 2; the position taken by the staff on Mill Stone 2 is that they will probably go in and chip concrete and replace the pipe. This has not been taken all the way to our management, to Darrell Eisenhut. I tried to contact him this morning, and he is at NDS. But Bob Tedesco, his deputy, is aware.

The second item I would like to talk about very briefly is on the stress rule index produced by GE on BWR plants. We have what the staff considers a topical report, submitted by General Electric — I forget, about a year ago?

We have now prepared a list of questions of approximately three pages. The questions have been generated and will be coordinated through Ron Gamble. I don't think Ron has seen them, but they will be coordinated through him at this point in time. It is our intention to release these questions, whatever comments Ron would have from DSS to GE, and then request a meeting on the NEDO report to go to a full discussion of the stress rule index.

I expect that to be done sometime this week, assuming we can get everything out this week.

MR. BENDER: Are the questions of a nature to cast doubts on the credibility of the GE approach?

MR. NOONAN: I wouldn't say cast doubts; concern maybe, not not necessarily doubts.

I think the questions, as I read them — and I read them Friday afternoon -- it seemed to me that all of the questions could be addressed; whether they could be addressed satisfactorily or not, I don't know. But they do raise a number of staff concerns regarding the stress rule index.

The last think I would like to bring before I let Mr. Hazleton take over is on the PWR pipe cracking. Again, we are looking at things that are called reportable indications, what this means in terms of -- particularly on UT, what this means has cost has caused us some concern.

Remember, on Duane Arnold we had very few reportable indications on all of the nozzles. It turned out that there were quite a few indications on second look and using better techniques by Mr. Lamberg and his team, that the indications became quite obvious, and they would have been called cracks had we used the proper criteria.

We are concerned with what criteria we are using in reporting UT indications. And the list that you see on the PWR feedwater piping, I&E is now taking action to go back and look at those plants that reported no cracks, to double-check and see if the indeed -- what criteria they were using, and if we were aware of the exact criteria, and if we are satisfied with what the criteria -- so indicated so for the -- when they said no cracks.

Unless there are any questions, I would like to turn the meeting over to Mr. Hazleton.

MR. BENDER: Let me get back to this list of questions that is being submitted to GE again for a minute.

I take it the list has gone out?

MR. NOONAN: It hasn't gone out yet.

I told Mr. Gridley about the list. It has been generated by our branch, Engineering Branch in DOR. It is to be transmitted to Mr. Gamble from DSS for his consideration if he wants to add to or comment on the list.

Then what we plan to do is send the list on to GE officially and then request a meeting to discuss the questions.

MR. BENDER: Has there been some internal discussion within the regulatory staff to establish how much of it could be resolved without sending it to GE?

MR. NOONAN: The questions we have right now -- evidently we feel that none of them can be resolved without sending them to GE. A lot of these questions were generated

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back in the time when we were looking at the Duane Arnold problem and when the GE stress rule index first came about. At that point in time, if you look at our safety evaluation, we decided since we did have concerns amongst the staff we would not use the GE stress rule index as part of our criteria in dealing with Duane Arnold.

So when we wrote our evaluation, we did our safety analysis on Duane Arnold. We did not consider the GE stress rule index.

MR. ROSSIN: May I ask a question? Wouldn't it be wise to get the list of questions together, have the meeting, and then questions that aren't resolved, then you issue the list?

MR. NOONAN: Yes, I see what you're saying, whether I can do that efficiently or not.

MR. ROSSIN: I say before you issue your list of questions, find out if a lot of those questions can't be answered very simply by communication, by sitting down across a table?

MR. NOONAN: I am willing to do that. In fact, I will do that. I will submit a list of the questions prior to issuance of them officially. I will talk to GE, but I really feel that in -- as the final result, that the only way these questions can be answered is through a meeting.

MR. ROSSIN: At that point, fine. The reason I bring this up is because I have -- as I said before, we live in an adversary situation. A number of these questions are the kinds of questions that are issued in all kinds of licensing activities. Many of them have straightforward answers. Many of them are a matter of the questioner and the answerer understanding what the disconnect is.

Once that list of questions is issued, the owner companies are going to end up badgered by those questions by people who don't understand the questions. And yet we are going to have to live with this badgering.

It helps very much if you are able to eliminate the answerable questions early in the game. The real questions, fine, we will live with those.

MR. NOONAN: I have to take some exception to that point. I can see no harm other than what you referred to as "badgered by." I can see no harm in officially asking the questions, putting them on the record.

Some can be answered very simply, I am sure. Some would be very hard to answer. From the staff point of view, I don't think I would want to be put in a position where I would say that I didn't publically ask all of the questions that my staff felt were required to be asked.

DR. SHEWMON: May I comment on that?

You certainly don't want to put yourself in the position where you get to be accused of being a tool of the

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industry. I am not sure that I fully understand what happened with regard to fuels last week; but as I understood the latest crisis that ended up in the New York Times, which is where I heard about it, by the time I got through my Saturday morning paper, it [illegible]ed out that staff and the industry maybe hadn't talked enough about what the hell the curve meant. If they had had one phone call before, we wouuld have been spared one round of effort by the New York Times to explain to us how dangerous reactors really were, and the staff and to bakd off and say, "Gee, we just couldn't read the curve right. Sorry." None of us what that to happen.

MR. NOONAN: Dr. Shewmon, rest assured that while Mr. Gridley from GE has not seen the questions that we will talk to him about the questions. I guess it will be up to us to decide what format the questions --

DR. SHEWMON: What the questions are is for you to decide.

MR. NOONAN: That's right.

I think at this point in time I would like to introduce Warren Hazelton, who will lead this discussion.

(Slide.)

MR. HAZELTON: Several months ago the staff was asked to reoort on the pipe crack study group report, so at that time we told you, in general, what was contained in the report and what the staff's further actions were going to be. So we mentioned then generic -- A-42, which was set upp to review the pipe crack study group's report and to determined what visions NUREG-0313 were required and to make those revisions.

Well, the task manager for A-42 just got that report issued. We have just a few copies.

What is expected now is that we will get comments back from the public, comments from the ACRS, and presumably that might end up with some kind of a supplement to the NUREG somewhere around March.

Then we would expect to implement those staff positions somewhere around May.

Now, a little later Sy is going to give you a quick overview of what is in NUREG-313 and the major differences between the new version and the old version.

But before we do that, I would like to cover some more general aspects. It was recognized that the pipe crack study group couldn't come up with all of the answers. You just can't come up with answers — they came up with questions, recommendations, and so forth.

One of the things that was identified in the new 313 is the list of general recommendations -- that is, for further work, what yet has to be done.

And I think we heard a lot about the kinds of that have yet to be done this morning.

Also, again, in response to the ACRS letter that we discussed earlier, the staff prepared an answer to that and pointed out that many, if not all, of the concerns expressed by the ACRS are somewhat shared by the staff. And plans to address them are going on.

(Slide.)

Just to give you a quick overview of this -- and if you think that A, B, C, H, J isn't the correct alphabet, I had a little trouble with the secretary on that also.

(Laughter.)

But these are subjects that are covered in the follow-on work recommended in 313. And I have for this purpose grouped them having to do with the subject matter, but I used the letters that were associated with — in the 0313 document.

You can see there is one main subject here. We have to work on improved UT methods, and basically it is improved crack detection. By that we mean let's do a better job of finding cracks before they get to be big cracks.

Of course, to do that you have to have effective inspection methods. And then you to inspect those welds that have cracks. If you don't inspect them, you will not find them no matter how good your techniques are.

On the other hand, you can't inspect every weld, so you have to some kind of focused inspection program. I think we talked about that this morning. We said look at the susceptible welds and the different ways of determining which welds are most susceptible.

So these things the staff considers very important. And of course the stress rule index is one possible way of pointing to susceptible welds. That is why that is an important subject to us.

Another thing, related, but more aimed at new plants, is the use of improved weld joint configurations. Some of the configurations are almost uninspectable. Many of them have to be machined on the outside, smoothed down, to get good ultrasonic inspection.

We feel that action should be taken in that regard, but it may take some action in the codes. It make take regulatory guides or something. These are things that we are planning to work on.

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Another thing that could possibly tell us which are the welds to look at is getting the use of EPR to detect the susceptible weld joints. That was talked about this morning.

Another thing, of course, is improved leakage detection methods. One of the things that the staff has in mind, again, is acoustic emission method of leak detection. It looks like it has promise.

MR. BENDER: Before you take that off, let me ask my question. Most of these, I presume, are long-range approaches?

MR. HAZELTON: Well --

MR. BENDER: If they aren't, which ones are not long-range? Let me put it that way. That might be a better way of our understanding what it is you want to do right now.

MR. HAZELTON: There are long-range approaches, but some of them have things you can do fairly rapidly, and some we just have to wait for the programs to be completed until we get the answers.

DR. CORTEN: You say it would be almost completed?

MR. ROSSIN: No, because we don't know the answers.

MR. HAZELTON: You know some of the answers. You know what not to do.

MR. ROSSIN: That is not really what you are after.

MR. HAZELTON: No. These are really going to be ongoing programs, and a lot of them we'll take steps, we will take small steps, in the right direction, hopefully.

MR. BENDER: This is alleged to be the resolution of the generic technical activity A-42. What I see here right now are a bunch of hoped-for improvements. I guess I am not really clear that there is any time associated with when they could be accomplished.

There is not much to tell me which ones really have the best chance of success. Neither is there anything to tell me whether, if I got part of the result but not all of it, I would be okay. Are you going to tell me all that today?

MR. HAZELTON: No, I am not going to tell you all that today. These are the kinds of things that the staff is doing, and plans to do.

It has come up with just answers to questions like that. We want to get some idea of the scheduling and staff programs, but we didn't say we had all of this wrapped up in a package today. We are giving the current status. I am saying these are the things we see that have yet to be done. I can't give you a definitive, scheduled program today.

MR. BENDER: I can appreciate that problem.

MR. NOONAN: The program, as outlined by Mr. Hazelton up there, the one that is not included under Revision One of 0313; 0313 was originally sent out to the utilities. A number of responses were received by utilities about two years ago. Those responses recently have gone through review by the staff, and we felt that rather than go back to the utilities with questions, or ask for an update to these responses, what we effectively have done in our "paper mill" back at the staff is to have taken the original responses and have deleted them. We have said that they are no longer applicable because of the Revision One.

Revision One goes out for public comment for the next 60 days. That has been done. Within 60 days after that, we plan to send to the utilities the NUREG and ask for their responses to the various areas involved.

Clearly, some of these are, as you say, long-range programs but if you looked at items A, B, and J, which I will tend to focus on as being maybe ones we can answer in a reasonable amount of time, I would think those are the ones we would try to focus our attention on.

MR. BENDER: I think that is the kind of answer we are looking to have.

DR. HANAUER: Perhaps I could add to that. What it means to resolve any technical issue is, to be blunt about it, is to put out a new set of requirements. The nature of this particular issue is that we know more this year than we did last, and we will know more next year than we do this.

NUREG 0313, Revision One, has two kinds of things in it. There are some new requirements for in-service inspection, for example, and there is also a list of things that are going to require more work. I think those are rather clearly differentiated in the document. That is why there is this funny gap in the numbering system.

Therefore it is possible, by a somewhat more careful reading of the document than you have been allowed to have so far, to find that it contains a set of new requirements, much stricter material requirements for new plants, and much stricter in-service inspection requirements for plants that didn't use the new materials; and also these things for the future that we are going to learn more about next year.

MR. BENDER: I think that is a help.

MR. HAZELTON: As I said, I am skipping over the main part of NUREG 0313 to hit these particular questions, because it appeared that in that ACRS letter, you had some concerns. And I wanted to show you that 313 also recognizes these same concerns.

When I get through with this, Sy Cheng will tell you more details about what specifically is in 313.

MR. BENDER: I can't discern the degree of concern from what is up there yet. Maybe one of these days I will.

