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UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

DATE: January 9, 1991

The contents of this transcript of the proceedings of the United States Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards, (date) January 9, 1991, as reported herein, are a record of the discussions recorded at the meeting held on the above date.

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

Subcommittee on Materials and Metallurgy

Nuclear Regulatory Commission
7920 Norfolk Avenue
Conference Room P-110
Bethesda, Maryland

Wednesday, January 9, 1991

The above-entitled proceedings commenced at 8:30 o'clock a.m., pursuant to notice, Paul Shewmon, Subcommittee Chairman, presiding.

PRESENT FOR THE ACRS SUBCOMMITTEE:

P. Shewmon

H. Lewis

C. Michelson

PARTICIPANTS:

E. Igne

T. Kassner

R. Baer

T.Y. Chang

R. Johnson

J. Davis

J. Bickford

S. Koscielny

F. Witt

W. Minners

C. Cheng

F. Cherny

P R O C E E D I N G S

[8:30 a.m.]

MR. SHEWMON: Good morning.

This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittee on Materials and Metallurgy. I'm Paul Shewmon, Subcommittee Chairman.

ACRS members in attendance, virtual and here and something are Hal Lewis and Carl Michelson, who's in the building.

Consultants are Tom Kassner and John Bickford.

The purpose of this meeting is to review and discuss the staff's proposed rerolution of Generic Safety Issue 29 on bolting degradation and hear a briefing on the status of erosion/corrosion and microbiological corrosion.

Elpidio Igne is the cognizant ACRS Staff Member for this meeting.

Rules for participation in today's meeting have been announced in the notice of the meeting previously published in the Federal Register December 21, 1990.

Transcript is being kept and will be made available, as stated in the Federal Register Notice. It is requested that each speaker first identify himself or herself and speak with sufficient clarity and volume so that they can be readily heard.

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

In the absence of any other preamble, I'll recognize Bob Baer, who will begin then.

MR. BAER: Thank you, Dr. Shewmon.

[Slide.]

MR. BAER: As you said, we are here this morning to discuss the proposed resolution of Generic Issue 29, bolting degradation for failure in nuclear power plants.

I'm going to present a little summary or overview, and then Dr. Johnson is going to describe the industry-recommended program and then Dr. Chang will talk about the past and ongoing NRC efforts in the area of bolting and then Mr. Davis will discuss survey of bolting degradation and failure and then I'll come up again and talk about the proposed resolution in the areas where we're still seeking some advice and guidance.

[Slide.]

MR. BAER: As I said, I'll just present a summary or overview before the detailed presentations.

As a result of Generic Issue 29 being prioritized back in, I think it was 1982, the industry organized an effort under EPRI to develop a generic program for handling bolting problems. EPRI -- there was broad participation by many groups, I think almost all the owners' groups participated and they, in turn, hired most of the nuclear steam supply system suppliers as consultants and I think there were architect/engineer participation. So, there was a pretty broad industry effort over a number of years and the output documents were EPRI NP-5769 2 volumes, entitled Degradation and Failure of Bolting in Nuclear Power Plants.

Then EPRI has put out Good Bolting Practices manuals, one for large bolts and one for small bolts, that has just come out. Then they've put out a series of training films or videotapes, 3 parts of those.

In summary, EPRI recommends the development and implementation of a plant-specific bolting integrity program. The staff has a few qualifications and exceptions, which I would personally categorize as being in the technical -- hey guys, hey -- give me a break.

MR. SHEWMON: Hey, one session.

MR. BAER: Has some qualifications and exceptions which I would personally categorize as into the details of some of the EPRI recommendations. But we basically agree with the recommended program, but, as we'll get into later, are not absolutely assured that the industry -- that the licensees are -- are implementing the program. Although, we've had some -- some reassurance along those lines -- some, I'll emphasize.

[Slide.]

MR. BAER: Let me summarize some of the ongoing activities associated with bolting.

Over the years, since this issue has been prioritized, problems with threaded fasteners have occurred, and the NRC has required specific actions on licensees in response to these problems.

In total -- well, since 1982, there has been requirements listed in seven bulletins, two generic letters, and one circular, and then, in addition, as other problems have occurred during the same period, efforts that didn't require specific licensee -- or problems that didn't specify -- I'm not saying this well.

Eleven information notices were published to inform licensees of problems, although those information notices did not require specific action on the part of the licensees.

But there has been a continual chipping away at this problem, so that it isn't clear that there is very much of a residual problem left at this time.

I was just -- T.Y. Chang, in his presentation, will discuss in reasonable detail a number of these generic communications.

I was just going to highlight four of them that I think are the most significant in regard to bolting.

The first that I was going to talk about briefly was Bulletin 82-02, "Degradation of Threaded Fasteners in

Reactor Coolant Pressure Boundary of PWR Plants."

Unlike most bulletins, which require only a one-time effort, this bulletin required a commitment from the licensees to have a continual program, that they were to develop and implement procedures on threaded fasteners, and specifically, this was limited to the reactor coolant system, bolts that comprise the boundary, pressure boundary of the reactor coolant system, and each time they had to open any of those bolted connections for maintenance or other reasons, they are required to clean and inspect the bolts per the ASME code before reusing them.

As I said before, that is a continuing, ongoing requirement.

Another bulletin published in 1987, 87-02, entitled "Fastener Testing to Determine Conformance with Applicable Material Specifications," had a combination of one-tire and continuing efforts.

Licensees were required to sample a -- test a sample of both safety-related and non-safety-related bolts or threaded fasteners on hand, and those results have been reported to the NRC, and a NUREG was written summarizing the results, and that was a one-time action.

But they were also required to describe and effectively commit to the additional actions or future actions that they would take to assure that the threaded fasteners used in the plant on safety-related systems met the specification.

Then there were two generic letters that I think are quite pertinent to this topic.

One was Generic Letter 88-05, "Boric Acid Corrosion of Carbon Steel Reactor Coolant Pressure Boundary Components in PWR plants."

Now, that Generic Letter was broader than just bolting, but it required licensees to commit to developing and implementing a program to monitor boric acid leakage, and four elements were prescribed in the Generic Letter, the four elements of that program.

They had to determine the principle locations where small leaks -- and they specific leaks less than the tech spec allowables -- could cause degradation of reactor coolant pressure boundary components due to boric acid corrosion, and then the second element was to develop procedure for locating the small leaks and then procedures for examining and evaluation of any such leaks, and then, finally, have corrective actions to prevent reoccurrence of any such leaks.

So, that Generic Letter, as I said, focused on boric acid corrosion and included other components than threaded fasteners but certainly applied to threaded fasteners.

Then, the last one I was going to mention was Generic Letter 89-02, and again, this was a broad generic letter: "Actions to Improve the Detection of Counterfeit and Fraudulently-Marketed Products."

Again, this was -- required licensees to develop and implement a continuing program.

The major elements of the program that were specified was engineering involvement in the procurement process, including determining appropriate testing requirements.

Another element was proper receipt, source inspection, and testing; actual conducting of the testing, as opposed to developing the test requirements.

Then, third, developing a dedication program for commercial-grade components that were being used in safety systems.

So, in total, these generic communications, as I said before, tended to keep reducing the magnitude of the residual problem associated with bolting or threaded fasteners, and most of them, as I indicated, were directed toward the reactor coolant system and bolting or threaded fasteners in those systems.

There's a couple other NRC activities that are relatively important that deal with bolting in other -- outside the reactor coolant system.

First that I was going to mention -- and again, T.Y. Chang, in his presentation, will discuss these in more detail -- was USI-A46, "Seismic Qualification of Equipment in Operating Plants."

The licensees are -- well, the program hasn't been fully implemented, but as licensees are being required to address the adequacy of equipment anchorages for the safe shutdown for earthquake levels up to and including SSE, and what we've found, in the course of A46, was that things associated with emergency power and shutdown, if they are anchored properly, tend to survive seismic events with a very high confidence, and many of these anchorages are, of course, bolted connections.

Then, a similar program that will extend to events beyond the SSE is the individual plant examination for external events, and a generic letter getting that program going, I think, has been issued fairly recently.

MR. MICHELSON: Bob, do any of these programs cover -- particularly cover the bolting required for pressure boundary valves, for instance, on the bonnets, keeping in mind that now you've got a new and interesting problem.

If your bolts start to waste, the loading on the bolting is quite variable, depending on whether the valve is opening or closing, and some of these are very large stresses on the bolts during full closure.

I didn't find any treatment anywhere in the discussion of that particular thing.

MR. BAER: Are you talking about the package we sent down?

MR. MICHELSON: The package you sent down.

MR. BAER: Well, why don't you let us go ahead and do our presentation?

MR. MICHELSON: Sure. I just wondered. I was just asking a general question: Did I miss it? Is it there somewhere?

MR. BAER: Well, what we're doing is suggesting that licensees -- suggesting that -- at least, Research is not recommending requiring licensees to meet the EPRI-required program.

That program deals with all safety-related bolting. So, it would cover the bolts.

MR. MICHELSON: I don't doubt it does. What I was trying to find is where does it, you know, treat the problem of excessive loading on the bolts during the time of full closure of, say, a wedge gate valve?

MR. BAER: I think that's the wrong question for a generic issue.

We're trying to look at whether additional requirements beyond those already covered in the regulations or in the generic letters -

MR. MICHELSON: Well, I think it's the right question, because you do treat what happens if a certain fraction of the bolting on a flange were to waste away and not be there, and then you treated the stress on the rest of them.

But on the valves, these bolting loads are extremely high.

MR. BAER: When you say "we," you mean the EPRI program or the EPRI-recommended program?

MR. MICHELSON: Talking only about the regulatory analysis in your generic letter. That's the two documents I was pointed toward.

So, maybe you can address it later.

MR. BAER: I'm confused by the question.

MR. SHEWMON: The regulatory analysis -- you certainly are familiar with that.

MR. BAER: Yes. I wrote most of it. Yes, I am familiar with that.

MR. MICHELSON: Is it in there?

MR. SHEWMON: It's not in there. He did not find it for bonnet.

MR. BAER: We didn't look at flanges in the details of stress analysis.

MR. MICHELSON: Yes. But this is a unique problem, because now, every time you close that wedge gate valve, you're putting a very high stress on the bolting, and your analysis just didn't seem to address that. It addressed it as if the stress was a constant, and it's not. It's a variable as you operate the valve.

MR. BAER: I guess you'll have to show me in the regulatory analysis what you're referring to, Carl.

MR. MICHELSON: Well, I was asking you where it is. I didn't find it.

MR. SHEWMON: He says it's not there.

MR. BAER: You're comparing it to a part that you say is in there, that we analyzed.

MR. MICHELSON: EPRI analyzed the case of a flange with -- I forget -- 16 or 20 bolts in it and what happens when you lose 4 or 5 of them.

MR. BAER: That's why I asked whether you're talking about our regulatory analysis or EPRI's document.

MR. MICHELSON: I'm talking about your regulatory analysis. I'm simply asking one question. Did you consider valve bonnet bolting?

MR. BAER: No. But we did not consider the other case that you're talking about in the EPRI analysis.

MR. MICHELSON: It is subject to corrosion.

MR. BAER: Certainly.

MR. MICHELSON: There have been cases already.

MR. BAER: Yes.

There have been problems with bolting. No doubt about it.

MR. SHEWMON: Let me ask a different question. It has been helpful in the past to find a definition of the generic safety issue which the staff wishes to resolve. Sometimes the problem gets changed over the years. I don't think this happened here. But I looked for a definition of the problem, hoping that if I found a definition of the problem, I'd be better able to decide whether or not it was closed. And I've been unable to find anything better than the title of it, which is "Bolting Degradation or Failure in Nuclear Power Plants."

If I come back into other documents, I can find a description that goes on for several pages, but I can't find a definition which sort of defines what the problem was.

Is the problem to sort of avoid failure of bolts in nuclear power plants?

MR. BAER: As it's evolved, yes. The scope has changed a number of times over the years, starting from a very broad scope, narrowing at one point -- and correct me if I'm wrong, Dick -- but I think at one point in only dealt with reactor coolant system pressure boundary back four or five years ago, until now where we've tried to consider all the safety-related bolting of the plant.

MR. SHEWMON: Someplace in the history I read that it started out in support, so presumably it had to do with the things that were in concrete and attaching things to things primarily at that point.

MR. BAER: I believe it started out as support bolting and then at one point evolved to where it was not support bolting at all but only reactor coolant system pressure boundary, and then re-evolved to now where we've tried to consider all the safety-related bolting in our deliberations.

MR. BICKFORD: I was chairman of a working group for the ASME O&M people, who, at the request of the NRC, was set up to try to define the issue and then to try to see what should be done about it.

And the reports that we received and so forth, material from the NRC, suggested that it was not merely failure of the bolts or wastage of the bolts that was causing the problem. This was a fairly small percentage of the incidents. Most of them were improperly-tightened joints which leaked, and therefore led to other problems, and this kind of thing -- vibration, loosening perhaps, or bolts missing, wrong materials being used, and so forth and so on. So it was quite a broad spectrum of bolted joint problems, I would say, as opposed to merely bolt failures or inadequacies themselves.

MR. SHEWMON: Thank you. Any other question?

MR. LEWIS: No, but I can contribute. This is raising some history in my mind. I remember 15 years ago when we did the Physical Society study, there was an issue of bolts. And it was a letter written by an individual to the then AEC which had an analysis of the stress on the threads. And this was pressure boundary bolting. It was an elastic calculation, and it was simply wrong. But these things start programs and become generic issues, and people forget how they began. I also looked for the definition of the problem and didn't find it.

MR. SHEWMON: Yes.

MR. BAER: Let me turn this over to Dick Johnson for his portion of the presentation.

MR. SHEWMON: Are you wearing a research hat these days?

MR. JOHNSON: Dr. Shewmon, I always did.

MR. SHEWMON: Okay. I was just wondering when NRR was going to speak.

[Slide.]

MR. JOHNSON: Good morning. My name is Richard Johnson, and I am on the staff in the Engineering Issues Branch under Bob Baer. And I had the pleasure for a number of years of being the task manager on this generic issue preceding Dr. Chang.

[Slide.]

MR. JOHNSON: I present for you the outline of my talk. Only three items. We'll keep it simple. The history of the generic safety issue Number 29 -- although you've just heard a little bit of it, my branch chiefs stole a little of my thunder; I will discuss some of the results of the Electric Power Research Institute, results of their research efforts; I will briefly tell you what is in NUREG-1339, which I authored.

One reason that I felt I should keep this outline fairly simple is that the last time I had the pleasure of being here at the ACRS, Professor Shewmon seemed to have a bit of a difficulty digesting a relatively simple theory about how large grain size seemed to mitigate the temperature effect in radiation.

Now, the bolting issue is much more complicated than that. There are many designs, there are many materials, there are many applications, and there are many failure mechanisms.

So it occurred to me that I should give you the full theoretical treatment at the outset.

[Slide.]

MR. JOHNSON: There you are. Now, the slide is self-explanatory so I am not going to dwell on it, and I'm going to -- you see how data and theory are fitted closely together.

MR. LEWIS: Does the denominator in the second equation ever go to zero?

MR. JOHNSON: I said I'm not going to discuss this in any detail, and I'm going to stick to that resolve.

[Laughter.]

MR. LEWIS: I don't think that integral converges.