(Laughter.)

(Slide.)

MR. HAZELTON: Going on to other items that were recommended for additional work, that should be "reducing incidence of cracking." In other words, we should see to and do what the NRC can do to see to it that cracking is reduced. Items under that are possible water chemistry control and, as you heard this morning, it is not absolutely certain that de-aeration is going to help, or how much it is going to help.

The staff can not make that judgment today, to make everybody out there put in $100 million deaeration equipment, when there is still disagreement or uncertainty as to whether it will do any good. So we have to wait until the results are in.

Obviously, we can take a look at system design to minimize stagnant or low-flow piping; the evaluation of new materials, evaluation of new process methods. This sort of goes along with the body of 313 where certain materials and processes were considered acceptable by the staff, and there are others that have to be looked at further.

MR. BENDER: Is there anything that I might infer from that list that is different from what I heard this morning when the BWR owners group made their presentation concerning what they were doing to reduce the incidence of cracking?

MR. HAZELTON: Nothing I can think of right offhand.

MR. ROSSIN: We have not emphasized minimizing stagnant or low-flow piping.

MR. BENDER: I didn't hear anybody saying that we ought to make Susquehanna cut off some piping, for example. I don't know what "minimizing" means today. What does it mean?

MR. HAZELTON: I guess we are not sure exactly what it does mean. That's why we have this as an item that we want to continue to look at. I could be very simple about it and say we should look at whether we are going to let these people have the bypass lines; but it isn't that simple.

MR. BENDER: How would you decide?

MR. ROSSIN: I told you --

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DR. SHEWMON: You may elect to do a local option?

MR. ROSSIN: No. On the other hand, we considered the options. We decided both were viable. Leaving them on the one pair of reactors, taking them off the other, that neither one was a bad decision and we could do one in one and the other in the other, and watch it and see what happened.

MR. BENDER: I think you made your decision on the basis that if you got in trouble, you could always cut off the lines that were left.

MR. ROSSIN: That was one consideration. But our major consideration was that we didn't believe that low flow, or stagnant flow, was really a significant contributor.

MR. HAZELTON: Perhaps intermittent flow would be worse, in my opinion. The reason these items are on here is because as of today, when we put out NUREG 313, we haven't come to any conclusions. And that is where we are today.

MR. BENDER: There is nothing in Item D, E, F, or G that represents anything very new.

MR. HAZELTON: That's correct.

MR. BENDER: It is the same old story we have been hearing for several years, at least.

MR. HAZELTON: That's right.

MR. BENDER: So it wasn't learned in the past year, that's for sure.

MR. HAZELTON: That's right. And I don't know quite what your problem is with that.

MR. BENDER: Well, I guess my problem is mainly if we are trying to resolve something, the impression I get is that this doesn't represent part of the resolution. This is part of the deferral of the resolution.

DR. HANAUER: I don't think that is quite true, although there are some areas that can not be resolved with today's knowledge, so we have to get some more.

DR. SHEWMON: Maybe we should get on to the third or nonexistent one that says indeed what we have decided to do differently from last year. Maybe he is starting at the wrong end.

(Laughter.)

MR. BENDER: That might be my problem. I heard Steve saying that you are going to have some more inspection. One of these days I will find out what the inspection will do for you; but go ahead.

MR. HAZELTON: A third item is -- I have called it pwa-8C

"evaluation of consequences of cracking." That is really two subjects, and one is what we call the "leak-before-break" concept.

The staff is not convinced that we have all of the answers, so we are proposing some additional work. And Ron Gamble will talk about that in a just a moment.

In addition, the Task Group on Bulletins and Orders is reevaluating the adequacy of the systems emergency procedures and operator training, et cetera, to cope with the small LOCA. This is again something that covers one of the items in the ACRS concerns.

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That is part of item 3?

MR. HAZELTON: Yes. This particular item was not in NUREG 0313, so it didn't have a number.

(Slide.)

MR. HAZELTON: Right at the moment, then, let's go to Si Cheng and let him give us a little more detail on 0313.

DR. SHEWMON: You guys can change places, but let me discuss things out loud for a moment. There are various exercises going on to clean up generic items, I guess, for half administrative, half cosmetic and political reasons, as I see it.

If I can address a question to Mike here, what we are supposed to be doing here is to at least be sure that we can report back as a committee to what the status is, rather than resolution?

MR. BENDER: My impression is that the Committee needs to find out whether there is a way to get to a resolution on these generic questions. Presumably, these task action plans are intended to provide a resolution; and they may. I think we need to find out whether they do or not.

MR. HAZELTON: I would like to make a comment here. Task Action Plan A-42 was clearly narrowly directed. I think perhaps Si can address any questions you have on that. It didn't presume to solve all of the BWR cracking problems.

MR. BENDER: What we need is not to solve the BWR cracking problems because we never will, but to establish that we have a way of being sure that there is no public safety problem left because of it, and to be able to show that to the public. That is what is troublesome about this thing.

While I haven't read it in detail, Steve, I have looked at it enough to know that it has some "icing" on it for the "cake," but there is a lot of chit-chat in it about things that we may do in the future that tend to confuse the practicalities of the thing with wishful thinking.

MR. HAZELTON: The two things that I think address specifically what you are talking about is this (indicating).

(Slide.)

MR. HAZELTON: If you let us --

MR. BENDER: Go ahead.

MR. HAZELTON: -- Si and then Ron Gamble will tell you what we are doing about these.

DR. SHEWMON: There is still the question of -- if I may rephrase it, or as I understand it, of what is your argument that it is indeed safe to continue operating BWRs. If that is the resolution of the generic items, then this is nice, but not responsive. We will get back to that before we get done. Go ahead.

MR. HAZELTON: All right. I believe you will find the answer to that in the Task Action Plan A-42, which tells us why it is safe to operate BWRs until everything is fixed.

DR. CHENG: I am from the engineering branch of the Division of Operating Reactors. Perhaps before I start, I should show this slide to show the chronological events, what actually A-42 intends to do.

(Slide.)

I think we may have problems regarding the A-42 task action plan. Of course, let me go back to the initial NUREG report.

The first NRC pipe crack study group issued their NUREG report back in '75 regarding the IGSCC, and based on that NUREG report, in '77 we issued the original 0313, the implementation document, that is essentially -- It took the study group report recommendations and put them into the staff position.

After the issuance of the original NUREG 0313, we know that the IGSCC continued to occur, in particular, the large diameter pipes in some of the safe ends. So last year, we established the second NRC pipe crack study group to look at more recent incidents.

And in February of this year, we came up with the NUREG 0531 report. In June of this year, A-42, which is classified as the unresolved safety issues; the task force was formed in June with two objectives. As the first, it took the NUREG 0531, recommendations of the pipe crack study group, and looked at their recommendations to see which recommendations can be put into the implementation right away. We know some of the recommendations might take a year, two years, three years, or five years to reach a staff position; but some of the recommendations which we can implement immediately.

And that was the first objective of A-42: To take those recommendations and put into the revised original NUREG 0313, and try to implement those immediately. That was the first objective.

Again, it was the objective of the A-42 to identify among all of these recommendations from the study group which items required further study; that we have to establish staff positions. That was indications of those items, the general recommendations in the 0313, Revision One.

Now, I guess we could have other groups who could establish NRC's staff positions. But at the moment, we haven't established that group yet.

MR. BENDER: I hate to be the devil's advocate here today, but somebody has to be the devil's advocate, and it might as well be me.

(Laughter.)

MR. BENDER: When I look at what you have talked about doing, the only question that stands out in my mind as being one that needs an answer is: What do we have to do in order to continue to run BWRs?

DR. CHENG: Yes.

MR. BENDER: I read into what I have been told so far that there are not very many things you can do in the short term. You can inspect more frequently, perhaps. Perhaps you have some method that will detect certain kinds of cracks; and perhaps there are some materials that can be replaced.

Now, I don't think there are any other things that can be done in the short term. But I have some difficulty in discerning which of those things need to be done for which reactors, and when. That is what I am trying to find out right now. I don't care about what is going to be done five years from now.

DR. CHENG: Those items you just mentioned are all included in Revision One. I will run through that one and see if you agree.

MR. BENDER: Go ahead.

MR. NOONAN: If I could offer one comment, some of your questions that you are raising right now will be answered by Ron Gamble when he makes his presentation. And then I plan to make a little followup presentation after Ron. So if you could allow us that much time, we will try to answer as best we can.

MR. BENDER: I will try to stop asking questions and let you answer the questions I have asked.

MR. NOONAN: We will answer to the best of our ability.

DR. CHENG: Revision One was printed last Friday and is going out for public comment, for 60 days of public comment, and also requesting the ACRS comment. It hasn't actually gone out yet. It will be published in the Federal Register.

(Slide.)

DR. CHENG: I guess the question was asked that -- Mr. Bender wanted to know if there was anything new in Revision One. He reached the conclusion of perhaps nothing new here; but here I tried to summarize some differences between the original NUREG 0313 and Revision One.

The first item there is that Revision One extends to cover the Class 2 piping which was not addressed in the original 0313.

The second item includes safe ends, nonconforming safe ends, which was not included in the original 313.

The third item is inspection requirements in terms of samplings based on the original old Section 11 code requirement. For this one, we updated that to the more recent Section 11 code requirements.

The fourth item is the one you have the problem with: Those areas which require further study. The staff can not come up with implementations.

MR. BENDER: Do the first three up there represent enough to satisfy the concerns about BWR pipe cracks?

DR. CHENG: Yes.

MR. BENDER: Is that what you are saying, Steve?

DR. HANAUER: Yes, sir.

MR. TOBOTA: It should be made clear that these are the differences between the revision and the original NUREG report.

The original NUREG report requires that you use low-carbon stainless steel and you use clad, resistant cladding, when you made repairs. Those requirements are an integral part of the overall NRC fix. If you consider the fact that there were some original requirements that are still in effect, then I think the answer is "yes."

MR. BENDER: I want to come back to the in-service inspection sampling, but let's go on.

(Sli.'e.)

DR. CHENG: Revision One, following the same format as the original 0313, the first item covered is "additional materials," the additional requirements presented in Revision One. In terms of selection of materials, in Revision One, we identified which materials were acceptable to NRC: Ferritic steels, the L grade and nuclear grade stainless steel, stainless steel CF-3. The rest of the regular grade s'ainless steel is in its original conditions. In the original 313, I guess, all that is specified here is that the stainless steel with carbon less than .035 percent would be acceptable.

We tried to show some difference between -- in the two 313s. There is the .035, the L grade, in the sensitized position. You do not allow it in the fully sensitized position, do you, just the weld; you put a specification of solution-treated on the greater than .035, but on less than .035, you wouldn't want it fully sensitized.

MR. ROSSIN: You mean zero sensitization.

DR. BERRY: You don't say -- You say on regular grade; you don't say it for less than .035.

MR. ROSSIN: You don't necessarily want to have to solution and anneal the low carbon.

DR. BERRY: You don't to further sensitize because GE's results show that it's bad.

DR. CHENG: The solution anneals.

MR. TOBOTA: I think the distinction here is that we would permit welding on the low carbon material but would not permit welding on the regular grade material. So when we say "solution annealed," we mean, "will permit welding."

DR. BERRY: But the material itself is heat treated.

MR. ROBOTA: Right. The standard spec requires it, in the annealed condition before, in order for it to reach ASME standards.

(Slide.)

DR. CHENG: The next is testing of materials. This shows the difference between the original 0313 and Revision One. In Revision One we endorsed the ASTME to six tier, which was recommended by the pipe crack study group. But in the

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original 0313, it is a reference to the Reg Guide 1.44, but was not specified as a requirement.

Now, in Revision One, in terms of the service sensitive lines --

DR. SHEWMON: Would you go back and translate that first item into words that a simple professor can then explain to his students?

DR. CHENG: Number 2?

MR. BENDER: Here we go again.

DR. CHENG: Practices A and E of ASTM A-262 are required for all newly-installed regular grade SS.

DR. SHEWMON: The average junior doesn't understand that. What are practices A and E?

DR. CHENG: "A" is for residual material, to see if the material is sensitized or not.

DR. SHEWMON: It shall not be sensitized as defined by --

DR. CHENG: ASMT. "E" is more of the 24-hour test.

DR. SHEWMON: Another sensitization test.

DR. CHENG: Right. But a 24-hour type of test. That is the way I understand it.

DR. SHEWMON: That says it will not be sensitized as defined by these tests.

DR. CHENG: That's right.

DR. SHEWMON: That is the "as received" material; or is that the welded material?

DR. CHENG: If you use the regular grade stainless steel.

DR. SHEWMON: We are testing a welded piece of material, or as-received piece of annealed material?

DR. CHENG: As-received material.

DR. SHEWMON: Thank you.

DR. CHENG: Next, on the leak detection requirements, this one is revised to include the requirement, instead of the four hours and the cumulative rate exceeds the tech spec limit, it would be acceptable but here we extend the four hours into 24 hours.

In the 24-hour period, if the cumulative leak rate exceeds the tech spec, 2 gpm, instead of the standard test of 5 gpm --

MR. BENDER: Can I continue the student's education process? Let's go back to "3" for a minute, because it is a little confusing, too.

It says that all service sensitive lines were and will be designated by NRC. And then it says, "examples include the following additional systems." I take it in the original Reg Guide there were a number of examples to be included among others.

DR. CHENG: That's right.

MR. BENDER: You have added three more?

DR. CHENG: Two more.

MR. BENDER: All right. Do I infer from this that now you have got them all?

(Laughter.)

MR. BENDER: Why did you add these two, unless the original list --

DR. CHENG: In addition to the original list, we added two more systems into the category of the service sensitive lines.

MR. STAHLKOPF: The sensitive line is one in which cracking has been found, and cracks were found in both the recirculation lines and reserve pipes of BWRs in Japan; and of course, recirculation inlet, we have already covered this morning.

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MR. BENDER: This is a list of everything you have found so far?

DR. CHENG: A service sensitive line.

(Slide.)

MR. DANKO: On the first item up there, I am very surprised that you are continuing to specify A-262, Practice A and Practice E. But under an NRC-sponsored program, the electrochemical, potentiokinetic reactivation technique provides for sensitivity exceeding A-262. And that could be misleading, Practice A. I don't see any indication that that particular procedure should be considered before the checking of materials.

DR. CHENG: EPR --

MR. HAZELTON: This is one of the recommendations for follow-on work as soon as we have some standard that we can apply. We would expect to use EPR --

DR. MUSCARA: We have finished the development of the EPR test this fiscal year. We have final results and the results will be transmitted in a regional information letter, and the ASTM committees will adopt it. And then the staff --

DR. CHENG: At the moment when we issue this -- I put it in a general recommendation category.

MR. ROSSIN: You might modify your wording to include, quote, "or equivalent test." That is an absolute requirement if you leave the words that way. It doesn't leave you any for anything better.

DR. CHENG: If you read the document, the document did mention some of this on a case-by-case basis.

MR. ROSSIN: Let me finish that. Does that mean that those words as they stand now are not the ones in the document? Those are abbreviated for the slide?

DR. CHENG: Right.

(Slide.)

DR. CHENG: This is the augmented in-service inspection requirement for those systems which we classify as the nonconforming system. Then we have two classes. One is the nonconforming service sensitive line and nonconforming, non-service sensitive line. Those are the two requirements of the augmented in-service inspection requirements.

For nonconforming and nonservice sensitive line, what we require is the code requirements that they require certain inspections over 10-year periods. We shortened that period to 18 months for the enhancement of more frequent inspection for service sensitive lines, in addition to the original requirement in 313, we have the class 2 piping in this category; also the safe end. This was discussed this morning. It is included in these requirements; in the in-service requirements.

So for the operating plant with that kind of configuration, the original, for the attachment weld, would be required to augment the in-service inspection under the Revision One requirement.

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DR. CHENG: The Class 2 is in revision one, including the attachment welds to the safe end. That is a new requirement compared to the original 0313. And then there is the nonconforming surface sensitive lines. And we also point out the effectiveness of the Code, the UT procedure, in detecting the IGSCC, and require, if they try to inspect, the ISI will have to use available techniques; not the Code requires, but the UT procedures.

MR. BENDER: How good is the improved UT technique? What kind of cracks will it detect and why is that good enough?

DR. CHENG: They are using improved from the conventional UT technique. You don't stick the base on the Code of the evaluation criteria. The Code requirement is anything exceeding 100 percent has to be evaluated. If we have 100 percent, we will be okay. The improved technique, you forget the 100 percent evaluation criteria and anything above the background level you ought to look into to see if that is a crack or not. That is an improvement.

MR. BENDER: It is certainly a more stringent test.

MR. PITZEL: With all this noise here in the last 15 minutes and people leaving, I am confused as to what you are calling nonconforming class two, pressure boundary piping. What is nonconforming piping?

DR. CHENG: The regular grade stainless steel piping.

MR. PITZEL: You are sanctioning across-the-board total ISI of all Class 2 piping systems for all BWRs; is that what I am hearing?

DR. CHENG: If your plant had the Class 2 system, we are requiring augmented inspection for the ten-year period, whatever the Code requires you have to inspect over the ten-year period. That inspection would be complete within an 18-month period.

MR. PITZF : What about systems that are ordinarily exempt altogether?

DR. CHENG: If they are non-surface sensitive lines, they are not required here; only Code-required inspections for non-service sensitive lines. But if they are service-sentivie, they would be covered here.

MR. ROSSIN: It is still not clear.

MR. BENDER: Let me get back to the question we were trying to answer a little while ago.

MR. NOONAN: I wonder if you'd allow Joe Collins to talk about the UT procedure since he has been involved from the -- what is being done in the field, and what we call better UT procedures. Joe?

MR. COLLINS: There are a number of things that have to be taken into consideration in terms of what you call improved techniques. One of them specifically is the Code callibration techniques under which you are required to do specific things in terms of setting of your amplitude curves and evaluating your signals as you see them from the piping conditions, general reflectors and evaluating them.

The second thing is, spoken to this morning, is the difficulty in evaluating the different geometrical profiles of the various welds, simply because in the absence of Code standard joint designs, there is a total spectrum of joint designs that one can encounter in these different types of welds. That is from a counterbore of various profiles up to zero counterbore and simply may encounter back ranging in some of your piping systems.

In this sense, some of the improvements that EPRI is working on now -- and I don't want to speak for them, but what we are hearing now in the way of improved techniques is some signal processing equipment which the operator of the UT equipment will be able to better discriminate between what is the energy of a reflector coming from a geometrical or boundary condition, or what is actually coming from a crack condition. This discrimination must be made, because one has to make an interpretation, made on the signal-noise ratios based on two factors.

One is metal path distances and amplitudes. And those are the only two parameters one has now within the techniques to interpret what they are seeing in the volumetric scanning condition.

MR. STAHLKOPF: Do I understand you to mean that you then are going to require that either confirmer or adapting learning type techniques be used for inspections?

MR. COLLINS: No. I am saying these are the improvements that, as I understand it, are attempting to be made for this type of work.

MR. BENDER: What I am trying to get at -- I will try one more time -- is what are we going to require in the short-term. I think the techniques you are talking about are probably good techniques and they probably ultimately will be developed. They are not here yet, as I understand it.

MR. STAHLKOPF: They are in prototypical stages. We are not ready to go to the field with them yet. They are not a long way off, but they are within -- I would say they are within a year or less of field evaluation.

MR. BENDER: There are two things that need to be sorted out with them: One is whether they in fact discriminate in the right direction and don't hide things you want to find; and secondly, whether they are practical to use. I think we don't know whether either one of those things are true yet.

But my question is, we are putting out that requirement; what does it mean to the people that are trying to use it? It doesn't mean the thing we just talked about.

MR. HAZELTON: I would like to say a couple of words, if I could. The staff is doing a lot of things, trying to determine specifically, what shall we tell the guy to do. We didn't come here expecting to say two and a half megahertz at 67-1/2 degrees, et cetera. What I can say is, there is work going on in standards development and actually in DSS. We have contracts with independent people, independent from EPRI, and we have actually three, four reports now dealing with improved UT examination for IGSCC.

One of the evaluations of NDE methods for Intergranular Stress Corrosion Cracking in austenetic stainless steel lines, by Reinhart of EG&G, was issued in September '78, and not only went into detail, but it had an Appendix A which was intended as a proposed Code revision that can go in the Code.

The NRC people on the relevant Code committees have given this to the Code committee. They have been mulling it for about a year. I think everybody agrees something ought to be done, but it is very difficult to get specifics changed in the Code. I think a lot of them are still kind of waiting around to see what EPRI is going to come up with, to come up with a magic black box.

Well, it would be much easier. But the staff is trying to do something to resolve the question.

Now, the other thing that I should say is that these improved methods that we are talking about are in general use; I can't say in complete use, but in general use out there in the industry today. They are doing things above and beyond the Code to try to detect and characterize Intergranular Stress Corrosion Cracking. You have to realize that about half a dozen UT firms are doing this. Some of them are using special techniques developed through EPRI programs, using special transducers so developed, et cetera. Others sometimes are not, but using other methods.

So we don't feel that the situation is all that bad out there now in the real world. The problem, of course, that we have is that we don't have any requirements for these. We really can't be sure that the best techniques are being used. So we would like to see something in as a requirement. It takes a little time to do this.

As you know, we have people from Oak Ridge and Sandia helping us on this, and we didn't expect to go into this kind of detail here today, or perhaps we could have.

MR. BENDER: I am not sure I expected you to, either. I think there was -- the issue that we had hoped this NUREG would answer was explicitly what we were doing to resolve the dilemma we are in, in which we are having a recurrence of cracks in stainless steel piping, some of which people are concerned about, and not having a definitive method of inspecting for them and being able to tell people that that will keep the plants out of trouble from a safety standpoint.

I don't think I heard today anything that told me we have an answer yet.

MR. GAMBLE: I would like to make a comment on that. I think we are drifting here.

MR. BENDER: I don't think we are, but go ahead.

MR. GAMBLE: If we can step back a moment to the pipe crack study group -- and one of the things the pipe crack study group was asked to do was to assess -- one thing we did do was assess the consequence of BWR pipe cracking. Could you operate BWRs today safely, and what did you have to do to do that? The pipe crack study group answered that question. They made analysis, did review, and they came to the conclusion in that report that, yes, we have significant incidence of cracking, but in our evaluation we felt the BWR pipe cracking was not a safety hazard to the public if certain things were done.

What happened was A-42 was supposed to take the recommendations, review the recommendations of the pipe crack study group and the conclusions, and come up with a document that implemented that.

Now, I think the staff -- as a matter of fact, it says in Revision 2, NUREG-0313, I guess it is, the staff agrees that in fact BWR pipe cracking will not present significant safety hazards or a hazard to the public today. I don't think the staff is saying additional steps have to be taken to get to that point. The staff believes that we are at that point today.

A-42 I think makes quite clear, if you do certain things, that you do not have a safety hazard, you do not present a safety hazard to the public with BWR pipe cracking. It outlines the materials that one can use that are acceptable to the staff. It outlines the processes that can be used that are acceptable to the staff. It says what to do if you do not have those materials or processes in your plant, what do you have to do to assure that you have adequate levels of safety. That document outlines all of those things.

The long-range things that Warren pointed out do not have to be done to guarantee that we have adequate safety margins for BWRs. Those items, in staff's opinion, should be done to reduce the incidence and increase the reliability of incidence of cracking and to increase the reliability of cracking BWRs.