MR. JOHNSON: You did hear a bit of the history of the generic issue, and, indeed, back in the days before we had the rather formal definition of unresolved safety issues under which we now work, there was an issue on the integrity of support structures which became Unresolved Safety Issue A-12.

That was grappling with all the many support problems, support integrity problems, and included finally bolting and bolting integrity. When you ask for the details of the program, the program itself, the definition of the program itself is a bit piecemeal.

You'll find some of it in the first NUREG that was written on Unresolved Safety Issue A-12. Then there were some letters that were written in May of 1982, I believe, which brought bolting and stress corrosion cracking into that issue.

That motivated the Atomic Industrial Forum working with the Materials Property Council to set up a task force, a committee. Meanwhile, the Nuclear Regulatory Commission separated bolting as a separate issue from the unresolved safety issue and identified it as a generic issue in May of 1981.

It was given its alpha-numeric of GSI-29 in April of 1983, prioritized as a high priority issue in November of 1983. Meanwhile, the Atomic Industrial Forum, along with the Materials Property Council, did charter a committee and the sponsorship of that was found under the Electric Power Research Institute.

That work began somewhere around 1982, and the products of that effort are three, as I see them. First of all, there is a research document in two volumes, EPRI-NP-5769 Volumes I and II, published in April of 1988, entitled Degradation and Failure in Bolting in Nuclear Power Plants.

If you find this title repetitious, it certainly is. As a matter of fact, that committee told us that their excuse for existence was to resolve this issue. That's what they felt they did with those two volumes and their research document. They also provided training tapes, video training tapes which Mr. Bickford had a large hand in.

As a matter of fact, I believe he appears on one of them in an interview. I believe that you can't find a date on their title, but I think that they happened somewhere around 1987. My reason for saying that is that they are cited in the EPRI-5769, so they were cited in 1988, so I think the preceded that document by about a year.

Then there are two bolting manuals which have been published. The first one, Volume I, on large bolts in 1987. The Volume II is entitled Small Bolts, although it has a lot more than that in it, is just out of the printers. You can probably get yourself a free copy by calling EPRI.

What I am going to do next is to talk about the research work that was funded by the Electric Power Research Institute.

[Slide.]

MR. JOHNSON: On this slide, what you see is a listing -- and that's all it is -- of the 19 stated tasks that the committee set forth to address. According to the document, the two-volume document, EPRI chose to give them -- put them in three different categories: general pressure boundary and internals. Those that dealt with the general subject of bolting were Tasks 1 through 9.

Those that dealt more specifically with pressure boundary bolting were Tasks 10 through 17 and the last two, 18 and 19, had to do with reactor internals. Now, as far as the funding is concerned, all of the funding for the first 17 tasks came from EPRI.

The owners groups, Babcock and Wilcox and I think Combustion Engineering and definitely Westinghouse and maybe

General Electric, the owners groups dealt with the reactor vessel internals. They published separate technical reports which are cited in the EPRI document and I'm sure they can be obtained. They're considered to be in the open literature.

Those tasks resulted in these specific items. What you see in front of you now are really the chapters or sections in the two volumes of Electric Power Research Institute Document NP-5769. There are the obvious things like the introduction.

Chapter 2 of Volume I deals with what they are calling the resolution of the issue. I could dwell on these things to some extent. I prefer not to get into much detail. The volumes are here. I have brought copies of them, not to give out, but in case we wanted to get into any detail.

There are a couple of things that I'd like to say and that is that some of this work gave rise to codes and standards types of documents. There's a code case which I believe is still in committee, being handled by the ASME pressure code committee Section 11. It has not yet made it through the chain of -- through the ladder of committees.

MR. SHEWMON: What does that deal with?

MR. JOHNSON: That deals basically with a way of handling the design of bolted closures. As a matter of fact, that's where the idea of treating a bolted closure with a leak-before-break approach can be found.

MR. MICHELSON: Are we going to discuss that now or later, the leak-before-break approach? I have asked that they come prepared to discuss it. Is it going to be now or later?

I don't want you to pass over it if this is all you're going to say. I've got a number of questions.

MR. SHEWMON: He just happens to have a viewgraph for you.

MR. MICHELSON: Good. Which we don't happen to have.

[Slide.]

MR. JOHNSON: When I come to a party, I don't ask the -- I generally don't expect to be asked to play, but I usually bring my saxophone anyway.

MR. IGNE: Do we have this in our package?

MR. JOHNSON: No, you do not.

MR. MICHELSON: Well, you knew we were interested in it.

MR. JOHNSON: Indeed I do.

MR. MICHELSON: We knew we were going to discuss it. It should have been in the package so we could read it. I can't see it on here.

MR. MICHELSON: I brought, Mr. Michelson, as a back-up slide. I'll give a copy of it to Mr. Igne.

MR. SHEWMON: Dick, move that, push that table this way about 2 feet, and see what that does to the magnification.

MR. MICHELSON: A lot.

MR. SHEWMON: Fine, now focus it.

MR. MICHELSON: All right. Now, we can really read it.

MR. SHEWMON: Now focus it and we'll be in fair shape.

MR. JOHNSON: Run copies for people.

Well, indeed, one can find, in Volume 1 if EPRI NP-5769, in Section 3, which is entitled Pressure Boundary Bolting, suggestions on a leak before break approach.

They prepared this, they offer it as a -- a means of ensuring closure integrity.

MR. LEWIS: Could you explain to a simple physicist what a "leak before break approach" means for a bolt?

MR. JOHNSON: It means that failure is going to take place, not instantaneously, but over a period of time.

MR. LEWIS: So, it means that you -- you tighten and then you go away and wait for the thing to leak --

MR. JOHNSON: And detect the leak and go and stop it when you -- when it's detected.

MR. LEWIS: Eventually.

MR. JOHNSON: That, of course, is one of the critical items --

MR. LEWIS: Yes, but that -- how did --

MR. JOHNSON: -- but if there's no means for leak detection, the leak before a break approach is futile.

MR. LEWIS: How does that give you any guidance on how to do the closure of the bolt, how to tighten the bolt?

MR. JOHNSON: Sir, as a materials --

MR. LEWIS: If you're planning to --

MR. JOHNSON: -- engineer, I would not be the best one to answer that. Perhaps your consultant, Mr. Bickford, might have an answer to that.

MR. LEWIS: Thank you.

MR. JOHNSON: I think what we're talking about is that a -- I think, in part, John correct me, but a properly designed joint won't leak in the first place.

MR. BICKFORD: That's not true.

MR. JOHNSON: It's not true, so erase that.

MR. BICKFORD: They could leak because they're not put together properly -- proper assembly.

MR. JOHNSON: Properly designed and assembly, and then it shouldn't leak.

MR. BICKFORD: The joint depends for its integrity on the preload, which is established only by the mechanic with the wrench, it's not established by the designer.

MR. JOHNSON: Yes. Fine.

MR. LEWIS: Does a leak-before-break approach mean that you don't worry about tightening the bolt because you know it will leak?

MR. BICKFORD: No. I shouldn't think so. No, not at all.

MR. LEWIS: Then, I'm still trying to understand number 1 on that viewgraph.

MR. JOHNSON: Well, there are so many reasons for the joint ultimately leaking.

MR. LEWIS: I know that.

MR. JOHNSON: The material may relax in service.

MR. LEWIS: I know all those things. I'm just trying to understand what it means as an approach to ensure closure integrity. Does it mean you don't worry about the bolting because eventually, whatever the cause of the leak is, you'll see it because there's a disaster? Is that what it means?

MR. JOHNSON: I wouldn't say that, no. I'd worry about the --

MR. LEWIS: I know you wouldn't say that.

MR. JOHNSON: -- the bolt -- no, well.

MR. LEWIS: But, I'm hoping that when you say that's wrong, then you'll tell me what's right.

MR. SHEWMON: Why don't we wait, and there is the word "proposal," up there, and maybe we can learn what EPRI's proposal is if we listen for another --

MR. MICHELSON: While you're thinking of that, though --

MR. LEWIS: Maybe.

MR. MICHELSON: -- what bothered me a little bit, in the regulatory analysis, is it states, on page 11, that the staff believes leak before break criterion should be applied to threaded faster reactor coolant pressure boundary joints.

MR. JOHNSON: And we do.

MR. MICHELSON: So, they have already endorsed it. It isn't proposed, it's endorsed by the staff, and I think that it needs to be reviewed.

MR. JOHNSON: We've just stated limitations and, as I said, one of the limitations -- and it seems quite obvious once you say it is that if one is going to rely on leak detection, then leak detection has to be part of the system.

MR. MICHELSON: How small a leak do you think you can tolerate from the corrosion viewpoint and not have a problem with boltage wastage? You can -- I think some relatively small leaks --

MR. JOHNSON: Yes.

MR. MICHELSON: -- can get you in deep trouble. Now, you're going to detect those relatively small leaks. The water evaporates, it doesn't come dripping off the component, it's gone into the humidity in the air. So, how are you going to detect it?

I found not discussion of this detection -- what levels could be tolerated or anything like that. You just -- I found your endorsement only.

MR. BAER: The safety significance is whether you'll get a catastrophic break of a threaded connection of a bolted flange or a bonnet on a valve without -- without some preceding leakage. There is, as I pointed out and in T.Y. we'll talk about more and perhaps a little more -- the generic letter where licensees have committed to programs. The staff audited, I think, 10 different licensees and found that they seem to have a program that would detect very small leakages below tech spec limits. And the tech spec limit is a gallon per minute loss from a reactor coolant system. It doesn't matter if it evaporates or not, it's the loss from a reactor coolant system.

MR. MICHELSON: Yes, but a gallon per minute is a lot of leakage, from the viewpoint of corrosion bolting.

MR. BAER: Yes, it is. So that's why --

MR. MICHELSON: In fact, I can get all the corrosion I might need well below one gallon per minute leakage.

MR. BAER: Yes, but I'm not aware, going back to both the events at Maine Yankee that led to Bulletin 82-02, of any situation where the reactor coolant pressure boundary, where you have the boric acid, where there's been a catastrophic failure of a threaded flange.

MR. MICHELSON: No there hasn't, but these are hopefully very low probability events, hopefully.

MR. BAER: Well, yes, but --

MR. MICHELSON: I'd also --

MR. BAER: -- you're starting now to get enough -- it's one of the few cases where you're -- you're starting to get at least a point estimate that agrees with what's being done in the PRAs.

MR. MICHELSON: Well, I've tried to take some comfort in the fact that you would know about leakage -- measurable leakage before the catastrophic failure occurred. But then I said, well gee, where's your analysis of the loading on bolting associated with valve bonnets.

MR. BAER: Well, you keep talking about our analysis, and you're really --

MR. MICHELSON: Well, I'm talking about your regulatory analysis. That's the analysis I'm talking about.

MR. BAER: -- and you're talking about the analysis done by EPRI on the flange.

MR. MICHELSON: No, no, no, I'm talking about your regulatory analysis wherein you endorsed leak before break with really -- without much discussion.

MR. BAER: That I agree with.

MR. MICHELSON: I'm trying to get the discussion out now. Now, how did you treat bonnet bolting from this viewpoint and where's your analysis?

MR. JOHNSON: Sir, bonnet bolting is a specific -- and specifics do, indeed, kind of get lost in the wash of a generic issue. Generically, we agree with this. There may be specifics. I think your point is well taken, that if one has a ring of studs or bolts that are all equally degraded --

MR. MICHELSON: I'm not saying they're equally degraded.

MR. JOHNSON: No, no, but if that -- if that would be the case I'm saying, then an unzipping is possible, and it's what would -- what one would have to say is should that kind of a situation occur, then leak-before-break is not applicable, as it is in the piping, where leak-before-break is applied, when we know that there's going to be a failure mechanism that may give us break-before-leak, we don't apply it.

So, therefore, there has to be point-by-point, item-by-item, component-by-component, a review on the plant-specific basis before this can be applied. But generally, generically, we're pretty much in favor of it.

MR. MICHELSON: Well, those --

MR. JOHNSON: The reason we are is that this takes us away from looking at -- at the problem bolt-by-bolt, to being able to look at it as closure as an entity.

MR. MICHELSON: Let's look at it by component-by-component, and I think the pressure boundary valves which do have bolted bonnets on them are pretty important, and if they were to fail, they are pretty large leaks.

MR. JOHNSON: Yes.

MR. MICHELSON: I just don't find any discussion of it even.

MR. JOHNSON: What I'm saying is that when it comes time to ask the question should a valve bonnet, should one apply leak before break to a valve bonnet, perhaps the answer should be no, just as we would say to some of the piping in systems, no, one cannot apply leak-before-break to certain systems of piping.

MR. MICHELSON: I simply don't find those kinds of caveats in you regulatory analysis. You seem to be blanketly endorsing leak-before-break. The criterion you give don't help me a bit.

Without some regulatory analysis of pressure boundary valve bonnet bolting, I just wouldn't want to buy off on this, and I found none.

MR. JOHNSON: What he is looking for, Bob Baer, I think, is what one reads in the leak before break -- in the EPRI document.

MR. MICHELSON: That was only for static closures. I'm talking about dynamic closures, which valve bonnet bolting constitutes.

Those are quite variable loadings, as that valve closes.

MR. JOHNSON: The caveats and the restrictions and the limitations could have, no doubt, been put in another document.

I suppose, when we wrote it, we considered that some of those things were repetitious, because they're already published.

MR. MICHELSON: Well, you seem to have been interested in check valves, and they're relatively static loadings. But in motor-operated valves, those are dynamic loadings on the bolting. That's what's holding the thing together.

All the reaction force is taken on the bolting, and I find no accounting of this.

MR. SHEWMON: Fine. We've made the point.

MR. MICHELSON: Yes, I think so.

MR. JOHNSON: I think we would agree that there are places where leak before break is inapplicable to bolted connections. We would agree with that.

Beyond that, I don't have much to say about it.

MR. SHEWMON: You will or somebody else will get to the caveats you have on the EPRI document --

MR. JOHNSON: Yes, sir.

MR. SHEWMON: -- if we let you get there, someday? Fine.

MR. JOHNSON: Yes, sir.

MR. SHEWMON: We'll wait with anticipation.

MR. JOHNSON: May I set aside, now, the leak before break?

MR. SHEWMON: Carl?

MR. MICHELSON: Yes. If we're going to hear it later, hear the caveats later, fine.

MR. SHEWMON: Fine.

MR. MICHELSON: I just don't think they've got any. I don't think you're going to hear any.

MR. BAER: I think Dick Johnson was responding to Dr. Shewmon's question about the caveats on the EPRI document as a whole, not on the leak before break.

MR. JOHNSON: That's correct.

[Slide.]

MR. JOHNSON: There they are.

MR. SHEWMON: These are the caveats?

MR. JOHNSON: Well, this includes them, sir.

MR. SHEWMON: Okay.

MR. JOHNSON: What we're dealing with now, what we have in front of us, is a slide that is -- I think I brought some unwanted visitors with me in my throat.

MR. SHEWMON: I hope you take them away with you.

MR. JOHNSON: That's what my wife said, but it didn't save her.

What you see here is a brief summary of what is in the NUREG that is part of the bolting resolution package.

The NUREG starts with an introduction where the bolting safety issue and the problem is stated, perhaps not in the way that you might have wanted, Dr. Shewmon, but it's in that NUREG.

Then, it treats, in an executive-summary way, the work that came out of the EPRI research effort.

That's what I, essentially, just covered in the previous slide. So, it's also part of this NUREG.

We took except to a couple of things, and in our conclusion, we said that we feel that the basis for the resolution of the issue is at hand, and what we mean by that is that the documents that were produced by EPRI -- to repeat, that's the research document, the bolting manuals, and the training tapes -- also, the work that's been done by INPO, the SOERs, and Dr. Chang will talk a little bit more about that, all the documents that relate to bolting issues either directly or indirectly that have come out of the Nuclear Regulatory Commission, the bulletins, the generic letters, and such, and the existence of the Bolting Technology Council, when taken as a whole, we felt, addressed the safety issue of bolting and bolting -- potential bolting failures.

So, we said that we -- the staff's attitude was that the basis for the resolution was at hand.

We did take certain exceptions to things that were said by the Committee in the EPRI documents.

The first item says expand Section 11 in Volume 2. That's not so much a criticism as to say that they didn't go far enough.

That chapter is entitled, if I can go back and look at it correctly -- it's an evaluation procedure for support bolting. It was prepared by one of the EPRI contractors.

Our attitude on that chapter is that it's very good, and it should be the basis for broader coverage. It could form the basis for a plant-specific bolting integrity program in the industry.

So, our criticism was it was good and wasn't taken far enough.

The second item -- there is quite a bit in their document about how to avoid stress corrosion cracking in high-strength bolts, and it gets down being quite specific, and the people who wrote on that subject were recommending several criteria which hovered around a yield strength of 150 KSI, but you'll find words in that document that say "the minimum specific y for example.

Well, aside from the fact that it's not consistent, we don't agree that the minimum specific yield strength of 150 is a proper target.

One can specify, in the ordering information, a minimum of 150 or less than 150, but heat treat to get above 150.

So, our attitude was it's the real yield strength of the material that's the criterion, and so, we suggested that the limitation be set at the yield strength of the material, no steels above 150 KSI actual yield, in order to avoid stress corrosion cracking.

Now, one can do that, of course, in ordering information for new and incoming material. For those bolts, studs, and fasteners that are already in place, then one has to go to a hardness conversion.

That brings me to item 3.

There is a procedure that was proposed and worked on to be able to do in situ hardness tests. It's a device that I, frankly, have never used. I don't even think I have actually seen one. But we find that the nuclear industry, in a few places, has used it.

There has to be some problem with what is in the EPRI document, because conversions from hardness to ultimate strength are in disagreement with the conversions that are in the American Society for Testing Materials.

So, that has to be cleaned up. It can be done by audit.

That standard is in as a proposal, proposed new test method, to the ASTM Committee on Hardness Testing, and it's my understanding that they are reviewing it.

I also understand they have a little bit of a difficulty not with the test procedure itself but just in the proprietary nature of it, which they have to get around.

MR. SHEWMON: Dick, out of curiosity, is this something like -- there was something called a shore scleroscope, I think, which bounced an Echotip, hardness tip.

MR. JOHNSON: It's a little bit more sophisticated.

MR. SHEWMON: Or you can put it on with magnets and actually do something else.

Is it the bounce type?

MR. P~CKFORD: It's the bounce type, but not shore. It's called Echotip, and you have to then correlate it to Rockville or any of the other correlations.

You can do it on the end of the bolt, whereas the ASTM procedure, we have to cut off two threads' worth of bolt and check four points on mid-radius and stuff, which is impossible in a bolt in site.

MR. MICHELSON: But you don't do it on the head.

MR. JOHNSON: You could.

MR. BICKFORD: Yes. I think you could do it on an exposed end.

MR. MICHELSON: Is there reason to believe the head hardness is the same as the shank hardness?

MR. BICKFORD: Yes. They go through the oven together, I guess, in a lot of different dimensions and thicknesses and all that sort of stuff.

MR. JOHNSON: It was used by one utility to find -- when they discovered, on one of their steam generators, that they had a mix of steam generator manway closure studs, they checked them. So, they checked whatever was protruding and were able to satisfy themselves that, indeed, they had both heat-treated, low-alloy steel and carbon steel, a mixture.

So, it's been used, and it's worked, and it's worked on just whatever protrudes.

MR. SHEWMON: Can it be used only on horizontal surfaces, or can it be used on vertical surfaces?

MR. BICKFORD: No. It's my understanding it can be used on vertical surfaces, as well as horizontal ones.

Midstone used it for checking -- Millstone. No. The guy in Ohio.

MR. SHEWMON: Zimmer, Perry, Dresser.

MR. BICKFORD: Out of business now.

MR. JOHNSON: Zimmer.

MR. BICKFORD: They checked 160,000 bolts or something.

MR. SHEWMON: Okay. Onward.

MR. JOHNSON: Item 4 is just that we were a little dismayed at the -- let's say the lack of condemnation of molybdenum disulfide as a lubricant.

A gentleman who has been Mr. Nuts and Bolts with the Nuclear Regulatory Commission retired just this past year. Mr. Sellers and I have had many conversations, and I once asked him why don't we just close the gate to moly disulfide? And he said, well, because it's useful elsewhere; for example, on electric switch gear.

So, used properly, it's all right. But put on high-strength bolts in an aggressive environment, it can be instrumental in leading to stress corrosion cracking.

So, we just felt that the words were not strong enough in their document.

Finally, there is a much more up-to-date fracture mechanics analysis of bolts than is now available in published form by Dr. Lee James, who is now at the Bettis Atomic Power Laboratory, we just felt that what was in there, which was by Dr. Cipolla of Aptech, was good but was a little dated.

That document has been given by a representative to the ASME boiler pressure vessel code for consideration, and the code committee is considering it. They have it as an agenda item.

That brings me through old history, up to modern history, and I am ready to step down.

Yes, sir.

MR. SHEWMON: What is your picture of how all these good things are likely to get brought into this? You expect them to reissue a document this like and then you'd bless it, or how do we know that these don't just sort of disappear into the Public Document Room and never be heard of again?

MR. JOHNSON: I could not ask a better question and about awareness I guess is about the only way -- this is going to be an issue as to whether we conclude this with regard to the industry by virtue of an information notice or a requirement.

I think my Branch Chief wants to say something in that regard.

MR. BAER: We'll be getting to this in one sense but when we get to the proposed resolution, the resolution being proposed by the Office of Research is to publish a information type generic letter which would have as an attachment NUREG-1339 and the information type generic letter which was a copy of the draft which was in the package would suggest that licensees implement the EPRI program but would not require that.

Attached to that letter would be our NUREG-1339, which would have these exceptions and qualifications to the EPRI program.

That would be the Research-proposed resolution.

NRR has some different ideas that we'll be getting to.

MR. SHEWMON: And the force of this generic letter you think would then be enough to bring it to everybody's attention or the ubiquity of this after it's distributed?

MR. BAER: The more major question is are licensees implementing the EPRI program? That's where I think we don't have any firm assurance of that case, of that situation, and I think that's the broader question.

I think the details of the program, if they were, quote, required to implement an EPRI program then the review of the program or the audit it would pick this up.

If they're not required to implement a program, then the question of whether they -- well, it's not a relevant question whether they are implementing it with or without these points if it isn't important enough for them to be required to implement a program.

MR. SHEWMON: Fine, okay. We'll return to that, clearly. Pardon? Go on?

MR. BAER: Go ahead.

MR. SHEWMON: One other question. On your NUREG-1339, in the first paragraph it/you state "The ACRS recommended that the NRC Staff expand its concern about stress corrosion cracking of high strength, low allow steel bolts."

Are there HSLA bolts? My memory of this is that Harold Etherington was very concerned about very high strength bolts like maraging steel and thought they had no business being used in this situation but I didn't remember that we'd ever singled out HSLA bolts.

MR. JOHNSON: Well, the point is that there has been a history of stress corrosion cracking. If you go back to the earlier documents relating to unresolved safety issue A12 you'll find that there is a related NUREG that Dave Sellers was responsible for a NUREG that came out of the Lawrence Livermore National Laboratory where they did a very comprehensive review of experience and failures regarding stress corrosion cracking and I'm sure you'll find bolts in there where the incidents are given in terms of the relative strength level.

It is out of all that work that goes back to USI-A12 where the NRC when this --

MR. SHEWMON: Okay, but those for example would be over 150 KSI?

MR. BICKFORD: May I say something? I think perhaps the confusion comes from the fact that the ASTM has a number of specifications called high strength bolting that involved materials that are definitely not high strength. They are well under 150 yield strength -- for example, A490; for example B7 bolts in A193 and so forth.

They refer to these in the title of their specifications as high strength and they're 4140 and things like that. They are not maraging steels.

MR. JOHNSON: But 4140 is a low strength, high -- low alloy, high strength steel but what we found, what the data told us is that stress corrosion cracking can be expected fairly commonly for yield strengths of 170 and above.

We didn't have anything much below 160. The 150 was established to give us a little margin but whether you call that high strength of not, I don't know.

MR. SHEWMON: Let me finish then. What really bothers me is HSLA or the use of that because if you ask anybody else, any metallurgist outside of this room what a high strength, low allow steel is, it's something where they used microalloy to restrain grain size and get a structural steel which has the yield strength around 60, 80, 90 KSI instead of the 30 or 40 that the regular hot rolled stuff that they were using before.

It just doesn't come to this so I look at HSLA steel, gee, that's rolled structural plates. What are we talking about that as a concern for?

MR. JOHNSON: No, that's not what is implied. The high strength really means of the order of 150 and above, really.

MR. SHEWMON: Well, you'll confuse at least many metallurgists if you put HSLA behind it and use it as an abbreviation for it.

MR. BICKFORD: In our work we're -- I don't remember them using that term at all in our committee work. We were using LAQT, low alloy quenched and tempered steels generically for the ones that we were concerned about.

MR. SHEWMON: Carl?

MR. MICHELSON: Yes. In looking at this whole bolting question, it appeared that the Staff was looking at both bolting inside of containment and bolting used outside of containment.

MR. JOHNSON: Yes.

MR. MICHELSON: And in the case of the leak-before-break question, if I look at the EPRI document they call it pressure boundary bolting, which means any boundary. It doesn't mean reactor coolant pressure boundary. It's any pressure boundary.

MR. JOHNSON: Yes.

MR. MICHELSON: Was it the Staff's intention to consider leaf-before-break design of flanging outside of containment as well?

MR. JOHNSON: Yes.

MR. MICHELSON: It wasn't clear, because on page 11 again your arguments all ended up with reactor coolant pressure boundary joint failure, which then led me to believe, well, how about outside cf containment?

You did intent to do the same thing outside of containment?

MR. JOHNSON: Well, apply the same principles.

MR. MICHELSON: Yes, okay, now we do the same thing in piping but of course not many people have attempted to use it other than perhaps on main team and feedwater because there's a whole lot of things you have got to do on a pipe.

MR. JOHNSON: Yes.

MR. MICHELSON: I didn't find any prescription of what you have to do on a bolted closure other than some leak detection.

Got to do any special analysis?

Let's say, for instance, that you have analyzed the pipe --

MR. BAER: We've got a problem --

MR. MICHELSON: Let me finish.

MR. BAER: You referred to page 11. Page 11 of what? I'd like to follow.

MR. MICHELSO' Your regulatory analysis, I'm sorry. I'll keep referring to your regulatory analysis, page 11 then. It's Enclosure 3 of whatever we got.

It's your regulatory analysis! It's your resolution, yes!

MR. BAER: Not the detailed design that you were talking about, the analysis of 12 bolts?

MR. MICHELSON: Oh, no. That was in the EPRI Report and of course it applies to any pressure boundary bolting. They didn't analyze the valve bonnet, which is usually many fewer than that.

Now if I were to determine that I couldn't qualify a pipe for leak-before-break, can I still qualify the flange that might be used in the piping system for leak-before-break?

MR. JOHNSON: That is a good question. I don't know that I have ever even seen that question raised before.

What you are saying is if a system would not pass the acceptability criteria for leak-before-break for the pipe proper, then would a flange connection be treated that way?

MR. MICHELSON: Because with the criteria you have given me, I think there would be many cases -- with the criterion you're using I think most of the bolting outside of containment can probably be qualified for leak-before-break.

MR. JOHNSON: I am just trying to think of the things that limit the application of leak-before-break to piping, like if stress corrosion cracking happens in the piping, no, you wouldn't want to apply leak-before-break where if you got a surge of pressure it could burst where there is just a little filament remaining.

Water hammer, if you expect water hammer in the system, you wouldn't want to apply a leak-before-break concept because we've already seen a big enough water hammer will surely give you a break before leak but I am trying to think of how those criteria that we use on applying or limiting leak before break to piping, how that applies to the flange connection.

Your point is well taken.

MR. MICHELSON: Well, I think most likely everything could qualify under this.

I did have a little problem also because it wasn't clear how you treat the corrosion question, as in the case of piping.

If it is susceptible to stress corrosion cracking, then you can't qualify it, I thought for leak-before-break.

Is that right?

MR. JOHNSON: Yes. That is correct.

MR. MICHELSON: Does that mean that if I've got a borated water system and I use carbon steel bolting on the bonnet flange that, you know, does it still qualify?

MR. JOHNSON: Well, let's get back to what --

MR. MICHELSON: You know, I don't know.

MR. BAER: If you care for me to answer any of the questions, pause long enough ar . I will.

MR. MICHELSON: Okay.

MR. BAER: I think you're reading this completely out of context. We're talking about, reactor coolant pressure boundary; we're talking about a cost-benefit analysis done by PNL, and asking ourselves whether their cost-benefit analyses warrant actions, and whether we believe the risk and cost numbers.

And we say we limit it to reactor coolant pressure boundary joints. The sentence you're reading says the staff believes the leak-before-break criteria.

MR. MICHELSON: I pointed that out, that it wasn't clear whether you were going to allow leak-before-break everywhere else or not. Because this analysis was only fo reactor coolant pressure boundary.

MR. BAER: All that we were trying to do is evaluate the possibility or the likelihood of catastrophic failures of the bolting, and saying hey, we believe that in the reactor coolant pressure boundary, that there is a good likelihood that you would get leakage before catastrophic break. And this reduces the probability of the catastrophic break. I don't think we were trying to say anything other than that.

MR. MICHELSON: Bob, I asked you people earlier, are you going to apply it outside of containment as well. And I thought the answer that came back was yes. And that's what bothers me. Inside of containment I don't have a problem. We're designing for large breaks inside of containment already. So if the bonnet comes off the valve, perhaps we can still handle it.

Outside of containment, we don't design for bonnets coming off of valves, causing such large leakage. It's just not in the cards.

MR. SHEWMON: Carl?

MR. MICHELSON: Yes.

MR. SHEWMON: The history of this, as you know as well as anybody in the room, at least for piping, was, is there a basis for taking out pipe whip restraints.

Are you suggesting that we should put bonnet escape restraints on top of bonnets, or where are we going?

There are not now such restraints in the system. So we aren't talking about is it safe to take them out. So I hear your concern, but I don't quite see --

MR. MICHELSON: The solution?

MR. SHEWMON: -- where Bob -- yes. Where Bob is coming from, as I understand it is, we wanted to see if the PRA sort of seemed to bound things in a reasonable way. What you are bringing up are other questions. But I guess the question that comes to my mind is okay, do we think it's enough of a safety issue that we should indeed be putting some other constraint on here in case of a failure, or have we done or the PRA wrong.