We don't like to have leaks coming out of the primary coolant pressure boundary in nuclear reactors. But based on our analyses and everything else, we do not believe, even if those cracks are there, that it is a significant safety hazard to the public. That is our conclusion. We have made that conclusion.

DR. SHEWMON: Let me pick up the line for a minute. So the staff has decided what -- why and under what conditions they think BWRs are safe to operate. This A-42 document is not a reg guide, as I understand it; is that right?

MR. GAMBLE: That's right, it's not.

DR. SHEWMON: So what is the status, if we get right down to what the regulations are, with regard to what instructions the utilities have? Has any letter come out of the task --

MR. GAMBLE: I think, as Vince outlined before, what will happen is this particular document is going to go out for public comment for a 60-day period. That will go out for public comment. The revision -- after 60 days, we will take the comments that have been received. We will consider them and either modify or leave the document alone, based on the comments.

Then we will take the document. It will be considered completed at that time. Then we will take it, and I think Vince mentioned before, we will send that document out to all of the licensees and applicants for CPs.

DR. SHEWMON: This then becomes a reg guide.

MR. GAMBLE: We will say, demonstrate that you need this document, or what plan do you have for meeting this document.

DR. SHEWMON: We do that instead of writing reg guides. When do we write reg guides and when do we promulgate NUREGs?

MR. ROSSIN: They can send us a letter that says, licensee do this or show cause, or whatever.

MR. HAZELTON: That is what we did the last time when

0313 came out. We sent it out, and then asked each utility what they were doing to implement the staff's positions. Before we got around to finishing the circle on that, we had a new pipe crack study group, and so now we have a new one. But that is our intent, is to send out a letter.

DR. SHEWMON: This goes out for comments first.

MR. HAZELTON: Yes.

DR. SHEWMON: That is probably an improvement.

DR. HANAUER: This is scheduled for discussion with the full Committee next Friday at 1:30. But it would be useful to have some of this discussion now. We have managed to add so much -- so many steps to the bureaucratic minuet involved in getting out a reg guide that it now takes two years. It is impossible to contemplate taking two years to get out the document, once having decided that this is an unresolved safety issue.

This document therefore has some of the properties of a reg guide and some properties that are not appropriate for a reg guide. In particular, it lists requirements, whereas reg guides have only acceptable ways of doing things. This public comment period, however, fulfills the Commission's promise to the public and to the industry that we would not adopt significant new requirements without an opportunity for public comment.

Since this and most other resolutions of unresolved safety issues do in fact impose new requirements, then, like this one, we anticipate that they will go out for public comment and that the comments will be received and resolved before any final Commission action imposing these comments. However, in some cases -- and this I don't believe is one of them -- the new requirements will have enough urgency that we will begin asking hard questions of licensees and applicants before the final imposition, which has to wait for the public comment and for management, and even in some cases Commission, review of the new requirements.

This document is therefore not exactly a reg guide, although it has some of the same characteristics.

DR. SHEWMON: Than you.

MR. BENDER: I think I would like to make a brief observation about what is going on.

DR. SHEWMON: All right.

MR. BENDER: I think the argument is being made that BWR pipe cracks are an acceptable condition and probably that is a practical observation. That is, they exist and unless we are really concerned about them, they probably are going to be acceptable.

The problem that appears to remain is how to inspect for them and when to decide that they are of concern. My belief is you are asking for more frequent inspection and probably some improved inspection technique. But I will be

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darned if anybody can tell what you are asking for in this reg guide or from the conversation here. My impression, from what I have learned from the industry people that are here, is they aren't sure either that they know what you are requiring.

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This may be a useful document, but not for regulatory purposes. It is just arm-waving, and I think we ought to do something about it. That is the end of my observation.

DR. SHEWMON: Vince, let me ask whether you think we are on status of BWR pipe crack program or in-service inspection of RCPB now.

MR. NOONAN: I think we are on both.

DR. SHEWMON: If we aren't on the second one, now I rule you out of order, and we will go on. If we are, I will let you talk about whatever you want to talk about.

MR. NOONAN: Let me talk one or two minutes here. We kind of got off of the schedule here. I would like Ron Gamble to get up, and I think he could address a lot of Dr. Bender's concerns that he has been expressing here. One thing -- I was going to bring this out later, but the appropriate time is now -- we are in the process of doing two things at the Engineering Branch level. One is at the Division of Operating Reactors level, and that is, we are forming a group -- and I hesitate to call it a pipe study group, a third pipe crack study group --

MR. ROSSIN: Don't call it that.

MR. NOONAN: I won't call it that.

(Laughter.)

It is basically a group of people including staff and consultants which will review integrity of piping in general, primary coolant piping. This group is chartered -- I cannot tell you what it is because it is basically in draft form, and it is going through many revisions -- this group of people would be available to us on an on-call basis to review new problems that crop up, regarding whether it is BWR or PWR piping. It would be available to look at public comments on the NUREG Revision 1-0313.

It would be available to us to assess any piping problem that we feel is necessary to have a group of experts look at in addition to the staff. That group has been -- Mr. Eisenhut has asked me to assemble this letter and formulate this group by the middle of November, so that we can be prepared to address, like I said, the public comments that have come in on NUREG-0313 plus any other piping problems that might formulate.

I can see the group being about four or five staff members, plust maybe about four or five consultants. The only consultant right now that has been contacted officially has been Dr. Bush, who has agreed to serve on this. The only other name I haven't talked to but am willing to formulate a name is Dr. Weeks. Those are two of the possible consultants that would help us.

This group, again, would be available to us to answer any questions regarding piping, whether on BWR or PWR piping.

One other statement regarding another subject on the steam generators. I am in the process of formulating a Branch Review Group at the Branch level to look at problems that we are now encountering on our steam generators -- leaking tubes, ruptured tubes, et cetera. This group I anticipate to be myself and my three Section Leaders, basically to look at each problem and then to determine what kind of manpower one would extend -- whether it is a materials problem, a mechanical problem, or corrosion problem or whatever.

We would then look at this on a weekly basis.

DR. SHEWMON: Let's come back. You know who you want to get up here this afternoon, and I think we probably have taken up most of Simon's time with our questions. There are five or six more pages here. Where do we go now?

MR. NOONAN: Let Si finish the one.

(Slide.)

Tobota will talk about our problems with the stagnated lines.

DR. CHENG: The last item is on the implementation. This will be covered in the Class 2 piping system. That is the only difference from the original 0313. The general recommendation has already been covered.

DR. SHEWMON: Thank you.

MR. GAMBLE: Let me just make one more comment about safety significance. Let me make a general comment about safety significance in the pipe study group.

The results of the pipe crack study group really define what we thought about cracking incidents and what had to be done about them. And to briefly summarize, I want to say that the pipe crack study group felt that undesirable BWR pipe cracking, as we knew it and as we know it now, does not present a significant safety hazard to the public. We still believe that. NUREG -- Revision 1 of 0313, we indicate things that have to be done to maintain that division for operating plants, for plants under construction, for plants applying for CP.

Those things are done, and those are indicated in the first part of the report. Those are the things that we are implementing or will try to implement in a very short period of time after the public comment period is over, and we have resolved any comments we have received.

As I mentioned before, there are maybe ten long term issues that are identified in the latter part of the report which made very clear in the report that the NRC staff does not feel that these have to be done because they are necessary for safety, but that it is desirable to reduce even further the incidence of pipe cracking in BWRs. We just don't like leaky pipes or significant cracks in the coolant boundary of nuclear reactors. That is why we are suggesting that the long term items be implemented.

We feel we are in a safe position now. We don't think we have to implement those long term things to get there. We feel we are there now.

With that little summary, I will go on.

(Slide.)

I want to present our fracture mechanics piping integrity program that we have. These are the main elements of our program. These are the highlights. I just want to touch on the highlights; I won't really talk in detail about any of these.

I also want to point out that this is not all-inclusive. There are additional programs within the NRC on fracture mechanics piping integrity. They don't necessarily fit into the scheme of things. We hope to have these things completed within 19 or 24 months. Some of the things that are going on within NRC and within industry are longer term than that, so we are having the program to develop evaluation methods and licensing criteria in that time frame.

This will be our basic approach. Just very briefly before I get into some details, this is assessment of integrity evaluation methods. There are various methods -- linear elastic fracture mechanics, limit load analyses. This was an assessment that the NRC is in the process of doing. I think the conclusion is set of which one of these particular methods should be used by the NRC for evaluation and licensing criteria.

We have already made our decision, and I will point that out later. The second aspect, of course, is a review evaluation and integration of industry programs -- not only the programs you have heard today this morning sponsored by EPRI and General Electric, but also specific analyses which have been done for specific problems such as asymmetric blowdown loads, LOCA blowdown, and others. This is across the board on light water reactors -- not only boiling water reactors, but also pressurized water reactors. Our program is for light water reactors, not just boiling water reactors.

The third aspect is application of elastic plastic analysis methods. One that is described in the pipe group study analysis for BWR and pipe cracking. That was one of the things that we used to make the judgment that there was no safety hazard associated with BWR pipe cracking. The second aspect of this is the generic application for light water reactors.

The fourth aspect is licensing criteria development, and then the fifth one is something very recent — full scale verification of light water reactor piping integrity. This is a program that we are asking Research to initiate for us.

I am not going to talk about the first two. I think they are straightforward. There is really nothing to be said that hasn't been said. I will talk about the last three items.

Application of elastic plastic fracture mechanics analysis, just very briefly, we have already applied elastic plastic fracture mechanics analysis in the pipe crack study group. It was the first time we did something like that. In that particular instance, we analyzed what I called the Duane Arnold pipe flaw. You would take any pipe of any diameter — it doesn't have a ten-inch line like Duane Arnold. It is a pipe that has 270 degrees part-through crack three quarters of the way through the wall, 90 degree segment that is through the wall. That is typically what is found at Duane Arnold, and that is what our analysis was based on.

We considered axial bending loads, bending or large loads, assuming you had something like a small earthquake load. The conclusion of the analysis was that the pipe must be longer than 200 feet in order to have what we would call rupture before burst. That is a very long length. BWRs typically have pipes in order of magnitude less than that. That is the main basis we used for drawing the conclusion that cracking incidents even as bad as you saw at Duane Arnold and even with earthquake loads do not present a safety hazard. You are just not going to have burst conditions. You will have leak before burst generic applications.

We are in the process of doing that now. We have some technical assistance programs to the tearing stability analyses for flaw and load conditions. We complete these analyses; we use this as the basis for evaluating flaws in operating reactors and also for development of a licensing criteria for operating at new plants.

MR. BENDER: Before you take that off, one question about the Duane Arnold analysis. Presumably the loads that are used were some that were either typical of Duane Arnold or some braketing load. What did you do?

MR. GAMBLE: It was a bounding load. It is one part of the analysis that there is a gap in. It was difficult for us to assess, because unless you go ahead and do a very detailed analysis of the loads that might be applied, we couldn't define the actually applied loads. What we did was, we said, let's assume that we have a bending load, a small earthquake bending load. We will use the maximum allowable stress that the code would allow if you were designing the plant.

We kind of back calculated, and we found out, if you in fact had a load that large, that the deflections in piping systems would be such that you would destroy most of the unflawed pipe anyway. So we said the bounding condition is such that flaws -- you just have yourself a tremendous problem. That was the way we looked at it. We tried to bound it that way.

It was difficult to do because we did not have specific analyses for the earthquake. We tried to use a bounding load by the code allowable.

One reason we are continuing to do this is, we think we have a very conservative analysis. We think that this, again, is another indication that you don't have a problem, but we would like to pin it down numerically better than we have done. That was a rather quick analysis.

(Slide.)

Let me just outline what the elements of our licensing criteria development are right now. Again, this is something that is under development. It isn't really finished yet and won't be, probably, for another 12 to 18 months. I will just outline the approach.