MR. MICHELSON: PRAs do not consider that the bonnet is going to fly off a valve outside of containment. It's simply not in there. And a lot of other things aren't in there, either. But that's one of the things they don't consider.

So now, we have to say well, what's the probability, anyhow? In some kind of a deterministic way we have to think about, could it happen? That's why you start looking at bolting, and you look at normal bolting, and you've concluded there's no problem even if several of the bolts were missing.

But now you look at abnormal bolting caused by leakage or whatever. Well, if it's bad enough --

MR. SHEWMON: Abnormal loads on bolting or abnormal bolting?

MR. MICHELSON: Abnormal bolting from degradation.

MR. SHEWMON: Okay.

MR. MICHELSON: And if you have variable loads, particularly on motor-operated valves, which are very large loads under certain circumstances -- namely, closure of a wedge -- have they considered the possibility now that the valve bolting may indeed fail?

MR. SHEWMON: Now these bolts presumably are something which have a fair amount of toughness and are operated below or have yield stress below 100,000 KSI?

MR. MICHELSON: But they're corroded.

MR. SHEWMON: Yes. But if they are ductile, then, and you do get these stresses which are of the magnitude you are talking about, then the bolts go plastic and the joint leaks.

MR. MICHELSON: Well, a normal bolt goes plastic. I'm not sure what happens to these corroded bolts under these circumstances.

MR. BICKFORD: They leak.

MR. SHEWMON: They leak.

MR. MICHELSON: How big a leak are we talking about, is my question?

MR. SHEWMON: You've got enough elongation in these bolts to open up the flange. They're not subject to stress-corrosion cracking, if they aren't these high-strength bolts, which would then be the catastrophic.

MR. JOHNSON: The failure mechanism is going to be one of wastage, gradual thinning.

MR. SHEWMON: Okay. And if we overload it, we plastically extend it.

MR. JOHNSON: You will indeed.

MR. MICHELSON: But you'll never break it.

MR. SHEWMON: Never is not a long time.

MR. MICHELSON: We're talking about low-probability events, now.

MR. SHEWMON: Well, I'm saying that you'll get plastic extension and that, indeed, if the scenario you are painting is as bad as you think it is, then there should be out there a fair number of plastically-extended bonnets that leak fairly regularly. There is a test, we run test quite regularly to see if that's a problem.

MR. JOHNSON: You said the key word. "Tests." And part of the application of the leak-before-break philosoph or design philosophy, in its application one of the criteria is one must routinely inspect the joint. And some of the work that was sponsored and I think had very outcome by EPRI was to develop a non-destructive method for detecting wastage. So these bolts are to be examined. They are a regular part of the in-service inspection routine. Wastage is detected even if leakage isn't.

MR. MICHELSON: Is this every three years?

MR. JOHNSON: Well, there's a routine.

MR. MICHELSON: Yes. It's three years, five years, kind of routines. Is it three years?

MR. JOHNSON: Yes.

MR. MICHELSON: Is that any good for this kind of corrosion?

MR. SHEWMON: Three, five, or 10?

MR. CHENG: Three and once a year.

MR. SHEWMON: I don't understand three and once a year. Once an outage?

MR. CHENG: Dr. Cheng from NRR staff. The current requirement is every ten years three times.

MR. MICHELSON: Are we talking about outside of containment, Class 3, Code Class 3?

MR. CHENG: Class 3 is every ten years too, visual only.

MR. MICHELSON: About every ten years --

MR. CHENG: Every ten years three times, but every 40 months you inspect, visually inspect outside of containment, yes.

MR. MICHELSON: How many of them get inspected every 40 months?

MR. CHENG: Every 40 months, yes.

MR. SHEWMON: How many of them? Every one has to be looked at?

MR. CHENG: Every one, you have to visually look at it, yes.

MR. MICHELSON: Now, every component Class 3.

MR. CHENG: Class 3 has to be looked at, yes.

MR. MICHELSON: So we're looking at a 40-month cycle.

MR. CHENG: Yes.

MR. SHEWMON: And this is out where we do not have borated water, so you don't build up crystals if there's a leak?

MR. CHENG: That's right, yes.

MR. MICHELSON: Borated water, depending on which valve you're talking about.

MR. CHENG: We cite Reg. Guide 145, to only address inside of containment leakage. When we tried to apply leak-before-break outside of containment, you don't have a means of detecting leakage.

MR. MICHELSON: That's true.

MR. CHENG: How are you going to do it? Unless the licensee is willing to detect the leakage outside of containment.

MR. SHEWMON: That's my point. Carl thought I was ignoring it, because you can't see it, that there is no borated water.

MR. CHENG: And one important things in technology in the leak-before-break is the leakage detection. Unless you can detect the leakage, it can be outside of containment.

MR. MICHELSON: Are you going to have leak-detection requirements outside of containment?

MR. CHENG: Well, unless the licensee is willing to provide that one, right now the Reg. Guide only addresses the RCPB, inside of containment.

MR. MICHELSON: That's the question I asked earlier. You said no, it includes outside as well.

MR. BAER: Frank Cherny would like to say a few words on the subject.

MR. CHERNY: I think we have gotten so embroiled in the details of all this that the status of this whole thing has gotten lost in the shuffle.

What we thought we were endorsing as far as leak-before-break is concerned, and I think Dick had some stuff in his NUREG-1339 on this, which referenced the EPRI document, in the EPRI document they talk about a leak-before-break approach for analyzing bolted joints. And I think in that document -- Dick, correct me if I'm wrong -- I think there's a draft proposed code case written in there.

MR. JOHNSON: Correct.

MR. CHERNY: A couple of years ago, that draft code case was sent to the appropriate Section 11 ASME committee for review. And it was at least two years ago that I talked to the chairman of that committee. And as far as I know, today it hasn't progressed any further. It's still in that same committee, being talked about and discussed.

Now, if and when that committee decides to do whatever it's going to do with that code case, put whatever more restrictions on it or add whatever more requirements they think is appropriate, it has a long way to go before it ever gets published by the ASME. And there's a lot of NRC members on all the appropriate committees in that chain that will have input to the final form of that code case.

After it gets published, if indeed it does, by the ASME, then the next thing the NRC has to endorse it in the appropriate Section 11 Reg. Guide that endorses Section 11 code cases. And at that point in time, we'll add whatever additional restrictions we think are appropriate.

So it's a long, long way between now and that code case seeing the light of day for anybody to be able to use that approach on these bolted joints. All we thought we were endorsing was the possibility of that kind of an approach on bolted joints and endorsing the concept of sending it to the ASME code committees for an in-depth detailed review and possible co-sideration for publication. That's what we thought we were doing.

MR. SHEWMON: When you say using that sort of thing, what they would get by using this case would be a relief from some other visual or disassembly inspection; is that right?

MR. CHERNY: Right.

MR. MICHELSON: Is it clear, from your referenced letter and see entry document that people are not supposed to be using leak-before-break considerations yet?

MR. CHERNY: Well, I thought it was. If it's not, we'll have to take another look at it.

MR. MICHELSON: If it were, then I would have no -- I withdraw all my questions.

MR. JOHNSON: It's my belief that we have not endorsed it. Therefore, if a licensee is using it he is using it without telling us.

What Mr. Cherny said is exactly correct and right to the point.

Mr. Michelson, I would only add that, when you ask the question would we be willing to accept the application of leak-before-break outside a containment, and I say yes, remember that that is qualified by the fact that there must be leakage detection.

As Dr. Cheng said, if they don't have leakage detection, they can't have a leak-before-break appr ach. If the licensee chooses not to do any leak detection outside containment, clearly that is the precursor and obviates any use of leak-before-break application to his bolted joint.

So there is this sequence that must be followed.

MR. MICHELSON: Well, with the clarification given me, I have no problem. However, I don't get that out o reading the Regulatory analysis. But it's in the record, at least.

MR. BAER: If we proceed with the generic letter, as proposed, we will make sure it's in there.

MR. JOHNSON: I am trying to step down. I'm doing my best to excuse myself from this position.

MR. BAER: The next section of the presentation will be given by Mr. T. Y. Chang.

[Pause.]

MR. SHEWMON: Mr. Chang?

MR. CHANG: Yes?

MR. SHEWMON: Through no fault of yours, we're running somewhat behind schedule. So, if you'd shorten it as you think is appropriate?

MR. CHANG: Okay. I'll try to. Yes.

[Slide.]

MR. CHANG: My name is T. Y. Chang. I'm the current task manager on generic issue 29.

[Slide.]

MR. CHANG: My presentation today will concentrate on the past and on-going NRC efforts on bolting.

In passing, I'm going to talk a little bit about the industry efforts, as well.

[Slide.]

MR. CHANG: As Bob mentioned earlier, since 1982 a number of NRC bulletins, generic letters and information notices were issued on bolting related issues. The bulletins and some of the generic letters required one time action and a continued program.

In addition to those generic communications, there are two programs on-going, namely the USI-A-46 program, and individual plant examination for external events, IPEEE program. Both programs contain one important element. That is the walk-down review.

The adequacy of anchorages to safety related mechanical and electrical equipment will be looked at during those walk-downs.

For the A-46 review, the earthquake level that's going to be used is the SSE level, and for the IPEEE we are looking at severe accident scenarios. Therefore, they are going to look at higher than SSE level.

As I understand, the A-46 implementation probably is going to commence in the early part of this year.

[Slide.]

MR. CHANG: I apologize. On those tables, I think it's kind of congested. But, since you have the hand-outs, I'll recommend you to look at the hand-outs.

These tables tabulate the bulletins, generic letters and information, notices issued since 1982, and they are grouped according to four major different categories.

The first one is on the reactor-coolant pressure boundary bolting degradation in only pressurized water reactors.

IE Bulletin 82-02 is about degradation of fasteners in PWRs, pressurized water reactors, reactor coolant pressure boundaries. It addressed both wastage and SCC. But, as found out from the review of the responses, most of the problems were in the wastage area.

The bulletin described experiences from two earlier information notices, and the required actions to develop and implement maintenance procedures for fastener practices.

Equipment that are required to be looked at are the steam generator and the pressurizer main way closure studs, valve bonnets, and pump flange connections bigger than six inches.

They are also required to, when the joints are opened, they are required to clean and inspect the joints. Those are two continuous programs, and there is a one-time action which is to identify and report problems.

A close-out document was issued in 1985, as NUREG-1095. The conclusions of the review of the licensee responses as published in this document are the following:

Up to 41 licensee responses were evaluated, and roughly 10 percent of bolted connections showed leakage.

For those older plants, there is indication that the frequency of occurrence of leakage is less as compared to the newer plants. So that indicates that the improvements in design and procedure practices, as plant crew members gain experience, it will tend to improve or reduce the leakage frequencies.

MR. SHEWMON: Are you saying in newer plants there is less of it? Or, in older plants, after we've fixed it, there is --

MR. CHANG: In older plants, there is less leakage.

MR. SHEWMON: So, it's sort of a back up curve? We've fixed the 10 percent we didn't do right the first time, and after that it works okay?

MR. BICKFORD: No. I think that --

MR. CHANG: The 10 percent is for the whole survey.

MR. BICKFORD: Yes. The data showed that plants that had been on line a long time had paid better attention to bolting, had better supervision, and did a better job and experienced fewer leakages over the years than newer plants.

MR. SHEWMON: Okay. Not too comforting.

MR. CHANG: In other words, there is a learning curve. As the plant gets older, their design and maintenance procedures get improved.

Another thing found from this survey is that improper lubricants, such as molydisulfide, may cause some trouble, to increase the leakage and corrosion.

In '88, a generic letter was issued on a broader scope. This generic letter concerned not only fasteners, but also components that seized the reactor coolant pressure boundary.

This is a 50.54-F letter. It's a generic letter asking for information from the licensees. They were requested to show evidence of a program in the reactor plants. That program should include the determination of principle leakage locations with rates less than the tech-spec limits, and the procedures to locate leaks, the methods for examination and evaluation of leakage, and the corrective actions taken.

The closeout document, NUREG CR-5576, was issued in 1990, last year. The conclusions are the following:

Up to 50 li ensee responses were revealed and out of those 50, ten plants were audited. For the ten audited plants, wastage prevention programs do exist, even though they are of somewhat varied programs.

All plants audited have wastage prevention program and training program for the inspectors to locate those leakages. All plants, except one, kept the plant relatively clean and most plants cleaned leakage quickly or they drained and contained the leakage.

As we can see the wastage problem has been looked at by the utilities to a pretty detailed extent and programs are in place to locate the leakages and to try to prevent the wastage. The second category that is of some importance is under non-conforming, misrepresented, counterfeit and fraudulent bolting.

NRC Compliance Bulletin 87-02 requested licensees to test bolting to determine the compliance with the material specs. I think this concern started around 1985, but the Industrial Fastener Institute sample-tested quite a few boltings supplied from various distributors all through this country. That's for all types of industries, and they found out that up to 70 percent of boltings tested were out of spec.

That raised the NRC concern. Therefore, this bulletin was issued. Actions required: they are required to report the existing receipt inspection procedure and the internal controls programs for each particular plant. They required to test 10 safety related and ten non-safety related bolting and nuts selected from the stock in the plant. The selection of those boltings were assisted by the NRC people.

They were required to describe further actions needed to meet requisite specs and the requirements. This testing is a one-time action, but the other two elements are considered to be a continuous program.

In 1989 a closeout NUREG Report 1349 was issued and the conclusion from this report are the following: From the test data submitted by the licensees, 8 percent of the safety related boltings were found to be out of spec, but with further evaluation, it turned out that only two percent of those testings of the safety-related boltings were off in a sufficient -- out of spec.

For the non-safety related bolting, it was found that 12 percent -- it's a higher percentage -- were found to be out of spec.

MR. SHEWMON: Now, the rest of the reports have not had a closeout document written yet? There's nothing in the last column.

MR. CHANG: That's correct, right.

MR. SHEWMON: Why don't we just assume that we're read this and that we know about the information documents and get on the to your next slide that has to do with industrial reports. Would that be okay?

MR. CHANG: Do you want me to proceed.

MR. SHEWMON: I want you to proceed faster and I think a good way to do this would be to stop reading about the information notices and to get on to the other things you have to talk about.

MR. BAER: Why don't you go to your last slide, Industry Efforts?

MR. CHANG: The next few slides are information notices issued over the years, concerning mainly non-conforming bolting. Stress corrosion cracking of component internals bolting and miscellaneous bolting problems; okay, the last slide is on the industry efforts.

MR. BAER: The last slide is the one that I will be giving.

[Slide.]

MR. CHANG: The first three bullets were already described by Dr. Johnson. I just want to point out that INPO issued a number of documents. Those were SERs, SENs and ONMRs. Notably, SOER 84-5, in that SOER, there were some recommended actions concerning bolting degradation and failure.

At that time, I believe the EPRI report is already in draft form and it was mentioned there that the EPRI work should be used to address those problems.

MR. SHEWMON: Now, is that something that INPO inspects against on their semiannual --

MR. CHANG: Yes. I understand an audit was done, but INPO was invited to this meeting, but they chose not to come. I don't think I can speak for them. I just want to mention that this was done.

MR. SHEWMON: Well, you could perhaps -- or you perhaps do know more about what INPO issuing a document to a utility requires the utility to do or what the usual reaction is. That's my question.