The approach we are using is deterministic analysis. There are people who are trained to do probability analysis. We are not trying to do that. We don't think we can be successful doing that. Our goal is to have something in the 12 to 18 month time frame. The second is, we are using J-integral analysis, which is one of the elastic plastic methods available.

The failure criterion that is associated with that particular method is tearing stability. These particular assumptions -- and this particular methods is the same method using in the pipe crack study group report. A detailed analysis is presented in NUREG-0838. If you want more detail on the analysis, you can look in those reports.

Right now, we are assuming, because we don't believe -- we don't believe that you will be able to say in the immediate future that you won't have throughwall flaws in piping. One of the things you have t o do is to show they can tolerate a large throughwall flaw. They will postulate large flaws, large enough so we don't have to worry about fatigue analysis for the event.

Whatever safety factors we end up using will be determined by frequency of event. In other words, if we have small earthquakes, that would have a safety factor associated with it And that would be larger than some large earthquake that has lower probability. So we will take frequency of event into account somehow.

(Slide.)

The last item is something that we have done in the last six weeks or so. There had been questions about load carrying capability of field degraded pipe. To gain increased confidence in the analyses that we have done, we wanted to actually do full-scale verification of piping integrity. Again, this is not just BWRs; it is also light water reactors.

The first thing we hope to do is measure load carrying capability of field degraded pipe.

MR. ROSSIN: What do you mean by field degraded pipe?

MR. GAMBLE: We are talking — on Item 3, we are talking about taking the remaining Inconel safe-ends and testing those in some manner, using bending and axial loads which would simulate normal operating conditions and transient event loadings, earthquakes, and also ferritic piping if we can get our hands on it, cracked ferritic piping in the pressurized water reactors. We want to actually take feedwater, cracked pipes, and the Duane Arnold safe-ends and test those.

DR. CORTEN: Will they have specific degradation crack sizes?

MR. GAMBLE: We know what Duane Arnold looks like. Basically, it looks something like this.

(Slide.)

This is a 90 degree throughwall segment. There is a crack segment that goes the rest of the way around the circumference. That is approximately three quarters of the way through. Of course, that varies in the real pipe. It is anywhere from 25 percent to three quarters of the way through the wall.

We know in the Duane Arnold case that the real cracks were something like these illustrated here.

DR. CORTEN: But will you know in each case what you are dealing with?

MR. GAMBLE: Yes.

MR. BENDER: Just like you did in Duane Arnold.

MR. GAMBLE: Exactly.

MR. BENDER: Well, then, answer his question.

MR. GAMBLE: We know what Duane Arnold looks like, because several of these have been cut open. The other thing we will do is try to do NDE of each section that we test beforehand to get some indication of what the crack looks like beforehand.

(Slide.)

The purpose of the program is verification of the tearing stability and analytical method, and we propose to continue to use --

DR. CORTEN: That assumes you know what the flaw is.

MR. GAMBLE: Yes.

DR. SHEWMON: The Duane Arnold pipe crack, if it

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had been halfway through, then how would -- if you keep increasing the 270 degree part, how far can you go before you get in trouble?

MR. GAMBLE: If you are going to develop a criterion, you have to make that judgment. You are going to have to make an assumption on what kind of flaw you are going to postulate. And you are going to try to prove, based on the postulated flaw, that you can in fact maintain leak before burst.

For stainless steel or any other material, I can always postulate a flaw in a loading condition where I won't have leak before burst. So now if you are asking me if I am going to postulate a Duane Arnold type flaw that didn't leak, that was 360 degrees around the circumference and was totally symmetrical and that flaw grew out to 99 percent of the wall thickness and I didn't find it, and you are going to ask me, will I get burst conditions in stainless steel, my answer is yes because you made me postulate that flaw.

DR. SHEWMON: I didn't; you did.

(Laughter.)

MR. GAMBLE: So I postulate it. Under that condition, there is no way that you can demonstrate leak before burst, and you ought to do something then to admit you are going to have it.

DR. SHEWMON: Vince, do you have a copy of the agenda for today?

MR. NOONAN: Yes.

DR. SHEWMON: Would you get one in front of you. This is interesting, but I have no understanding of how it fits into the agenda. Would you enlighten me?

MR. NOONAN: We are talking about, under Part II, the status of the pipe crack program. We kind of got a little bit off the track when Si was up there, and we got into the in-service inspection program, but Ron is basically addressing Part II of the agenda.

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DR. SHEWMON: Okay.

MR. GAMBLE: Well the way Part II was explained to us, it was the significance of cracking.

DR. SHEWMON: Do we have more on Part II before we get to Part III?

MR. NOONAN: We are basically done with Ron's presentation in Part II.

MR. BENDER: May I comment?

DR. SHEWMON: Yes.

MR. BENDER: If I understand correctly, what you are saying is, your analysis has shown that it isn't important to inspect for these cracks from the standpoint of public safety because you will get leaks before the crack propogates catastrophically .

MR. GAMBLE: It is important to inspect, and in the pipe crack study report we require inspections to be done.

MR. BENDER: Why is it important to inspect if the analysis shows you will get a leak before the crack propagates?

MR. GAMBLE: It is likely that pipes are going to leak before we have a crack that extends uniformly, 360 degrees around.

MR. BENDER: I think we all agree with that, and Duane Arnold showed it, as a matter of fact. But I think what I am trying to get it is if you think it is importantt to find the cracks before the leak occurs --

MR. GAMBLE: No, I didn't say that. We thought -- it is always important to find the crack as soon as you can. It is not essential that we find all cracks before we have a leak. I don't think we said, and I don't think we mean that. It is a question --

MR. BENDER: Somewhere along the way you have to tell us what your criteria are for deciding when your crack detection capability is adequate. That is really what we are trying to find out. The analytical argument is very good and very useful. It tells us something about what the risk is.

MR. GAMBLE: You are saying -- are you looking for a statement by the staff that says if you can detect a flaw, let's pick a number, 25 percent through the wall -- you can detect a flaw before it gets 25 percent through wall, that that is acceptable to the staff; is that the type --

MR. BENDER: That's a kind of thing that I think anybody would l'.. to have, so people who are doing inspecting know what to shoot for.

MR. GAMBLE: I will make a comment on that, and maybe somebody else can address it. But in the pipe crack study group the conclusion of the pipe crack study group was that the methods -- I can't tell you what methods were being used out there today, but the methods that were being used today for in-service inspection of stainless steel piping -- it was felt -- and I don't remember the number, Warren; was it something like 20 percent, that cracks that were 20 percent, whatever that number was; it was not greater 20 percent -- that cracks, 20 percent let's say, could be reliably detected by UT methods today.

The conclusion of pipe crack study group was that that was adequate. I think your question has been addressed. It may not have been addressed explicitly in this document, but it is in the pipe crack study group definitely.

MR. BENDER: I am looking for it -- it's addressed as it relates to the particular tasks that we were trying to resolve.

MR. GAMBLE: That document does not pick up and make a statement that the staff feels the UT methods you use have to do that. The pipe crack study group made a statement that if felt they -- they thought our consultant's evaluation and staff evaluation that current methods could reliably detect flaws of that size.

MR. BENDER: It wouldn't be unreasonable for us to expect as a result of this meeting the staff will come back and tell us what it thinks an acceptable sensitivity capability for the inspection technique is and which technique meet that requirement so we know what you are really asking for.

MR. GAMBLE: I think the staff is going to address those questions. I don't think you are going to get that answer back in a few weeks though.

MR. BENDER: I don't know when I am going to get it back. We have got a letter from Mr. Denton that says you are working on it.

MR. NOONAN: If I could address that, when the 0313 is out for public comment, which is the next 60 days, we will take all of those comments. We would like to receive those types of questions.

In addition, what I will do, I will go through the transcript of today.

Any questions -- if we haven't satisfactorily answered, and I think there are quite a few, we will make an attempt to answer them.

MR. BENDER: I think I have made my questions amply clear. I don't need to ask them again.

DR. SHEWMON: Let me bring up one other point on this. And I backed you into an untenable situation with regard to the zero wall, 360 degree break a minute ago. What you h e addressed, as one research man to another, is a set only of stability criteria.

It would seem to me if you were going to look into that and convince yourself that reactors were safe, I would be a little bit happier if you would look at some of the criteria which -- or phenomena which give rise to 180 versus 360 degree and see if indeed you can begin to eliminate some of the things that give rise to the 360 degree crack phenomena.

I am convinced that the stresses don't end up that way. The crevices do sometimes.

MR. GAMBLE: I agree. But what we are trying to do in developing the licensing criteria -- that is based on resistance to flaws, is not not different from what we have done in reacttor vessels. I think people feel today, with justified confidence, that they can build reactor vessels without flaws that are two inches deep. But yet we make

make people who postulate flaws that are two inches deep to establish a certain margin against the flaw-induced fracture.

That is the same kind of approach that we are taking here. We are postulating large size flaws, but not because we don't anticipate that the incidence of cracking is going to be reduced and we won't have those anymore.

DR. SHEWMON: Look at what your CE/GP friends are doing. I think they have a more interesting program in that regard.

MR. NOONAN: We can continue on to the TMI-1 borated pipelines.

MR. HAZLETON: I have one slide on the in-service inspection. This is included in NUREG-0313. And basically what are we doing about the Duane Arnold syndrome?

DR. SHEWMON: Is in-service inspection all it should be? You can call it after-post Duane Arnold if you want to, or have we changed anything since?

MR. HAZLETON: The only thing that is different about Duane Arnold was that the weld that cracked didn't go all the way through the pressure boundary. It was inside, and there was a crack starting from that weld, so the question has been, when we have a situation like that, what are we going to do about it regarding in-service inspection, because that weld is not required to be inspected?

So 313 has addressed that, and essentially here is the story.

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(Slide.)

It might need a little bit of interpretation, augmented ISI of all internal attachment welds at safe ends that are not throughwall welds, but are welded to form part of the pressure boundary. Augmented ISI -- Brunswick 1 and 2 internal attachment welds, that has been done.

(Slide.)

There is a Duane Arnold type 1-A. The crack went through from this weld. Where is the Brunswick, the 1-B? It is the same kind of a thing, the same little capillary crevice here. And to really differentiate, here is another type where you have a weld to the pressure boundary, but not through it, where you have an annulus, not really a crevice.

And here is another type, called the tuning fork type, where this weld is way out here. And this is a solid piece of metal, so this weld is not to the pressure boundary part of that.

DR. SHEWMON: This is all internal attachments at safe ends. It does not cover internal attachments anyplace else.

MR. HAZLETON: That's right.

DR. SHEWMON: All right.

MR. HAZLETON: And there is -- let's see.

essentially what 313 says is that if you have a crevice there, you have to consider it a service sensitive area. And it throws the in-service inspection into the category of service sensitive components.

If you don't have a crevice there, then it puts it into the category of welds that you must inspect in accordance with the normal augmented ISI program. So it is addressing those. Welds of that nature must be inspected; that is covered in 0313.

DR. SHEWMON: Good.

Why don't we take a 10-minute break since we are -- the schedule calls for one at 3:00. Then we will come back.

(Recess.)

DR. SHEWMON: Can we come to order?

What I would like to do at this point -- I think in view of where we are in our schedule, or aren't -- is to skip the borated lines item in the feedwater cracking situation. As I see those, those are — I am tempted to say benign. That is probably not a good choice of words, but they are problems we don't have a complete answer on, but are getting words, and they probably won't cause us great embarrassment in the interim.

So why don't we pass on down to the tech specs on control of water chemistry.

By way of background -- or at least my perception of this, the staff has recently moved to take tech specs on secondary water chemistry or the control of what secondary water chemistry out of the tech specs, because trying to set the general tech specs here has been particularly -- at least irritating, and maybe counterproductive with regard to the utility's operation of the reactor.