Is it their practice that they will then audit on this each time they go out, which is every five years or something, to a given plant? Or, do they issue it and never thing about it again, or do you know?

MR. CHANG: I think they go out to the plants and audit a number of things. They will stay in the plant for a certain duration. They have inspectors, a group of inspectors.

MR. SHEWMON: I'm familiar with that procedure, yes. Okay, fine.

MR. BAER: I don't think there's any problem with you telling what you were told by INPO when you talked with them.

MR. CHANG: Okay.

MR. BAER: They gave you some specific information. We were hoping they would come here and address it themselves.

MR. CHANG: Well, we got this information through NUMARC. It's not a direct response from INPO, but through NUMARC, we got the information that the result of the audit indicates that more than 90 percent of the plants, they have done this. They have performed what's recommended in the SOERA for -5.

Also, last year, NUMARC issued a letter to their members informing them of the publication of the two volume EPRI reports and the good bolting practice manuals. It was stated in the letter that they were encouraged to refer to those reports as a basis for -- to those reports, and those reports provide the industry's technical basis for the resolution of Technical Issue 29. That's NUMARC's position; that they endorsed the EPRI reports.

MR. SHEWMON: They sent people a notice and said, hey, this EPRI document is out. Maybe you should get it for your library. Did they do something more than that?

MR. CHANG: That's all they did, just to issue a letter informing them that those reports were issued.

MR. BAER: We were not given a copy of the letter but T.Y. went down to the Numarc offices and I believe from your notes -- didn't you say the words were that licensees were encouraged?

MR. CHANG: Encouraged to refer to those reports. They said the reports provided the industry basis for the resolution of 29.

MR. SHEWMON: Fine.

MR. CHANG: Okay. That concludes my presentation.

MR. SHEWMON: Okay. Let's talk a little bit about what you were saying, Jim, earlier.

I went back and asked Dick Johnson if the discussion of programs and exceptions was something that was finished and he said, no he wasn't the only one that was going to talk about that. So, could you tell me briefly what is or isn't coming yet from the agenda or that differs from the agenda we have in front of us?

MR. BAER: I think -- my understanding is that Jim Davis will be talking about a survey of industry failures in degradation, and then I plan to speak briefly about the proposed resolution and really give that last slide.

MR. SHEWMON: Okay. What about this item that says "discussion of programs and exceptions taken by NRC staff." Dick's covered it?

MR. BAER: Dick's covered that, as part of his presentation. Those were the exceptions to the -- or qualifications to the EPRI program that he was discussing.

MR. SHEWMON: Fine. Okay. Well, let's take a 15-minute break now and then we'll come back to whatever.

[Brief recess.]

MR. SHEWMON: Who's next, Jim Davis?

MR. BAER: Jim Davis.

MR. SHEWMON: Okay.

[Slide.]

MR. DAVIS: I'm going to give the NRR staff presentation on this issue.

[Slide.]

MR. DAVIS: The outline -- I'm going to just touch briefly on 2 of th more common types of bolting failures; boric acid corrosion, just very briefly, and stress corrosion cracking of high hardness materials.

Then I'll give the safety significance of Generic Issue 29 and then the NRR proposed action plan.

[Slide.]

MR. DAVIS: The first incidence of boric acid corrosion occurred in 1968. The latest occurrence is in 1989. So, it is a problem that is continuing. Basically, it's corrosion of carbon and low alloy steel caused by leaks from the pressure boundary system. Those are containing borated water. But if you go to a stainless steel-type of bolt, the corrosion doesn't occur, but the strength isn't sufficient for the intended bolting purpose.

MR. SHEWMON: Now, there was a case down in Florida a few years ago, where -- I don't know -- an awful lot of boric acid accumulated by the pressure vessel and after that, people were supposed to come, go around and look for such things more religiously than they had before. Does this '89 event indicate that they'd been doing that and that's why they found it or that they hadn't been or do you know?

MR. DAVIS: I think they've been doing a better job of looking at the problem. But it still does exist. These are below code leak rates in many cases, and they are trying to detect these leaks, but they're not completely successful.

MR. SHEWMON: Okay.

[Slide.]

MR. DAVIS: Stress corrosion and cracking of high strength stainless steels. Basically, the problem started with 410 stainless steel valve stems and valve internals where the 410 was tempered at too low a temperature, it was too high a strength.

17-4 PH stainless steel shows similar behavior. This is also true in sea water in high-speed ships and things of that type. I've run into this problem before as well.

With proper tempering, temperatures are for 410 stainless steel 1125 to 1350; and for 17-4 PH stainless steel, above 1100. I think this is being followed pretty religiously at this point.

Also, you need to avoid contact with copper, sulfides, chlorides, fluorides and boric acid.

All the anchor darling valves have been inspected because that design of valve contained very high hardness 410 stainless steel.

MR. SHEWMON: 410 stainless steel has also given problems [illegible] pumps, hasn't it?

MR. DAVIS: Yes, I believe so.

MR. SHEWMON: But that isn't a bolt, and so, it doesn't ever come under this question you're talking about.

MR. DAVIS: It doesn't come under this specific one.

[Slide.]

MR. DAVIS: The safety significance is that bolting and structural applications can be very highly loaded under faulted and/or accident conditions.

Degraded, loose, or missing bolts may result in a system failure. Bolting with manufacturing defects may cause system failure.

There's a situation right now on broken ice condenser U-bolts. They were defectively manufactured. They had quench cracks in them.

They have been in service for quite a number of years, and we're still seeing some failures of these bolts. Some of it is weighing of the ice baskets.

They twist the baskets to break the ice away before they weigh them, and cracks tend to propagate. They look like they may be hydrogen cracks.

We're looking at some of this right now.

Each basket has two U-bolts, and if both bolts would happen to fail on one unit during a steam accident, the basket could become a missile and be ejected into the containment.

MR. SHEWMON: Were the bolts tempered properly? The hardness was okay. It was just there were quench crackings?

MR. DAVIS: Yes.

What happened was they substituted 1541 for 4140 when they manufactured the bolts originally, and if you water-quench those bolts, they will develop quench cracks, and then they're cadmium plated, and some of the spares have been examined, and there was cadmium plating in the cracks. So, they were definitely quench cracks.

There have also been some occasions of hydrogen cracking. There was a lot that occurred in the first two years of service, which is what you would expect. But they've been in like 17 years now, and we're seeing more hydrogen cracking, and it appears to be corrosion from a fracture surface that introduces the hydrogen, and then when they twist the baskets to break the ice away, the cracks will propagate a short distance.

Counterfeit bolts: This has been touched on already.

From a small sample, no counterfeit bolts were found, but 10 percent of the overall population were out of spec, and 1 percent were seriously out of spec, and there's a large number of bolts out there.

MR. SHEWMON: Jim, one of the problems which was more spectacular but may be relatively unimportant in number was very large bolts which were off-strength or too strong, and these were often somewhat bigger bolts.

If you looked at the ASTM inspection procedure, you can inspect one 1,000, but they were heat treated in batches of two dozen or something.

So, if somebody screwed up in the heat treatment once, the batch could go through and completely miss a quite proper inspection, proper in the sense that it met the ASTM spec.

MR. DAVIS: Yes.

MR. SHEWMON: Does anything in the new procedures talk about a more frequent inspection of high-strength bolts?

MR. DAVIS: I'm not sure about that. That's one of the things we would like to see, but it's not resolved.

MR. SHEWMON: A hardness test would do it.

Okay. Go ahead.

MR. DAVIS: There's no -- prior to this point, there is no receiving inspection on bolts, where you would -- like in aerospace, they get a little ridiculous and inspect half of maybe the incoming material.

Here, there is no real incoming inspection. I think that's part of the program.

MR. BAER: One of the generic letters -- I have to refresh my memory on the number -- did require licensees to establish a continuing program.

It isn't a large -- I don't think they're required to have a large sample, but I think they are now -- I think most of the licensees have committed to doing some receipt inspection.

MR. DAVIS: And our Receiving Inspection Branch is issuing a generic letter.

MR. SHEWMON: I was looking at something about -- in the specs in some of this information you sent us, it was so many -- once or twice -- so many per heat; that a heat, as I understand it, is sort of whatever came out of the furnace as a liquid metal all at the same time and has nothing to do with the heat treatment.

MR. DAVIS: That's correct.

MR. BICKFORD: The ASTM is, I believe, changing the requirements to increase the numbers that have to be tested, but still probably not enough to catch them if they're only heated 12 at a time.

MR. SHEWMON: Yes. Okay. Thanks.

MR. DAVIS: That's a problem in industry, in general. If you're making 80,000-pound heats, then you do one chemistry check, one hardness check.

You know, that's really not enough.

MR. SHEWMON: Yes. Okay.

Onward.

[Slide.]

MR. DAVIS: A given type of bolting may even be used on a number of components, and this is in relationship to the Anchor Darling valves, where a very large number of valves were constructed with overly-hard 410 stainless steel, and when one failure is found, then it's important to look at all similar equipment.

MR. MICHELSON: Why were they using 410?

MR. DAVIS: Internally.

MR. MICHELSON: Oh, these were the internal bolts.

Okay.

MR. DAVIS: Internal bolts.

MR. MICHELSON: Okay. Thank you.

MR. BAER: Now, a bulletin was issued on that, and all the licensees were required to look at not only Anchor Darling but some other valves, also.

MR. DAVIS: Any similar valves.

The Anchor Darling seemed to be the only ones that had the high hardness 410 stainless steel.

Then just a general comment: Severe general corrosion of bolts caused by a leak could result in unzippering. As far as I know, this has never occurred.

MR. MICHELSON: Now, you looked at the EPRI analysis of unzippering, I assume, in this EPRI Report 5769.

MR. DAVIS: I haven't in detail.

MR. MICHELSON: Beg pardon?

MR. DAVIS: I haven't.

MR. MICHELSON: Well, I just wondered, because it didn't seem to me that they concluded unzippering was credible, and I just wonder why -- where I missed the boat. Or did I misinterpret their conclusion?

MR. BAER: I think their conclusion was that it wasn't credible. That's why they were proposing this leak before --

MR. MICHELSON: Yes, because it wasn't credible to unzipper. You could get a few breaks and get some leaks, but you wouldn't unzipper.

MR. BAER: I believe that's what their position was.

MR. MICHELSON: So, that's why I was a little confused about this bottom bullet here. Somebody else thinks unzippering is credible, I guess.

MR. DAVIS: Dave Sellers, the fellow that retired --

MR. MICHELSON: I would sure like to hear that argument, because it's extremely important to the whole business, whether it's credible or incredible.

MR. LEWIS: Well, I wonder whether somebody could tell me what's meant by the words "credible" and "incredible," because I notice that this says safety significant, says things could happen, and you know, is 10 to the minus 9 credible?

MR. MICHELSON: We're using it in a little more of a simplistic sense.

MR. LEWIS: Well, you know, 15 or 20 years ago, the NRC did use the terms "credible" and "incredible" to distinguish and sort of got out of that habit, and we got into the probabilistic world.

MR. MICHELSON: Well, it's whether it's a design basis now or not.

MR. LEWIS: But that's a regulatory statement. It has nothing to with probability, safety significant.

MR. SHEWMON: He has said something about the credibility by saying he knew of no case of it ever having occurred.

MR. MICHELSON: But the bullet says it could happen.

MR. SHEWMON: Well, one can conceive of it. You did. Dave Sellers did.

MR. MICHELSON: But EPRI doesn't.

MR. LEWIS: Well, no. I [illegible] they're consistent. That's my problem with the statement.

MR. MICHELSON: I'll withdraw my statement.

MR. LEWIS: I wanted to press your point.

MR. SHEWMON: Go ahead.

[Slide.]

MR. DAVIS: I want to get into the Generic Issue 29 NRR Action Plan.

I did an LER search and I'll discuss what we found there through a contract with Oak Ridge. Looking at receiving inspections, and that's been handled by the Vendor Inspection Branch, and they will be issuing a generic letter very shortly on incoming inspections what we talked about Paul about how many inspect, so they will be handling.

MR. SHEWMON: This is from a few plants who do indeed do receiving inspections or whose receiving inspections were these that you're --

MR. DAVIS: This is a generic letter asking what -- suggesting what a receiving inspection everything they should be doing, and that includes bolting.

MR. SHEWMON: Let me back up. The LER search is something which Oak Ridge is going to do for you.

MR. DAVIS: They have done for me.

MR. SHEWMON: Okay. Now, what about McIntyre? Has he done something on receiving inspection for you?

MR. DAVIS: He has the generic letter an final drafts about to be sent out. It hasn't been finalized yet. I've seen a copy of the draft -- I haven't seen the final generic letter, and it may be --

MR. SHEWMON: And that would require people to do a safety inspection or to send you information, if they happen to have one or what?

MR. DAVIS: It's for receiving any -- any purchase that the licensees do. They have to describe what type of income inspection they do.

MR. SHEWMON For bolts only?

MR. DAVIS: For everything, including bolts.

MR. SHEWMON: We've done a cost benefit analysis and we're sure we're going to send that one out as a generic -- or as a requirement?

MR. DAVIS: I'm not sure.

MR. SHEWMON: Okay.

MR. LEWIS: Am I allowed -- am I allowed to ask a really stupid question? I discovered the hard way last week, in my American-made car, that one of the bolts in it was a metric thread. I wondered to what extent mixtures of different disciplines exist in nuclear power plants. That is, do we have, as we have ni the rest of the world, a mixture of metric and English threads floating around?

MR. DAVIS: It is my understanding we have all English threads.

MR. LEWIS: All English?

MR. BICKFORD: I think you would find that the only industry in the U.S. that uses metric threads is the automotive industry, and they've gone to them across the board.

MR. LEWIS: Not in my car.

MR. BICKFORD: Really?

MR. LEWIS: Yes, my car is all English threads except for this one --

MR. BICKFORD: Is that right?

MR. LEWIS: -- God damn bolt.

MR. SHEWMON: Just to prolong the discussion, I have a neighbor who is responsible for the stockroom in a large Chevy dealer in Columbus and he has said that General

Motors has gone back and forth and that their mechanics bitc[illegible]ase they have to have both sets of wrenches, or depending on which year it was they had for that car.

MR. BICKFORD: That can't be true because all wrenches are English systems, even metric wrenches are in English units surprisingly enough -- you've got a one-inch socket set and so forth and so on. Then they have, of course, different nuts and stuff. But the -- we -- we do a lot of work with the automotive and they certainly -- they heavily use metric. Maybe they don't use them across the board, but I wouldn't think you would find that to be a concern at all in a nuclear plant environment.

MR. LEWIS: Well, the -- I asked for a reason other than my car, because there was an accident in Ohio, I think, in which some tritium got released because somebody pulled the wrong thread bolt out of a box and jammed it onto something. That happened last year. So, the potential for that kind of --

MR. BICKFORD: But, the wrong thread was metric as opposed to English?

MR. LEWIS: Well, the thing I had -- I seem to remember that, I won't swear to it. In my car, I can tell you that a 10 millimeter nut can be jammed onto a 3/16th's-inch bolt.

MR. BICKFORD: Oh sure, yes. The reverse is not necessarily true. Course versus fine pitch in things can -- in English systems, you know, there are other things to mis-match threads and things.

MR. LEWIS: 3/8th's 16 is an approximate match to 10 millimeters, 1&1/2 millimeter pitch, I can tell you.

MR. BICKFORD: Large millimeter bolts are really not available in this country yet. So, I wouldn't think it would be a problem. There are some, let me see.

MR. SHEWMON: Onward.

MR. DAVIS: The next step then would be the generic letter to assess the industry implementation of the EPRI bolting manuals, what would be the purpose -- the proposed NRR action. Finally assess the need for future action.

[Slide.]

MR. DAVIS: We had previously done a search to -- of LERs up to 1984, so this one was 1984 to September of 1990. There were 349 incidents reported. The most common ones were stress corrosion cracking, boric acid corrosion, vibration and loosening of the nuts, loose nuts due to improper or no torqueing instructions, missing bolts as a cause, improper, no installation or wear inspection requirements, improper design of material and counterfeit bolts.

MR. MICHELSON: Now, in the 1984 to '90 time frame, how many events do you think would have to have been reported under the LER reporting rule?

MR. DAVIS: Well --

MR. MICHELSON: In other words, what fraction of all the failures and all he screw-ups and so forth are you looking at? Do you think you're looking at 100 percent? Do you think you are looking at 5 percent?

MR. DAVIS: It's hard to judge.

MR. MICHELSON: Because the LER rule didn't any longer zero in on individual little events like a broken bolt, it had to have a lot more criteria to be met before a report was issued.

MR. DAVIS: Yes. Most -- in most cases, there was --

MR. MICHELSON: A lot more associated.

MR. DAVIS: -- something else that occurred to --

MR. MICHELSON: But on the day somebody found a corroded bolt, there wasn't an LER necessarily written?

MR. DAVIS: That's right.

MR. MICHELSON: I just wonder what fraction of the incidents -- how many more incidents were there of corroded bolts that didn't meet the LER reporting criteria?

MR. DAVIS: Werer t you saying something like 30 percent of all LERs have some type of a bolting issue?

MR. MICHELSON: Yes, but how many more bolting issues are out there that didn't even get reported? You have to look carefully at the LER reporting requirements --

MR. DAVIS: Yes.

MR. MICHELSON: -- and then make a judgment as to -- I think you're looking only at the tip of the iceberg --

MR. DAVIS: I think you're right.

MR. MICHELSON: -- under the LER part, at least.

MR. DAVIS: I agree with you.

MR. BAER: Well we -- I'm on the distribution list for results of in-service inspections and pass those on to Frank Cherny and Dick Johnson. They've observed that a lot of the Section 11 inspections do come up with some degraded or problems with the bolts and again, it's -- it gives us 2 possible interpretations, that the ASME inspection system is working and they're finding these problems and fixing them. We've seen no catastrophic-type failures over the years or you could say this is the tip of the iceberg, they don't have to inspect all the bolts all the time.

But they are finding, you know, some -- some defective, you know, corroded bolts, and they seem to be taking care of them, certainly the ones they find.

MR. MICHELSON: Now how many -- but that's under Section 11; but if I just experience a leak and I go there and I find a degraded bolt, that leak and that degraded bolt do not necessarily meet LER reporting requirements; they don't meet Section 11 reporting requirements either, do they? Because I wasn't doing a Section 11 inspection at the time, I just had some water release and I went there and found what the problem was and fixed them.

So I don't think even Section 11 reporting will show you what the picture is. But, it may be that these are very good indicators, I just don't know.

MR. JOHNSON: They'll report it if that leakage results in some degradation of something, even if it is a degradation of one of the studs or bolts, it will get reported, I'm reasonably sure.

MR. MICHELSON: You mean the LER reporting requirements prescribed?

MR. JOHNSON: I don't know that it will be reported as a LER, it may only be reported to a resident inspector.

MR. MICHELSON: Oh, yes. Everything is documented. If they find a degraded bolt, I hope they document it somewhere in the plant records.

But, I'm just wondering what these kinds of studies really tell me.

MR. JOHNSON: All right. Somebody has got to pass a judgment as to how bad it is, whether it gets into an LER or not.

MR. DA IS: I agree with you. I think there are more than what come up here.

MR. SHEWMON: I think the critical question is -- what you've got is types of incidents here and whether we have missed any types of incidents. I think that's different than whether you've got a reflect.on of the total number.

[Slide.]

MR. DAVIS: Here is the trend that I saw. And remember, for 1990, it's only three quarters of the year, in the reported incidents. So it seems to be fairly constant. Slight variation year-to-year, but not all that much.

[Slide.]

MR. DAVIS: The NRR proposed schedule then would be to prepare the draft generic letter by the start of February; do a internal management review to see if we're going to issue it, and that would be in March; meet with CRGR in February; and issue the generic letter in May; and then in September review the responses; and then determine future action in mid-September.

MR. SHEWMON: I've got something in my notes which doesn't quite fit with that, but I got the impression from what I read -- would you comment on it? -- we could resolve the issue now or nine months from now, NRR would like to watch things for nine months and then declare victory if they think it's appropriate. Is that the resolution?

1

IMAGE EVALUATION
TEST TARGET (MT-3)

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MR. DAVIS: I think what we would like to do is issue this generic letter and see what people are doing, not necessarily the EPRI program. Just find out what the plants are doing on bolting, that they have some plan for inspection for the whole bit.

MR. SHEWMON: Okay. So the positive action would be to write a letter which they would have to respond to.

MR. DAVIS: That's right.

MR. SHEWMON: And then see what their response was.

MR. DAVIS: Yes. See what they are doing, if they're looking at the EPRI manual or some similar program.

MR. MICHELSON: That's a different generic letter than proposed by Research.

MR. DAVIS: Right.

MR. MICHELSON: But both generic letters would not go out. Research's would be canned in favor of this NRR; that would be your proposal?

MR. DAVIS: Yes.

MR. MICHELSON: Is that right?

MR. DAVIS: Yes.

MR. MICHELSON: Only one generic letter goes out.

MR. BAER: It would be either/or.

MR. DAVIS: Right.

MR. MICHELSON: Okay.

MR. DAVIS: That's all I have.

MR. SHEWMON: Thank you.

[Slide.]

MR. BAER: I have one final slide that talks about the proposed resolution and the choices. Some of this we've already gotten into.

When we evaluated this issue in Research, our regulatory analysis proved to be inconclusive regarding justifying a mandatory requirement or program on safety-related bolting in operating plants. And that is, our analysis did not indicate that the risk and cost-benefit met both of the tests of the backfit rule. We discussed in our reg. analysis that we looked both at the reactor coolant system pressure boundary bolting and then we looked at the risks associated with bolting outside of the reactor coolant pressure boundary. And the results were rather inconclusive.

MR. SHEWMON: The basis for this is that there's a fair amount of redundancy and reasonably good experience; is that the basis?

MR. BAER: Yes. In parallel, Dick Johnson has kept all the applicable LERs over the years, and I know for the last four years since I've headed the branch, I've been on the distribution list for LERs and I get them all and I pass them on to Frank and Dick and T.Y., if they are associated with bolting. And we haven't seen any "smoking gun," so to speak, or any indication of anything that looked like it was a major precursor to the kind of core melt probabilities that are needed to show a risk that would justify a specific action.

That's not to say that we don't think bolting is something that deserves a fair amount of attention. It is a highly judgmental subject.

MR. MICHELSON: How do you conclude that there is no change in core melt probability when you don't model these bolts into the PRAs that lead to these conclusions? How do you draw that conclusion?

MR. BAER: Well, in the case of one cost-benefit analysis that was done a few years ago, by PNL, were they looked at the reactor coolant pressure boundary, they did make an estimate based on bolting failures of what the probability of core melt was due to bolting failures in the reactor coolant system.

MR. MICHELSON: Outside the --

MR. BAER: No. Let me talk about it a piece at a time.

MR. MICHELSON: Okay.

MR. BAER: And their numbers, if I recollect correctly, we talk about it in the reg. analysis, were in the range of 10 to the minus 6th, 10 to the minus 7th core melt probability.

We looked, in a separate cost-benefit analysis, at bolts outside, beyond the reactor coolant pressure boundary. And the conclusion was that the risk was associated with seismic events and the emergency power supply.

In other words, a seismic event had a fairly high probability, approaching one, for a severe seismic event, or knocking out offsite power, and that the failures then of anything associated with the onsite power system would then have a significant risk. And that was a fairly quick look at this problem. And it did show a risk of onsite emergency power.

But when we looked at what was being done already on A-46, which treats pretty much the same set of concerns, it didn't seem like there was much else that we could define that we could require licensees to do.

My boss, Warren Minners, kept asking us what exactly would you want licensees to do, beyond what is covered in generic letters and what is covered in A-46? And we were having trouble identifying anything that would be risk-significant.

MR. MICHELSON: Is A-46 requiring that they look at the bolting on flanges that might release water?

MR. BAER: No.

MR. MICHELSON: I didn't think so. So what's A-46 got to do with flange bolting failures, for instance? Nothing, I don't believe.

MR. BAER: I think the water intrusion question is one we --

MR. MICHELSON: Yes, it's an internal flooding question. Internal flooding is poorly treated in the PRAs already, and it gets back to your conclusion that the PRAs seem to indicate that this is not a big contributor to core melt.

Well, if it's not in the model, of course, it won't be a big contributor.

MR. BAER: As I said, the focus was on the emergency power systems, which are included in A-46.

MR. MICHELSON: Yes. But they may be flooded by such pressure boundary failures outside of containment. I don't know. As it is also potentially possible for the emergency power to be jeopardized, depending on where the pipe is and so forth, and the size of the leak.

I don't think these are in your PRAs. I don't think you can draw PRA conclusions about these kinds of potential hazards. You have to do it some other way. A-46 could do it, but I don't recall that it was in the prescription to do it.

MR. BAER: The A-46 focused on the seismic event and talked about ways of achieving safe shutdown.

MR. MICHELSON: A-46 chose to even ignore the release of water from non-seismic tanks that were dumped on the floor. So that's as far as A-46 went.

MR. BAER: Not quite.

MR. MICHELSON: Yes, we on't go through it again; but you remember the long arguments on that one.

So I couldn't find the basis to believe that this was a non-significant contributor outside of containment. It could be. But I haven't seen your basis.

MR. BAER: Well, unfortunately the test that this committee and CRGR applies to us is not that we show that it's not unsignificant, insignificant, but to show a risk, credible risk that is significant.

MR. MICHELSON: Yes. And to do that, you have to model it into a PRA; and I don't think you've been modeling it into a PRA.

MR. BAER: We haven't seen any of these events in better than 1,000 reactor years, as a starting point. And that's as an initiating event. And then you have to find a sequence where this initiating event leads to a core melt with a reasonably high probability, then, if the initiating event is something 10 to the minus 3 per reactor year or less.

MR. MICHELSON: You've already seen the precursors of what happens when you release even modest amounts of water outside of containment. You've seen plenty of LERs of what happens to electrical equipment and so forth. And I don't have to have a catastrophic failure of the flange. A good, big break might do it very well.

MR. BAER: Yes.

MR. MICHELSON: And these aren't included, these are not included in pipe breaks outside of containment. They only look at pipes and not at the flanges and not at the bolted closures. They don't even look at bellows.

MR. BAER: The resolution of A-17 asks licensees as part of the IPE program -- more than asks, I guess requires them -- to explicitly look at water intrusion into --

MR. MICHELSON: A-17 hasn't done anything yet. All you're trying to do now is to prioritize whether it is a problem or not.

MR. BAER: No, no, no. A-17 is done.

MR. MICHELSON: Well, yes, it's done. It moved it over to a prioritization process.

MR. BAER: No, but all licensees are required to perform this individual plant examination. And one of the things specified in that is water intrusion problems from internal sources.

MR. MICHELSON: From failure of bolted closures?

MR. BAER: No, just in general.

MR. MICHELSON: Okay.

MR. BAER: But the sources we've seen aren't so far from bolted sources, failures. We've seen them from overflowing johns, and other places.

MR. MICHELSON: You seen them from a lot more serious things than overflowing johns.

MR. BAER: No, that one was a fairly, I thought, significant one. It shows how subtle the paths can be. And that is a worry.

But all I can say is we started off, frankly, with a prejudice that we ought to be able to take some action. And we could not convince ourselves and our management that we had a basis for, quote, "requiring" some actions.

Both Research and NRR agree that with some qualifications and exceptions that Dick Johnson spoke to that the EPRI recommended program would be an appropriate resolution.

The question or the major concern is really not with the, in our minds with the technical aspects of their proposed program, but whether or not licensees are implementing this across the board. I think that is where we and NRR have --

MR. SHEWMON: What's NRR's basis? They have a different set of rules or --

THE REPORTER: I'm sorry, could you please speak into the mike?

MR. SHEWMON: Well, Baer would kind of like to know what they are doing too but he doesn't see a basis for requiring that they tell him.

MR. CHENG: Our proposal is not general -- you know, general is just --

MR. SHEWMON: You know, volume is not our problem in understanding you -- so, thanks.

MR. CHENG: C.Y. Cheng from NRR staff. The proposed draft, you know, general data, is just -- we want to know how the licensee is implementing the EPRI guidelines. We want to know that before we decide to cross out the generic issue 29. That's the whole focus.

MR. SHEWMON: And you don't see a problem with getting CRGR to approve that?

MR. CHENG: We don't know yet. We haven't come to the management. Right now the management's thinking is that, yes, we are going to issue a generic -- draft letter, general data, to find out whether the licensee is following the EPRI guidelines or not.

MR. SHEWMON: Fine, okay.

MR. BAER: Research certainly wouldn't object to finding that out, whether a letter can be written that's information gathering and get through the process or not I guess remains to be seen.

I do want to point out that regardless of what action we take on GI-29, that the licensees are committed or will continue to be committed to the actions necessary in response to the bulletins and generic letters that have been issued. That also is another factor, as I said in my introduction as to why we found this a tough, tough issue is that as each of the concerns have come up, actions have been taken by generic letter or bulletin so the residual problem seems to constantly being reduced.

Jim Davis talked about the Anchor Darling check valve problem. You know, that's a very recent example of where a problem was identified and immediately an action was taken and so the residual problem, as I say, it's hard to find much of a residual problem that one could point to with any specifics.

We are proposing in research and have sent this over to NRR as part of our package some ideas on a SRP section to be developed for future plants. This would be largely to codify existing requirements and assure good design and installation in the review of future plants on bolted connections.

The proposed generic letter that Research has developed and put in a draft in the package we sent to you, and I think this is already clear from the discussion, informs industry of the EPRI efforts. It would have our

NUREG-1339 as an attachment with a discussion of the exceptions and qualifications that we think ought to be included in a bolting integrity program, suggests that industry, that individual licensees, develop and implement such a program but does not require a specific answer or an action.

As we've discussed, NRR is proposing to develop a 5054(f) type generic letter for issuance to the licensees and in the last bullet -- slide it up high enough for everyone to see -- we're seeking some advice and guidance from this committee on this matter.

That concludes my presentation.

Are there some questions?

MR. SHEWMON: Any questions?

[No response.]

MR. SHEWMON: Could you go ahead before lunch, John, instead of right after lunch?

MR. BICKFORD: FIne.

MR. SHEWMON: Fine.

MR. BICKFORD: Okay, you can hear me? I am turned on?

MR. SHEWMON: Yes, I think so.