My particular concern is that its impurities in the secondary feedwater, which has given rise to the trouble in steam generators, or at least they are a major contributing factor here, and I would like to be assured that the staff indeed has a fair idea of what they are going to put in its place and that they have some assurance that we are likely to end up chewing up steam generators at least no faster with their new procedures than we did with the old, and hopefully might evolve into procedures that would make steam generators last a little bit longer.

MR. NOONAN: Dr. Weeks is here to address generically the technical specifications of water chemistry. I will let him go ahead and start the presentation.

DR. SHEWMON: As I understand it, you people will decide whether or not the new procedures which were sent in to you are acceptable?

MR. NOONAN: On the secondary side? Yes.

DR. SHEWMON: You will tell us what criteria you are going to use before you quit? Will John speak on that?

MR. WEEKS: No, I am not going to speak on that.

MR. NOONAN: We will address that.

MR. WEEKS: I have prepared a very brief -- where is the pointer -- I am John Weeks of Brookhaven Laboratory.

I have prepared a brief discussion of the situation, Paul, the idea being what is the problem associated with tech specs? Why do I think perhaps at this state we shouldn't have it?

The possible technical specifications you might conceive on the secondary coolant in a PWR relate to the pH of the coolant; it's conductivity, which can be correlated to the in-leakage of imperatives; oxygen, which can be a promoter of corrosion or stress corrosion cracking of various materials; and chloride.

The question that one comes up with was: What are the problems associated with this? How low should we make these things? How low can we make these things?

If you make a tech spec for chloride sufficiently low that you have reasonable assurance there won't be any onset of denting or stress corrosion cracking, you are probably kidding yourself for the very simple reason there are concentration factors in the steam generator of greater than 10 to the 4th possible, and in very secluded regions.

And I don't think of the steam generator designs in vogue today -- exclude such areas.

Therefore, if one wants to set a meaningful technical specification that has a basis in fact that you can't get -- that the chloride never gets above that, you won't have any problems. I think we are kidding ourselves.

Then we have the question of if there is an excursion in one or more of these things, what is the best thing to do about it? Does it make sense always to shut the plant down?

Admittedly, if there is a harmful impurity that we think might be hiding out in a crevice, then reducing the power level at least is one way of flushing it out, one way of flushing it out of that crevice.

But other excursions that one might make, can conceive of, might be better -- to keep the plant running while correcting the situation in the condensor.

Therefore, one comes up with the conclusion that it is not necessarily practical to do it at the present time.

(Slide.)

This is the fourth one in that package. This should have been my first one. I wanted to review briefly the history of the various machinations that have been going on regarding the need for technical specifications.

You will recall the early PWR steam generators adopted the model treatment when they had in-leakage of impurities. That was at an in-land plant, Beznau.

The vogue then switched to the low phosphate treatment. It was carefully controlled. At least at some units -- and Ginna is one of the better examples in this country -- it was possible to avoid stress corrosion and to avoid wastage with a very careful control.

However, quite frequently, for one reason or another, particularly if there was a small leak in a tube -- crevice, as happened at Robinson, the utility was concerned about radioactivity getting into the lake. So they sealed blowdown and allowed the phosphate chemistry to go wild.

It was suggested -- and I wrote such a memorandum about six and a half or seven years ago, suggesting that perhaps a technical specification based on the low phosphate treatment might in fact be a way out of the problem. Such a specification was actually drafted, and I believe it is still in vogue at Robinson.

I think the representative of Carolina Power & Light left, but because of the problem they went to a higher phosphate. Going to the high phosphate eliminated the swings do to condensor leakage that helped with the stress corrosion but led to wastage. Then there was a conversion to AVT, which is the process of the conversion, caustics developed into units, more stress conversion. There was some continued wastage staying on AVT, or plants started on it had denting and some stress corrosion cracking of the piping.

So it certainly seems that in a technical specification one might have written this year, this year, or this year would be definitely counterproductive because it gets into a portion of the plant's license. This is a learning process; it may be almost a learning -- tragic learning process we have been going through in this area, but based on which it seems rather unlikely that any technical specification we could write today -- and I have an example; this is on my third viewgraph.

(Slide.)

This comes from the testimony of Ray MacCary at the Prairie Island hearings. And I believe this is -- if you notice, Prairie Island technical specifications are the pits. I think we need some humor at that time in the afternoon.

(Laughter.)

They talked about primarily controls on the -- in the cation and in the condensate, the pH and the blowdown, and the hydroxide in the blowdown. These were recommended at those years; I believe, I am not certain, that they are still in vogue at Prairie Island. Prairie Island has not had any denting. It has not had an wastage. It has not had any stress corrosion cracking that I know of to date. It also is on a fresh water plant, does not have any copper alloys in the feedwater train, which is one of the contributors to denting.

The use of these technical specifications on a universal basis may not make sense. The fact that they were in vogue at Prairie Island at one time may not be the reason why Prairie Island has avoided difficulties.

(Slide.)

Finally, if we look at what the cause are of the principal problems that have developed in the steam generators, the cause of the denting is chloride in-leakage. This can be reduced or minimized by technical specifications. But, as I said earlier, I question that it can be reduced enough to be meaningful. A low pH swing, associated with chloride -- this has happened at the seawater plant in the presence of the copper or nickel ions.

If we have a seawater-cooled condensor, if any leakage at all occurs, chloride and low pH will come in, and there is a copper feedwater tubing, it may be impossible to set a water specification that will totally prevent, in my opinion, denting developing at some time in the course of the operation of that plant.

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I think that is all I have to say on the subject. The point I am trying to make is it would be awfully nice if we were smart enough with the existing plants that we have and the combinations of material and alternate cooling water, that we have at these plants, we could invent some plant-specific technical specifications on secondary water that would minimize the probability of difficulties developing in the steam generator. I personally think that if it is written as a tech spec, unless it is tight enough to prevent the problem, it is meaningless. Then if it is that tight, I don't think the utility can live with it, simply because there are always slight excursions of one type or another.

DR. SHEWMON: Thank you. I guess my question to you, Vince, is -- okay, the old procedure wasn't perfect. What evidence do we have that your new procedure won't be meaningless, to use the phrase John used? Or are you giving up and saying, "Gee, whiz. Utilities lose a lot of money when they have to burn up all of those workers and replace the steam generator, and that is motivation enough for them to worry about it," or what?

MR. NOONAN: I would like to have Dr. Almeter address that. He was in on our decision to take off the -- recommend taking off the tech specs on the secondary water chemistry. Frank has a lot of background in that area.

Frank? Would you take the stand?

DR. ALMETER: If you would restate your question again.

DR. SHEWMON: What are you going to put in place of this thing? What basis do you have for thinking it is going to be an improvement, or have you quit trying?

You figure there is enough motivation for the utilities to worry about it, and you are going to let them chew up steam generators whenever they feel it is economically -- or whatever, useful?

DR. ALMETER: I don't know.

(Laughter.)

I would start with the last statement. I don't think we will let them chew up steam generators.

DR. SHEWMON: Are you going to try to inhibit them?

DR. ALMETER: Yes.

DR. SHEWMON: How?

DR. ALMETER: I would like to start out -- one of the reasons I think John Weeks has pointed out -- the events that led up to certain requirements for water chemistry, we did impose a similar tech spec that was proposed for Prairie Island on one plant. That was Beaver Valley. That was a new plant starting out, and it turned out that they were having very much difficulty in starting up. They couldn't get out of hot shutdown on this type of specification. It was loose enougn, but they were basically holding to the NSSS requirements. During the startup period, we were noticing that they were running into conductivity mode of something like 50 micromodes. It took along about two months to bring it down to 25 micromodes. They were operating in this range and still were not out of hot shutdown. We had to revise and we -- on our intial requirements we let down about two micromodes, to about 15, in order for them to get into an operating condition. This was a condition -- we realized we were going to have to redo this on every new plant during startup.

DR. SHEWMON: You aren't speaking to my question. You are bringing out your violin about how bad the old procedure was.

DR. ALMETER: Yes, realize that these were in a mode or a condition where they would have to report a licensee event report. It did not cure the problem of what they were having. That was a mode where they could not get out of this condition of even keeping within tech specs. Then realize that the number of shutdowns they would have to do -- there was an EPRI report that showed that every time they shut down, they would deposit frozen product into the generator; in other words, they were not keeping a mass balance every time they shut down.

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They could not keep a mass balance because of this. They didn't allow adequate blowdown in this mode. Then we learned that any tech spec that we would require on the secondary side may affect the steam purity factor, or eventually the turbine. So if we require a low chloride, perhaps .5, which did not show --

DR. SHEWMON: When are you going to answer my question, Frank? Come on.

DR. ALMETER: We are going to ask the utility to set up a monitoring program to make sure that he is monitoring this water chemistry. And we have asked --

DR. SHEWMON: Is that different? You didn't have to have a monitoring program before?

DR. ALMETER: That's right, we never had a monitoring program. We had a requirement that was a review plan, a standard review plan, that would ask them to look at certain parameters, but there was never a requirement that he had to monitor this. That is why it came up as a technical specification.

We introduced the technical specification. So now, we are asking him to monitor this secondary water and put this as a licensing condition.

DR. SHEWMON: Do you have a monitoring program in for Surry-2 yet?

MR. NOONAN: No.

DR. ALMETER: Yes, we have a list of plants that resronded to our request, that was sent out last fall.

DR. SHEWMON: Can you put it up so the rest of us can see it?

DR. ALMETER: I don't have a slide. I can read it off. It is very short. There are about a dozen plants that responded so far. Some of them have rejected our licensing conditions. Two of these, so far, are Connecticut Yankee and Millstone Unit 2.

The facilities that have adopted or accepted our monitoring requirements are Arkansas Unit 2; Beaver Valley Unit 1; Braidwood Units 1 and 2; Byron Units 1 and 2; Farley 1 and 2; Maine Yankee; North Anna Units 1 and 2; Rancho Seco Unit 1; H.B. Robinson Unit 2; Three Mile Island Unit 1; San Onofre Unit 1; Surry Unit 1 and 2; Yankee-Rowe and Midland.

Now, Midland, North Anna and Byron and Braidwood are still in their licensing procedure at the moment. They have not been turned over to the operating reactors division. I have tried to collect kind of a head count of those that feel, Yes, they realize that they need a monitoring program, they will accept our licensing condition.

DR. SHEWMON: So they give you a monitoring program, so what?

DR. ALMETER: They have sent those in for our review and we are in that process, reviewing each one of these.

DR. SHEWMON: What are you looking for?

DR. ALMETER: I am looking for a program that will monitor condenser in-leakage, a program that will monitor the feedwater control, as whatever their plant procedures require --

DR. SHEWMON: Let's say Surry-2, which happens to hold a track record for chewing up steam generators, currently, hands down, isn't taking part in the EPRI steam generator study group, so it is not sure where they are getting their wisdom on how they should do this. What are you going to use for criteria? Let's say they monitor it, they have procedures of what they did before, but they meet all of your requirements; don't they?

DR. ALMETER: Not necessarily. They never laid out a program.

DR. SHEWMON: You say they have agreed to whatever you asked them to do.

DR. ALMETER: But we never saw the program before, of what they were doing.

DR. SHEWMON: What are you going to do now? What are your criteria?

DR. ALMETER: We are reviewing their program and

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what they plan to do in control on their secondary water. If that is going back and keeping a tighter condenser, if they have installed demineralizers, and if they are actually doing some program as far as administratively to control - if they do run into a problem --

DR. SHEWMON: A minute ago you said you had -- you had asked them to put in a monitoring program, and they had agreed to it. Now, a monitoring program is not full line full demineralizers. Now you are bringing in other things.

DR. ALMETER: Each utility has laid out a progr of what they intend to do and they are submitting that to us. And we are reviewing it.

DR. SHEWMON: What are your criteria, then?

DR. ALMETER: Looking at the conductivity; looking at the pH; looking at the total solids like copper, iron; looking at chloride.

DR. SHEWMON: You still haven't given me criteria.