MR. BICKFORD: Okay.

MR. SHEWMON: Whatever turns you on, John!

MR. BICKFORD: Whatever turns me on. Well, let me just start, since I haven't met most of you yet, let me just start by giving you something very quickly of my background in the nuclear bolting issue so that you'll know where I am coming from here.

My background is definitely not the nuclear industry. I have been involved for a number of years in bolting in general with an emphasis on the assembly, control of the assembly process, why you want good assembly, what happens if you don't get it, so forth and so on, bolted joint failure modes, if you will, and so forth.

I am active with the -- have been for many years active with the pressure vessel research committee, am Chairman of their task group on elevated temperature behavior bolted joints.

I am Vice Chairman of the Research Council on Structural Connections and a member of the Industrial Fastener Institute.

I was involved as a consultant with the AIF/MPC EPRI business that's been talked about so much here and at the conclusion of the AIF/MPC thing I was asked by Ed Merrick and others to set up a group that would perpetuate this activity, if you will, and so I founded and until last year was Chairman of this Bolting Technology Council thing which has been mentioned.

I wrote about 75 percent of this Good Bolting

Practices Manual you have seen and I defined the content of the three videotapes that have been discussed.

I think my most significant involvement however in this issue was that I was recruited by the ASME Operation and Maintenance people in response to a pressure I believe from Mr. Jordan and others at the NRC to become chairman of a working group on bolting to define, if you will, the bolt -- generic bolting problem and to suggest what else should be done about it.

I chaired that group for its entire existence, which was as I remember two, two and a half years sort of a thing.

I would like to start by telling you what the conclusions of that group were and showing you some slides that I prepared for presentations to the ASME because I think there is some discussion here at least as to what the problem is.

I think you could define the problem as we saw it as being the failure or potential failure of safety-related bolted joints of all kinds to perform their intended functions in a nuclear power plant.

This involved joints in the pressure boundary or component supports which is what the AIF/MPC has focused on. It could also involve electrical connections, valve actuators, and so forth and so on, so that the problem as we defined it went beyond that which the AIF/MPC had done.

Things like changes in bolting materials to avoid stress corrosion cracking, avoidance of moly and other types of lubricants which led to stress corrosion cracking -- these things had already been taken care of and so that the remaining work if you will for the working group was really to deal with the whole issue of miscellaneous bolting problems and assembly practices.

[Slide.]

MR. BICKFORD: Now in the pass-outs that I have given you, you have in the first two pages a flow chart that I developed for presentation to the Operation/Maintenance people which attempted to define the problem and the cause and effect, if you will.

The thing that we were concerned about it seemed to us was radiation released which might be caused by a large or small LOCA or to damage to components which would prevent a smooth shutdown in case of an emergency or just in general.

None of those things had been actually reported. We started incidentally with a two inch deep thick pile of computer printouts on safety-related bolting incidents that had been given to me I believe by Richard Anderson -- yes, Richard Anderson, so anyway, we were generating this information from safety-related reports from the operating plants.

These things as far as our committee work was concerned, LOCAs and so forth, might have been caused by either simultaneous failure of several bolts -- in other words a joint failure, unzipping as has been talked about, or loose parts in the system and those things might be preceded by the rupture of individual bolts or the loss of individual bolts.

Now loose parts in the system had been observed and were reported. Rupture of individual bolts had been observed and reported. Loss of individual bolts had been reported. Simultaneous joint failure had not been reported.

I think it might be pertinent to say that some time after this work I was approached by Tampa Electric Company to be an expert witness in a trial. I refused this. I was a Vice President of a company and they didn't want me to get involved in this kind of thing -- we weren't consultants -- but this involved the total failure of a joint. I believe it was in a heat exchanger in a conventional power plant.

The problem was that the joint had been sealed with Fermanite, which had trapped corrosive materials and so forth inside this thing and the joint just suddenly exploded and one person I believe was killed and so forth and so on. That is the only incident that I am aware of in

20 years of bolting where a pressure vessel joint has failed catastrophically like that.

Many times leaks, many times partial failures but never -- that's the only incident I know of, of that kind.

So the rupture of individual bolts might be caused by any of the normal mechanisms of failure that we see for bolts and all of these were reported. The locations in which they were reported are listed underneath them.

Corrosion wastage, boric acid and so forth and the reactor closure pressure, steam generator manways and so forth and so on, stress corrosion cracking, hydrogen embrittlement, fatigue, mechanical failure and self-loosening; so all those things were reported.

These were the essential conditions for those kinds of failures. There are only three or four essential conditions for each one. More important, as far as the safety related reports were concerned, a whole number of things were listed as being possible contributors to that problem.

For example, as far as stress corrosion is concerned, they felt -- some operators felt that the material was not as specified or it was a poor choice of material or wet or humid environment, use of moly or joint sealants, unnecessarily high preload and so on and so forth. Those were some of the things that were fingered for the failure.

MR. MINNERS: On the previous slide were hydrogen, embrittlement and self-loosening of fasteners reported?

MR. BICKFORD: I don't remember any single incident of hydrogen embrittlement being reported. I would, I believe, have put down the location if they. Nor do I remember any self-loosening in that pile of safety related reports.

I noticed that they were both listed on this more recent summary of -- more recent, 1984 to 1990 events.

[Slide.]

MR. BICKFORD: This was a tabulation, again, I did for them on the location of problems, number of reported incidents. Perhaps it's more meaningful to put it sideways like that.

The most common source was in valves. Incidentally, I'm talking here about approximately 180 incidents, I believe, if I'm not mistaken, over about a three year period. Valves, anchors and supports, diesel generators, pumps and so forth and so on, including instruments and switches, manways where the stress corrosion thing was big, was a relatively small percentage of these things.

MR. SHEWMON: Before you leave that one, I'm interested in loose bolts.

MR. BICKFORD: I'll go on to the next one. I may have done these in reverse order. Sorry.

The reasons for failure were these, and these are not necessarily mutually exclusive. If you count the number of incidents and look at the reasons for failure, you'll find more reasons for failure because some people may say, well, I had loose bolts and that led to stress corrosion cracking, in my opinion.

What these were were the opinions of the operators as to what had caused the concern or the failure of the individual bolt or the leakage or what have you. We have loose bolts, improper installation, joint leak, fastener self-loosened and corrosion involved. All those things may mean that we had a leaky joint and we think that why it leaked was that the mechanic hadn't done his job or we had vibration loosening or something.

I'm sure, from the reports as I remember them, that this was pretty much of a guess. Nevertheless, there very definitely were loose bolts in the system. As to why they were loose, that would probably take a more stringent analysis than I think was probably made.

Improper design was blamed, broken bolts unexplained, stress corrosion cracking and so forth and so on, so again, you're looking at pretty much the whole gamut of bolting problems that the world faces in general.

MR. SHEWMON: What I wanted to ask about was, in answer to the earlier question, you said you knew of no cases of self-loosening, yet you come here and say the biggest single event was loose bolts. Are you postulating that these fell out of a mechanic's pocket in every case, or were they put on and did loosen in some way?

MR. BICKFORD: My guess would be that when you tighten a group of bolts, you have a very intricate situation going on that involves -- we can easily identify several hundred variables. It's a mathematically chaotic situation.

Many of the -- let me also say that the bolted joint, unlike welded or bonded joints, is an energy storage device. It will provide a clamping force only as long as potential energy, in effect, is stored in the bolts. Something there is that doesn't like energy, it tends to dissipate and leak over time or with use or, I think, more very significantly, as you tighten the joint, those bolts which were first tightened, lose some of their preload, their potential energy, when their neighbors are tightened and the joint is further pulled together at that point.

We commonly see in pressure vessel work, ranges in residual preload of 10:1, 20:1, 4:1 and this kind of thing between maximum and minimum. My guess is that the large number of loose bolts that were discovered here were for that kind of simplistic or practical, every day reason.

MR. JOHNSON: Mr. Bickford, if I may interrupt. I recall at least one licensee event report which came through which reported that studs or bolts were loose because of relaxation of the gasket where the licensee had changed from one kind of gasket in the original design to another and the gasket is what relaxed and let the bolts be loose.

MR. BICKFORD: Again, the PBRC has done a lot of work on gasket relaxation and it's our general opinion that this usually constitutes a relatively small percentage, unless you're using a Teflon gasket or something, which are not in this situation.

Again, people mistakenly say when they encounter a loose bolt in a pressure vessel joint, gee, the gasket must have crept because we know that's an elastoplastic thing, whereas, what really happened is that they had these elastic interactions between bolts or things like thermal cycles on a joint will pump some of this energy out of the joint progressively. You've got embedment relaxation and so forth and so on.

There are a large number of phenomena that will give you relaxation and loosen the bolts both during assembly and afterwards. So, I think when you say loose bolts, it's not likely, in my opinion, that many of them were vibration loosening.

MR. MICHELSON: Are these restricted to pressure retaining bolting?

MR. BICKFORD: No, no, sir, these are --

MR. MICHELSON: There are a lot of loose bolts showing up, of course, inside of valve works.

MR. BICKFORD: Yes. Valves were the most common source of the failures, as I said earlier.

MR. MICHELSON: They're loosening, too. Loose bolts have been found.

MR. BICKFORD: And loose bolts on instruments and switch and valve actuators and electrical connections in the line that were going to tell the valve to close or open and so forth and so on. This is the whole gamut of things.

Back to self-loosening, there is not a great deal of vibration in these systems, in my experience, which is, I admit, very limited, but there are thermal cycles and things. Thermal cycles can encourage self-loosening over a period of time, so that is certainly another possibility.

MR. MICHELSON: There's load cycling, of course. In the motor operated valves, there's a lot of load cycling.

MR. BICKFORD: Pressure loads as well as thermal loads.

MR. MICHELSON: No, no, the mechanical loads are cycling.

MR. BICKFORD: Anything of that sort will tend to dump and allow some of the energy that's stored in those bolts to leak out. Okay, so it was decided that since we were dealing with a wide variety of bolting problems, that what was needed was an improvement in the assembly practices in these plants.

As I say, changes in material and so forth had already been addressed. Considerations such as leak-before-break, which I am certainly not prepared to discuss, were design issues and that had been addressed by the AFMPC and EPRI and so forth. Therefore, our mission, my mission was to do something about the assembly practices.

It was already known at this point that older plants had significantly less trouble with bolted joints because of improved experience. Bolting is very much an empirical art and experience matters more than anything else you can do. This gave us confidence that if we could improve the assembly practices, supervision and training of workers and so forth in the other plants, we could probably make a significant difference.

This was also confirmed, if you will, by my company's work. At one point we did fuel bolting services using ultrasonic measurement of bolt tension and so forth, and it had been our general experience in petrochemical and other industries, that supervision and operator training made more difference towards reducing bolted joint problems in that kind of an environment than did better tools, for example, or fancier practices or changes in materials and changes in preload.

You just wanted those guys to know that what they were doing was important and how to go about it.

So, we prepared these Good Bolting Practicing manuals. The large bolt one came out first and it is virtually identical with the small bolt manual.

The reason for 2 manuals was that EPRI decided that people who were dealing with things electrical connections would never get to see the manuals being used by people who were dealing with reactor pressure vessels, and therefore, they needed 2 manuals.

There were also issues like set screws, bolting, small boltings, little screws and that sort of thing, and again, electrical connections, different materials and so forth, which made some differences between the 2 manuals.

MR. MICHELSON: What's the difference between -- where's the break point between small and large.

MR. BICKFORD: Yes, generally speaking, about an inch I think.

MR. MICHELSON: Inch diameter of the bolting?

MR. BICKFORD: Yes.

MR. MICHELSON: One inch and up is large?

MR. BICKFORD: I think, pardon -- is large.

MR. MICHELSON: One inch and up is large?

MR. BICKFORD: Right.

MR. MICHELSON: Okay.

MR. BICKFORD: I would think you might say that anything over half an inch is large. I think that the large bolt manual has been used pretty much across the boards.

We also did the videos. There are 3 videos, one for engineers and mechanics, one for mechanics and one for engineers. These were made available to their people by EPRI and as I say, we founded the Bolting Technology Council.

It was recommended that plants -- each plant designate a bolting specialist to -- for example, to implement the video and the manual.

Now, the video and the manual, incidentally, are supposed to be complementary. The video sort of gives it to you in words and show and tell and then the manual is a reference manual to which you can turn when you have a specific problems, it's in an encyclopedic format. If you have a problem with vibration loosening, you go to vibration and see what is recommended to do about it.

Now, as far as the question, did the industry respond properly to our recommendations, I can state very little, because I really haven't been involved since the working group was closed.

Certainly they did not respond to the Bolting Technology Council. This Council, again, was formed at the urging of the AIF/MPC and the MPC became the sponsoring body for the Bolting Technology Council and remains so today. Martin Praeger took that under his wing and provided us with legal assistance and a safe bank and all the rest of the things that you use to set up a professional society.

But of the many people who were involved in the AIF/MPC task group, and there were, as I remember, 30 or 40 different institutions involved, only TVA and Westinghouse ever sent anybody to the Bolting Technology Council meetings. As a result, the Bolting Technology Council was sort of taken over by aerospace and automotive and other interests. Had a hell of a time raising money in the first few years. We're finally doing some research now.

But it has no -- certainly no real ties -- it's general research on how to assemble things, but I don't think it had an specifics dealing with the nuclear industry. The nuclear industry, in effect, did not participate.

MR. SHEWMON: How much do you have contact with either fossil plants or petroleum people who would have comparable kinds of joints and vessels?

MR. BICKFORD: A fairly substantial amount with petrochemical plants and this sort of thing, and very little, I think, with fossil plants.

MR. SHEWMO": Okay. Thank you.

MR. BICKFC D: Again, the PVRC work is primarily oriented around the petrochemical kind of thing. Section 8 of the Code as opposed to Section 3 and so forth.

In addition to this, I have designed and give, once or twice a year, an ASME short course on bolting. The next one is in Los Angeles in a couple of weeks. This has typically attracted a number of people from operating plants each time, so that there is that ongoing contact, but it's pretty informal as far as the work of the AIF/MPC or EPRI is concerned.

The first reports I've ever seen as to whether or not the incidence of troubles has decreased or increased since we theoretically said what should be done and backed off, is this report we had a few minutes ago from Mr. Davis, where he reported 394 incidents between 1984 and 1990.

I would say that that means that the number of incidents that are out there has not changed at all since we addressed this issue. Because we had half that many for a period of about half that length. So, I think the number of incidents is the same and the thing she reported as happening are virtually the same as the things I report here on my list. I think they're -- except for counterfeit bolts, which were not identified or known about in our work, his list is essentially the same.

I don't know what else I can add, but I'll be happy to answer any questions you may have.

MR. SHEWMON: I guess one of the messages that comes through from your part would -- or is that assembly is an important part of this, which gets back to a broader question of maintenance, which we won't get you involved with right here because it's sort of a disagreement between the Commission and the Committee sometimes.

But let me particularize it. If you look through these EPRI documents, do you feel that they satisfactorily address the assembly worker training aspects that you feel or you found were important?

MR. BICKFORD: Yes, we certainly feel that the Good Bolting Practices Manual, accompanied by the videotapes do that, and we have some -- my company has some customers operating plants who have used these things and report on them very favorably and so forth and so on. It's not a complicated thing to do. It's not something you have to get a Ph.D for.