MR. BENDER: Let me try a different tack.

DR. ALMETER: The limits the tend to hold to, they interd to hold to?

MR. BENDER: If I understand correctly, Ginna has a very successful program for monitoring their water chemistry, and clearly their steam generators show it. What do they do that's so good?

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DR. ALMETER: They haven't submitted it, but I will give you what I know about that.

MR. BENDER: They ought to find out, if they are the only ones that are doing a good job -- you better find out what a good job is.

DR. ALMETER: Back in 1977 they installed a complete demineralizer system on the secondary side. That was a complete facility in addition to what was already there. I think they did some retubing of their condensers. They have a tighter control on the amount of condenser in-leakage that they will tolerate.

MR. BENDER: The fact that they are pumping out using cooling water out of the Great Lakes, is that an influence on why they are so successful?

DR. ALMETER: That may be a factor, sir.

MR. BENDER: I think the problem is you are saying you are going to require something, and you are being very unclear as to whether you would know whether what is proposed is useful or not. There is no model program that you can hold up and say, "this is a good program." My guess is that you need one for systems that are operating from fresh water supplies and another for systems that are operating with salt water cooling supplies. And probably, you need different ones for different kinds of steam generator configurations.

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But for the life of me, it is hard for me to see how you can just develop these things out of thin air. Somebody ought to be trying to develop some model bases.

DR. SHAO: I think it is a legitimate question. I think the answer is -- I don't think, really, we have definite criteria. I think everybody is in the learning process. Maybe there are many variables. We really don't know if a certain content beyond a certain percentage is any good.

DR. SHEWMON: We agree to that. We are wondering what you are doing to find out.

DR. SHAO: What we are doing is a learning process. Certain areas we know, and certain areas we don't know. We don't know the whole story. I think just like a doctor looking at pictures doesn't really know if the disease is bad or good -- but from this program hopefully in the long term we will learn.

DR. SHEWMON: How many steam generators do you think it will take?

MR. HAZELTON: I want to make one comment. We have received these detailed procedures that we asked for on some plants. When you look at them they are much more detailed than we had ever proposed doing in a technical specification. I think after we have a little bit of experience in seeing what these different plants are doing,

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then maybe we can make some judgments that you are talking about.

I think the important thing to steam generator integrity is not to have specifications that shut them down when they have a big in-leakage of chlorides; it is to keep the chlorides out. So I think that is the important part regarding steam generator integrity. Regarding what kind of details in the procedures would be required, I think we already addressed that point. I think we ought to address it by saying we don't know enough on any individual plant what the detailed procedures should be, therefore just because we make a tech spec on the basis of ignorance doesn't make it any better.

As I said, some of the procedures that I have seen, these have just started to trickle in, some of them that I have seen are real good. They are a heck of a lot tighter and more all-inclusive than we would have thought of putting in the tech spec. So we are in a learning process right now.

DR. SHEWMON: You are taking a page from the professor's handbook, that says you don't have to know as much to ask a question in order to know that you are getting a straight answer, as to answer it yourself.

MR. BENDER: The point I was going to make -- or along those lines but in a different direction. Conceeding that you may not know what to require, then the next move is to say, How do you know the people that are specifying it are qualified to specify? Do you have any requirements for the chemistry capability of the organization? Do they have to have any experience? Do they need any experimental data to back up their decisions? What approaches are you using?

MR. NOONAN: Maybe I can address that a little bit. Clearly, when we took off the tech spec requirements, off of the plants, that decision was discussed quite intensively. We felt at that point in time that we were doing more harm than good by having tech spec requirements. We felt, just because they exceeded the tech spec and had to bring the plant down, it wasn't doing that plant any good, from the standpoint of economics. It is up to the plant — it is beneficial to the plant to have a very good secondary water chemistry program.

It is just common sense that says that the plant will do that. We are now looking at these responses. We don't have any pat answers. We don't know what the criteria should be. No, I don't know whether people who are setting up these programs are experts. We do have the people who can review these programs and they can look at these programs and say, "This guy, indeed, is trying his damndest to put together a program where we can assure ourselves we are going to have the minimum amount of steam degradation due to the secondary water chemistry," or "This plant is not going to do his job."

That, basically, falls within the responsibility of Frank and Dr. Weeks.

DR. WEEKS: Can I inject one other thing? I think we are making the observation that the EPRI steam generator owners group has extensive programs in trying to determine what would be acceptable water chemistries under those conditions. There is no one here at the moment who is representing the EPRI steam generator owners group who could perhaps fill you in on the details of what they are. I certainly cannot, but I am aware that these programs are underway, that their results are being made available to the NRC -- you are shaking your head, Paul.

DR. SHEWMON: That is a separate point, though. They have told us they will give them to us when they write them up, and present them to the public, but they are doing something. So that is good.

DR. ALMETER: I can give you a slight overall. I know what they are doing.

DR. SHEWMON: So can I. I read their published papers in the open literature.

DR. ALMETER: They are looking at the different -- one of them -- they are looking at demineralization. They are looking at the condenser problem.

MR. STROSNIDER: I am involved in the unresolved safety issues regarding steam generators. I think the approach, while the approach we are taking in the unresolved safety issues is regarding technical specifications on water chemistry -- it is not clear how much they will do you,, because even if you have them set, if you don't stop condenser leaks and if you don't stop intrusions of these chlorides and things like that, it will not do you any good.

Our position is you have to attack it at the source. I think the way the task action plans are going to address it is in the context of: what can the NRC do to guarantee condenser integrity in order to keep copper ions, copper-based metals out of the condenser tubes, feedwater heaters and things like that.

I think that is the only way you can really solve this problem, is to attack it at the source.

DR. SHEWMON: That is not a solution. That is a way of surviving while it exists.

MR. STROSNIDER: Wait a minute. If you come in and put on a tech spec limit on chlorides and you have a big condenser leak --

DR. SHEWMON: I am not suggesting that. I am willing to admit the tech spec approach is not a good one. I don't think it is a good one to say, "Can't do a damn thing about it, so we will try to keep them from rupturing too many tubes," or we will make them plug tubes as soon as the denting gets bad enough to where we have got so much contraction.

MR. STROSNIDER: I am not talking about failure of steam generator tubes. I am talking about condenser tubes. The only way you can keep chlorides out is, for instance, to stop the condenser leaks. Whether you have a tech spec or not, it won't do you any good unless you have a good condenser integrity.

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DR. SHEWMON: Maybe I heard you say "steam generator" when you said "condenser." Do you want to back up and say some of the other things you said then?

(Laughter.)

MR. STROSNIDER: The approach of the Task Action Plan is that in order to solve the denting problems you have to attack them at their source, which is condenser leakage and copper-based alloys and heat exchanger tubes, feedwater heaters, to keep those bad actors out of the system.

The point I am making is to have the tech spech limit on chlorides, for instance, won't do you any good if you have condenser leaks and you are going to exceed the limit anyway.

DR. SHEWMON: We all agree on that.

MR. STROSNIDER: That is a long-term sort of thing, but that is something that is going to resolve the problem. I think that is an important point to be made.

DR. ALMETER: I might go further. I think when Jack and I finish on the Task Action Plan, the recommendation will come out that we are going to have to go back and make other requirements on the condenser. They have better materials than that; and we will require, perhaps, on the feedwater, but this would be on new plants. What we will do on the existing plants I am not prepared to say, but there is --

DR. SHEWMON: Actually, Salem and Turkey Point have both gone back and retubed, when they had trouble with their

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condensers. I understood Schnabel said Salem was on an operating plant footing in full-flow demineralizers.

DR. ALMETER: Many are doing that.

DR. SHEWMON: It is not out of the question. They may not like it when you tell them, but if they are enlightened enough to do it themselves --

DR. SHAO: They do it voluntarily.

DR. ALMETER: I would like to point out something, to say that this is an absolute "cure-all," if we go and say, this utility is putting in condensate polishers, that this is going to control the problem 100 percent and prevent anything, because of the problems that you are going to have with those condensers, you could have -- There is a good deal that has to be done on the resins, preventing sodium throw, silica throw, which can all add to this.

Now if they have a problem, and they have a condenser break through, we are right back to the same situation. They have contaminated.

DR. SHEWMON: The only thing, I don't care about what I hear from the staff is that since nothing is perfect, why do anything? That is what I hear part of the time, and that I don't care for.

DR. ALMETER: I don't think we are doing nothing.

DR. SHEWMON: Good.

DR. ALMETER: I think that this is a step, but that we have never had a requirement that they force the utility to monitor that secondary water. I think the first step is the licensing condition.

Now, to go back and say that that utility has the qualified staff to do this program, I think it is a regulation, in our regulations, that there is adequate staff to run that plant, in some part of the codes. I can't specify that.

Now, after the TMI problems are reviewed, there may be new regulations on what staff are going to do what, as far as the utility.

DR. SHEWMON: There will be several after TMI.

DR. ALMETER: This is where we stand, at this stage.

DR. SHEWMON: Are there questions on this? Is there anything else on this?

DR. MUSCARA: On the monitoring, is the philosophy to be able to get operating experience with particular levels? We are not putting limits on the materials.

DR. ALMETER: We don't know what the limits are.

DR. SHEWMON: The answer is "yes." We are getting experience.

DR. ALMETER: It is a learning program, but it isn't designed for that specific purpose. It is designed to make the utility aware that they are apt to have a problem.

DR. BERRY: You have to judge each one on its individual merits.

DR. ALMETER: Indeed we do. Each utility is coming in with something different.

MR. BENDER: They need a few chemists. The problem is still the same one.

MR. NOONAN: Are there further questions, Dr. Shewmon, on the secondary water chemistry?

DR. SHEWMON: No.

MR. NOONAN: I would like to have Jack Strosnider get up and talk about the steam generator problems very briefly that we have seen recently.

(Slide.)

MR. STROSNIDER: I am with the engineering branch of Operating Reactors. I have been asked to give a summary of the recent operating experiences in steam generators.

In that respect, there are four significant incidents that I would like to go over quickly:

(Slide.)

The tube leak at Prairie Island that occurred on October 2nd; Point Beach; the U-bend tube failure at Doel, a foreign reactor; and U-bend tube leaks at Trojan.

MR. BENDER: Can I ask a question? Have their been any significant problems with the once-through steam generator, this kind of problem? There are vibration problems, I know.

MR. STROSNIDER: On the open cape (phonetic) line is the major problem. There have been reports of erosion corrosion phenomena on a very small scale affecting a dozen tubes or so.

(Slide.)

A little background on Prairie Island: Westinghouse steam generators start operation in December of '73. Operated on phosphates until fall '74. They changed to AVT. No pluggable tubes found in any previous inspections.

On October 2nd, there was a steam generator tube failure. The leak rate was approximately 390 gallons per minute. The inspection following shutdown at the plant revealed that R4-C1 had burst in a fishmouth fashion about 3 inches above the tubesheet.

This was a periphery tube. It is the fourth row out from the flow slots, right on the periphery.

The third tube out was 65 percent throughwall thinned, and the second tube was 20 percent throughwall thinned.

The cause of the failure was a loose part, specifically, a steel coil spring which was trapped under a flow blocking device in the steam generator. The flow blocking device sits on the open flow lane. It is lifted up during inspections to move it out of the way, and apparently it was set down on top of this spring. One end of the spring was pinned under the blocking device and during normal operation, the flow, moving the spring against the tubes, wore through the tubes.

Remedial actions were to plug the tube and surrounding tubes, including the 65 percent throughwall; 12 percent eddy current inspections in both generators -- the reason for doing that was to see if there were any other loose parts -- and also visual inspection of the peripheral areas.

No generic implications other than the QA during steam generator maintenance operation. The spring was believed to be from a suction hose used in sludge lancing. Westinghouse now uses plastic hoses; no springs to loosen. That's Prairie Island.

(Slide.)

Point Beach, another Westinghouse steam generator operating on phosphates until fall '74. It changed to AVT. August 5th, the plant was shut down because they exceeded their tech spec leak rate limit which is .35 gallons per minute.

The cause of the leaks was determined to be deep crevice cracking of three tubes. By "deep crevice cracking," I am referring to cracking of tubes within the tubesheet. This crevice we are referring to is between the tubes and the tubesheet, where the tubes are not roll-expanded.

Remedial action was 100 percent hot leg inspection of A and B steam generators. That was up through the first support plate. 52 defective tubes were plugged in each steam generator. All the defects were deep crevice cracking. They were all within the depth of the tubesheet.

Now, the significant thing is during their current

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refueling outage, they went back in to look at the steam generators again. Information is still coming in on this. In fact, the staff is meeting with Point Beach, or they did meet with them, this afternoon. This is not complete.

When I last talked to them, they had done 100 percent of steam generator A. They found 73 tubes with deep crevice cracks, and 73 tubes were plugged. In steam generator B, eddy current testing was in progress. They decided to remove three tubes from steam generator A for examination.

The steam generator B inspection could potentially result in a plugging of, in plugging, that would put them over their 10 percent assumption, using their ECCS analysis.

The staff met with them in the afternoon. I don't have any more details than that.

MR. NOONAN: The point to be made on this, the disturbing point, is the fact that in August they did 100 percent inspection. They plugged all of the tubes that had any indication of deep crevice cracking. Two months later we are back in the same mode, and we now find another 73 tubes that have to be plugged.

MR. BENDER: How many months later.

MR. NOONAN: Two.

MR. STROSNIDER: Two to three.

MR. NOONAN: It is disturbing from that standpoint that three months later we are finding this many tubes, 73, that now require them to go back in and plug them.

MR. BENDER: When did they go on AVT?

MR. STROSNIDER: Fall of '74. It implies two things. Of course, they did have an extensive wastage problem before that, but it implies that they have a very fast rate of degradation or the eddy current testing is not seeing all the cracks; as I say, I don't know which explanation. We will probably get some information this afternoon.

MR. MUSCARA: Do they use the same method for inspecting?

MR. STROSNIDER: They should be able to go back. That is something I would be interested in seeing: How it correlates with previous inspections. They looked at 100 percent, so they have looked at this tubes before.

DR. ALMETER: Point Beach, I think we know the history on that plant and what is happening there in the tubesheet crevice. For a long period they were on phosphate, and back in 1974 or '75, I think it was also '73, they had many tubes that cracked due to high caustic. And then they changed over to AVT. If we can imagine what is happening in the crevice zone with the deposit of phosphates in there, I think we can imagine that has gone to a high pH, and perhaps it has been on the sodium side for some time. And we postulate that the time for stress corrosion cracking and caustic, we could --

MR. BENDER: It seems like it has taken a long time

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to get there.

DR. ALMETER: The number of years, sir, I think the French have been doing quite a bit of work on this, and it takes something like -- It depends on the concentration of sodium hydroxide. It takes over 1000 hours or more to do this.

MR. BENDER: That I guess I would agree with. But if it went on it in 1974, it seems to me like it should have shown up earlier than it did. The fact that it didn't is a surprise.

MR. STROSNIDER: They are removing tubes for laboratory examination. Maybe we will get more information from that. I would like to point out that not all Westinghouse generators have that crevice. I don't know the exact number, but the majority were full expanded.

This is applicable to a few plants. I can't tell you which ones they are right now. Doel Unit II --

(Slide.)

This is located in Belgium, in Antwerp. It is in commercial operation. In November '75, two Westinghouse designed steam generators that Westinghouse did not manufacture -- the tubes were manufactured by a German company which I heard the name of but couldn't write down. I didn't understand it. It was not manufactured by Westinghouse.

Exclusively AVT secondary water treatment, full flow demineralizers.

On June 25th, 1979, they had a tube rupture, 135

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gallons per minute, in steam generator B. The failed tube was a Row 1, 24. Inspection revealed it was a longitudinal crack at the top of the U bend.

The significant thing here is, we had similar experiences at Surry, the significant thing is that there was no denting or tube support plate hourglassing; that is, no flow slot deformation in the upper tubesheet or in any of the tubesheet support plates.

They have had indications in the crevices. They remedial action was to do ball gauging and plugging of all tubes with excessive ovality and the tube and cross section, 50 tube testing -- You can't get the probe through; you have to go to the smaller probe sizes.

So to better quantify the degree of ovalization, they used a ball gauge which went through the tubes, and they determined that a number of tubes had ovality in excess of the fabrication specifications.

Their remedial action was to plug those tubes at -- That was 50 tubes in steam generator A and 42 in steam generator B. The Doel Unit II operators attributed the tube failure to stress corrosion cracking resulting from an increase in tensile residual stresses due to excessive tube ovality from improper fabrication.

There are high residual stresses in the U bends. They say that these were fabricated, the process, they had excessive ovality and even higher residual stresses.

DR. SHEWMON: And then the ovality was there from Year One?

MR. STROSNIDER: Yes.

DR. BERRY: Did this occur after a shutdown and startup? It is the sort of thing -- You are sitting there for four years and nothing has happe d and then all of a sudden --

MR. STROSNIDER: I am not real sure. I don't know if they were returning to power or not.

DR. SHAO: It is coming from the residual stresses only at Row 1?

DR. BERRY: But the residual stre s has been there from Day One.

DR. SHAO: But it takes time.

DR. BERRY: But why did it occur at this time?

MR. STROSNIDER: I have the information.

DR. WEEKS: If we extrapolate the data on this so-called "pure water," depending on the amount of cold work and the exact temperature and the heat of the material, it extrapolates to anywhere from two to 20 years, from slightly higher temperature data. So it is not surprising that it would happen in about four years, based on that, on our results.

Maybe there is a little bit of straining during heatup and cooldown that adds to that, but --

DR. BERRY: I would bet my money on that.

MR. STROSNIDER: There may be some differential expansion in the hot leg and cold leg. But the U-tubes are free tc expand. These are not locked into the support plate as dented tubes would be. So it is true there may be some thermal stresses involved. I can't quantify them. I don't think they would be that much.

DR. SHAO: It would not be very large, but most of the stresses -- Surry 2 had the same problem, the hourglassing, and it was at the crevice.

DR. DILLON: Do we know if it is at the U-bend?

DR. SHAO: At the top of the U-bend.

MR. STROSNIDER: They were at the top of the U-bend. They were skewed toward the hot leg side on the extruders, the very top.

(Slide.)

MR. STROSNIDER: Trojan. This is Westinghouse. That began operation in '76, exclusively AVT condensate demineralizers. In June '79, they detected steam generator leak, 15 to 20 gallons per day, a small leak rate. It fluctuated, with a maximum rate of 180 gallons per day, until shutdown, October '79. They went in.

The hydrostatic tests revealed four leaking tubes in A, one in D. All leaks were in Row-1 tubes in the U-bends. These are believed to be not right at the top of the U-bend, but perhaps down in the tangent point, where you start going

mte 2

into the bounding. They detect that by lowering the water level to see when the leakage stops. That is how they determine the elevation. It is not perfect, but it is in the U-bend.

Again, no tube denting or support plate deformation in the Trojan plant.

The remedial action: They are performing eddy current tests of the U-bends and small or ball gauging is being performed similar to what was done at Doel. Interesting point not stated here is the tubes which were leaking were ball gauged. They did not show excessive ovality.

The final remedial actions are under discussion. Their plant is shut down right now. Staff is talking to them what they are going to do.

DR. WEEKS: This one developed in service, not during heatup or cooldown?

MR. STROSNIDER: Yes. It was over a long period of time. It is also significant that these -- this leak rate developed slowly and stably. All of the other U-bend experiences we have had -- Doel, Surry -- were sudden. There was no leak before burst. In this case they had quite a lot of operating time.

MR. NOONAN: The tech spec requirement for shutdown is 500 gallons per day.

MR. STROSNIDER: They were under the tech spec.

mte 3

DR. SHEWMON: What is their condenser experience?

MR. STROSNIDER: I don't have any specific details, but their water chemistry has been very good, comparatively speaking. Full-flow demineralizers, I believe. I don't know if they have full-flow blowdown, continuous blowdown, or not.

DR. WEEKS: I believe they had trouble with it in the early days. I believe they had condenser leakage problems early. Some repairs were done. I don't have the facts here.

MR. BENDER: Is Trojan still shut down?

MR. STROSNIDER: It is currently shut down. They also have a problem involving walls and piping supports, seismic design piping supports. We are discussing with them what their actions will be. Westinghouse was talking about removing a tube. It is not clear when they will do that. We are talking to them.

DR. BERRY: Do you think you are beginning to see a generic problem of cracking with AVT?

MR. STROSNIDER: The staff is very concerned about Row-1 tubes. The way these things are manufactured, they have an internal mandril. They are bent. There is no stress relief. We know that the residual stresses are high. We just don't know what the incubation time is for stress corrosion cracking.

DR. SHAO: When Surry happened, Surry 2, there were six plants had had very severe denting, the rolling tubes.

mte 4

But now it seems like even plants that have denting, the rolling tubes have problems.

MR. STROSNIDER: We are concerned about rolling tubes.

MR. BENDER: Are they manufactured the same way as previous tubes or is this some new technique?

MR. STROSNIDER: To my knowledge, all of the operating steam generators right now, Westinghouse generators, were manufactured by this process. The new design steam generators are stress relief.

DR. DILLON: Isn't the popular assumption that this process originates on the primary side? What is the consequence, then, of the AVT treatment? I don't quite see it?

MR. STROSNIDER: I put the water chemistry in here as background. I am not sure that is significant at all to this problem.

DR. WEEKS: I don't think we know which side it originated on at Doel. I don't think we know what side at Trojan yet.

DR. SHAO: It is mostly inside.

DR. WEEKS: Surry was inside.

MR. STROSNIDER: Doel did not remove a tube, and of course, we haven't looked at any from Trojan.

DR. BERRY: You have no high-purity water in either one of them.

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DR. WEEKS: We did some U-bend tests with AVT as opposed to high purity water. It reduced the time to failure somewhat, not a great deal. It wasn't better than pure water; it was worse.

DR. BERRY: B&W operates under AVT and they have stress relief tubes.

DR. DILLON: What is the effect of the boric acid? Is anything known about that, on the initiation process?

DR. WEEKS: I don't think we have seen an effect yet. If it is similar to AVT, the hydrogen and/or the hydrazine, either one of those decreases -- decreases time to failure on a few specimens.

DR. MUSCARA: We are planning on doing the boric acid, also.

MR. STROSNIDER: The license was asked about that. We asked them to see if there was any relationship.

MR. NOONAN: Dr. Shewmon, that finishes us up for the day. There are two other handouts that you have in your possession. One is on the finished piping problem, where we had the longitudinal split reported by a plant in Finland. And there is also reference in that same report made to similar events in a Swedish plant a year earlier. There is also a report on the French under the clad cracking problem. We are going to be talking to the French Thursday. We don't have much more detail than presented in that handout.

mte 6

DR. SHEWMON: Well, the Finnish one was a temperature -- this was just below a mixing?

MR. NOONAN: Downstream of the valve where two different temperatures of water, a six-inch pipe downstream. We don't have much more detail than what is in the handout.

DR. SHEWMON: All right. I guess this does us up. Is Surry going to come back in again to the full Committee, or do we have a Subcommittee meeting with that before they go up again, or do you know?

MR. NOONAN: I don't know. I know my staff is prepared now to start writing whatever we have to write regarding any kind of safety failures.

DR. SHAO: They had the steam generator and the seismic.

MR. NOONAN: Well, 2 will be down longer than anticipated.

DR. SHEWMON: I guess -- are there any other questions?

(No response.)

The meeting is adjourned.

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(Whereupon, at 4:35 p.m., the meeting was adjourned.)

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