We think that those have been addressed in the EPRI work.

MR. SHEWMON: A Ph.D might well be a disadvantage, but we won't get into that either.

[Laughter.]

MR. SHEWMON: Let me come back though.

You answered a good question. I'm not sure you answered mine.

MR. BICKFORD: Okay, let me try again.

MR. SHEWMON: You said the Good Bolting Practice would be a help?

MR. BICKFORD: The only thing -- the only EPRI work -- sorry.

MR. SHEWMON: Now, my question had to do with these fat EPRI documents, which it's my impression is what everybody has said the industry should use, I'm not sure that this is part of the package which the staff has urged and would like to check on being used.

MR. BICKFORD: It was listed on their slides as being something they are suggesting. Those things in your right hand have nothing in my memory to do with assembly problem.

MR. SHEWMON: Okay. So, we'll get rid of them.

MR. BICKFORD: The only EPRI-sponsored work that deals with assembly is that book and the videotapes.

MR. SHEWMON: And this is part of the staff-recommended program, whether it is mentioned --

MR. BICKFORD: I believe it's mentioned in Mr. Baer's final slide there.

MR. SHEWMON: Well -- Mr. Baer's final slide is very good but it's not deathless, whereas --

MR. BICKFORD: Okay.

MR. SHEWMON: -- something like NUREG-1344 approaches more and it's in here.

MR. BICKFORD: Yes, it's in there.

MR. SHEWMON: Fine, you've answered the question then. Thank you.

MR. BAER: Yes. And it's listed in the generic letter also.

MR. SHEWMON: Okay. Tom?

MR. KASSNER: Yes, I have a concern that I didn't see mentioned in any of these documents and I wonder -- maybe you could enlighten me a little bit. It has to do with the fact that as these nuclear plants age and we have to replace -- or repair/replace major components, such as reactor coolant pumps and some of the large valves, the problem of exposure involved in removing studs that let's say have been in place for 20 years, where we have corrosion in the threads and galling and maybe we don't have the optimum lubricant that was probably adequate for getting the proper torqueing, but as the time goes on, they produce galling.

I was wondering, to the extent that NRC might be concerned about this problem and let's say monitoring how much radiation dose is going to go into this effort of taking care of fasteners and removing them at some time, like now for example in some plants. I'm really concerned about the documentation that might be available to people to expedite these operations -- things that probably could occur maybe in several hours, would probably take weeks or a week to accomplish.

I just wondered if you know about this or did the videotapes address this problem?

MR. BICKFORD: No. Many of these bolting problems do take several days, especially if, as you suggest, the lubricants have migrated and dried up, and so forth and so on. Galling is very common, especially with stainless steels, as you take them out after a long exposure to time and thermal and so forth and so on.

The closest that I can think to something, to anybody addressing that issue, was with the Pressure Vessel Research Committee a few years ago. The suggestion was made that in the work being done on life extension, that they address the bolting issue. And the general response from the people that were chairing that, and I can't even remember their names was that, oh, well, bolted joints, the bolts get replaced periodically anyway as they are found to be corroded and so forth, so we're not going to complicate our lives by worrying specifically about bolts when it comes to life extension. But that's the only thing, and that's not really getting at what your exposure would be why you do these jobs.

MR. SHEWMON: Are stud bolts removed for inspection any time during the 40-year life of the plant, or is it all done in-situ?

MR. BICKFORD: Oh, no. In manways, for example, they are always removed.

MR. SHEWMON: And by "removed," it means they are taken, not only is the manway taken off, but the studs are taken out and put back in?

MR. BICKFORD: Yes. Westinghouse had, I think they probably still have, a procedure where the studs have to be taken out, cleaned, lubricated, installed; the cover has to be installed; the thing has to be torqued to a portion of its final tension; then the whole system has to be taken apart; the studs have to be removed again, relubricated, reinstalled, and so forth. So there can be some very elaborate procedures.

On couplings and turbine shafts and so forth they are sort of forced to replace the studs because they usually gall when the take them apart and so forth. There may be studs that aren't so removed, but most of them, or many of them are.

For example, we were involved in some studs that had failed for stress corrosion at Midland -- which is the plant I was trying to remember the name of, not Zimmer -

- and these were studs several inches in diameter that had failed, after very shorts periods. These were foundation bolts.

MR. SHEWMON: Yes, I'm familiar with them.

MR. BICKFORD: Okay. Heavily loaded, and so forth and so on. And so EPRI sponsored an effort to find ways to detect, ultrasonically, corrosion wastage in large studs.

MR. SHEWMON: In that case, they were too strong, weren't they, and then torqued up heavily, too hard?

MR. BICKFORD: Well, no, they were 4140 studs, so they needn't have been torqued as far as they were. They were loaded to something like 90 percent of yield, which was unnecessary for a foundation bolt.

MR. SHEWMON: Was the yield higher than normal? Some of those plants they did in-situ hardness and found that they were out of spec.

MR. BICKFORD: Midland is where they did 160,000 tests and found only 40 percent were absolutely within spec and the rest were either too hard or too soft.

But I don't specifically remember on the foundation studs. I think the general conclusion was that they had just plain been preloaded more than was necessary and if they could reduce the stress in the bolts, then they would not have failed; and that's how they did it. They put them back in place and retightened them. And we were involved in that effort. We measured the tension ultrasonically.

But EPRI did develop a procedure, rather complicated I'm afraid, for looking at detecting corrosion wastage in large studs, including those several feet in length, because they felt that leakage, modest amounts of leakage, could not be detected, but corrosion wastage could be.

MR. KASSNER: I guess my point was that we will probably see more exposure to people removing these large, four-inch diameter, three-feet long studs than we will from the consequences of catastrophic-type failures, LOCAs and so forth. In EPRI and the industry, I think it would be well-spent if they would put some more effort into documenting how you get these apart, not just degraded fasteners, but if you are removing a large component. Things like that are going on now, and they are having great difficulties with that type of maintenance.

MR. BICKFORD: Yes. There are no really good magic bullets for a large-diameter stud that's galling. That's a tough one. You have to remove it by EDM or something. It's really bad. Takes a long time.

MR. SHEWMON: Okay. Interesting.

Any other questions?

[No response.]

MR. SHEWMON: Okay. Thank you very much.

I'm about to break for lunch. But before we do that, let's look at little bit at the afternoon.

Let's take a few minutes here, because after lunch we have a different topic, namely, erosion/corrosion.

We have this as an agenda item at the full committee meeting. What would you like to see presented there? Carl, what do you think would be appropriate?

MR. MICHELSON: You're talking about corrosion/erosion?

MR. SHEWMON: No.

MR. MICHELSON: The rest of it?

MR. SHEWMON: No, I'm talking about what we're heard of so far. This is the end of the bolting question, and we've got time at full committee on this.

MR. MICHELSON: How much time?

MR. SHEWMON: Two hours, which I think is probably more than one might need.

MR. MICHELSON: That's overkill, maybe.

MR. SHEWMON: Yes.

MR. MICHELSON: Considering the interest range there might be.

MR. SHEWMON: I'd like to hear a summary of the issue. And it seems to me the level of what sort of action there is is something, and there is certainly a question then of whether it's a mandatory letter or a non-mandatory.

MR. MICHELSON: And we don't know the situation, and we haven't seen the other generic letter yet, so we have no way to recommend one side or the other. We don't even know what they're going to talk about in their proposal, the NRR's proposed generic letter. We never received it.

MR. SHEWMON: Is there a chance of seeing the draft generic letter?

MR. MICHELSON: NRR draft generic letter. It doesn't exist yet, does it?

MR. SHEWMON: It's known as a "pig in a poke" in some parts of the country.

MR. MICHELSON: Yes. I'm not even sure it's that.

MR. SHEWMON: You're not even sure the pig is in the poke?

MR. MICHELSON: No. I think it would be important to highlight to the full committee at least the question about how they are treating these leak-before-break considerations outside of containment. The clarification we got I think would be important.

MR. SHEWMON: How they would. Nobody is implementing leak-before-break yet.

MR. MICHELSON: Well, that's not clear. EPRI doesn't seem to exclude it outside of containment. If they clearly excluded it, I would have no problem.

MR. SHEWMON: The way I understood it was that there was a current set of regulations and that there was a code case which would allow them to change this, but that neither the code case or any other basis for change was yet available.

MR. MICHELSON: Well, the staff apparently intends to endorse leak-before-break as identified in this section. But then they clarified it to say no, they really aren't going to quite do that, there will be a number of caveats. And we don't know what those caveats are, because they weren't listed.

MR. SHEWMON: We don't know what the code case is yet, either.

MR. MICHELSON: They can do it without a code case; they don't need a code case. There's no requirement for it.

MR. SHEWMON: Well, they ought to know what they're endorsing.

MR. MICHELSON: Yes.

MR. SHEWMON: And without a code case, I don't see they would know what they were endorsing.

MR. MICHELSON: Yes. I agree with you. That's why I had a question about the basis for their statement on Page 11 of the regulatory analysis in which they endorsed it without basis. That was the whole argument that went on all morning.

So I think this needs to be highlighted, though. And the staff has assured us that they are going to clarify their position on this at the appropriate time, which is a time when either NRR's generic letter goes out or Research's generic letter goes out, because it's not presently in the generic letter. The generic letter appears to endorse the EPRI document, with a few caveats, but doesn't seem to include this caveat. But maybe I'm unjustifiably interpreting the generic letter.

MR. SHEWMON: Yes. It would seem to me that what we clearly want to get is what Research would feel is an adequate or justifiable resolution of the problem, what NRR sees as an alternate resolution. And the question comes, then, how much do we want to talk about what the problem was that drove this?

Do you want half an hour on that or just do you think the committee's level of interest would be that yes, there's been a problem?

MR. MICHELSON: I think one of the things the committee has heard from time to time and may very well raise, and ought to be covered, and that's this unzippering question.

What the committee worries about is catastrophic failure of a bolted closure in a location where we had never considered such a possibility. I think they want to be assured that we still do not have to consider such a possibility, catastrophic failure.

I really heard no basis today on why I should be comfortable that catastrophic failures do not have to be considered.

EPRI attempts to address that in certain respects, mainly on big closures with 20 bolts, and they considered four or five bolts missing and said it's a non-problem. And I didn't have any problem with their analysis. But I'm asking how about small bolted closures with six-inch, eight-inch, ten-inch valves, which doesn't have 16 to 20 bolts, which is designed under a little different set of rules.

MR. LEWIS: Then you have the question of whether you wi- something. Redundancy is always a complicated one. I once owned an airplane in which each wing was held on by a single bolt. And that always astonished people. But it was, in fact, a very fine bolt.

MR. MICHELSON: Sure.

MR. LEWIS: Quite safe.

MR. MICHELSON: Yes. But what we're trying to do here is protect that bolt now.

MR. LEWIS: Took it out every year and looked at it.

MR. MICHELSON: Yes, well, we aren't going to do that. We were going to take these out I think every ten years and look at them.

MR. LEWIS: I'm only saying that sometimes redundancy isn't the --

MR. MICHELSON: What I'm saying is I think they need to do a little bit better job of insisting on good materials that aren't susceptible to borated water attack. And they're not requiring that. And I think that plus inspection is probably an adequate addressing of the issue.

MR. LEWIS: I'd like to understand a little more about the probabilistic analyses that go into the assessment that you don't have to worry about these things, because once you get into the kinds of low probabilities we're talking about, you are talking about common mode failures, among which materials problems are there. And I don't know how people make those calculations in this business.

MR. SHEWMON: Well, if we write a letter, we can say that that is a basis of concern. But I'm not sure it's something which the staff is going to generate anything different than they gave today when they come in and talk about it tomorrow morning.

MR. MICHELSON: I thought it was just a matter of making sure the staff states their position to the full committee.

MR. SHEWMON: Well, insofar as it's developed on that, I'm sure they'd be pleased to. But if it doesn't exist, it's not going to come into existence. So I think some we're talking about things that will happen tomorrow morning, and others maybe sometime later.

MR. MICHELSON: One other area that I think wasn't adequately covered, in fact, I couldn't find any words that told me they even considered it, and that is this question of the mechanical loading of the bolting when you're using it on motor-operated valves. There are significant mechanical loadings of the bolting. In fact, there have been some failures of bolting. But generally, the failures were on the motor operator bolting instead of on the bonnet bolting.

MR. SHEWMON: That tells you something.

MR. MICHELSON: Yes. It tells you that's the weak point. What do they do? They come in and put some more bolts on the motor operator, and then I wonder, well, have they rechecked the flanges now to see if that has become the weak point next time?

MR. SHEWMON: The question is, have they ever done an analysis or has anybody done an analysis of the stress, in doing no more than the fact that they don't generally go into yield when it operates?

MR. MICHELSON: I'm pretty sure they must have done some kind of an analysis on it. But see, we're finding now friction factors are far higher, therefore loadings are far higher. Have they considered those new loadings in terms of what effect it has on the bolting? I assume they have.

MR. SHEWMON: To come back to my point, I guess I'd be more comfortable if they went out and measured them, than if they calculated them.

MR. MICHELSON: Some people have. That's one of the techniques for measuring the motor loading in fact, is to put a stress washer under the bolt, the bolting on the bonnet. Some of them put it under the bolting on the motor operator.

MR. SHEWMON: To digress slightly, John, one of the things I was intrigued by as you went through was you said you actually measured the stress in these bolts. Is that a matter of having a long bolt and ultrasonically seeing how much the length changes with and without load?

MR. BICKFORD: Well, there are two effects that happen when you tighten a bolt. The path length changes, because the bolt stretches .02 percent, or something like that; but then the velocity, acoustic velocity is also a function of the average stress level, and it goes down as stress goes up, and gives you an effect that's about double that of the path length change.

So then all you can measure is the change in transit time, and then you have to have a mi_roprocessor or computer to sort out what that means in terms of a change in stress in the threaded region of the bolt, or tension in the bolt, if you will, or the change in length, whichever you're interested in.

MR. SHEWMON: Which one produces the larger effect?

MR. BICKFORD: Well, the change in the velocity produces the larger effect. And it's of course affected by things like changes in the temperature of the bolt and so forth and so on, and there are different velocities f r different materials. So it's quite a technology that's been developing now for 25 years or so, and my company is pre-eminent in the development of this and selling of the equipment, and so forth and so on. But it is widely used in petrochemical work, aerospace, automotive, and so forth.

MR. SHEWMON: And you can do this down to what length in bolts?

MR. BICKFORD: Well, we don't like it, but we have gone to quarter 20 screws that are maybe 3/8ths of an inch long and we've gone up to tie rods that are 10 inches in diameter and 40 feet long. So it's quite a wide range. We can't deal with small socket-head screws and things. But most of the bolts that you're concerned about in your industry are certainly big enough.

MR. SHEWMON: These things that are flanges on the bonnets that Carl is talking about are inches, anyway.

MR. BICKFORD: Sure. And those are typical kinds of joints that we deal with in pressure vessel work and petrochemical work. The smaller sizes flanges generally don't have enough, by code design at least, don't have enough bolting to really clamp them adequately, and so forth, so you have to get them very uniform and things, and we do with those kinds of bolts a lot.

MR. LEWIS: But you have to do the bolt before it's been tensioned and then after it's been tensioned?

MR. BICKFORD: Or during, yes. If you can get at both ends, you can do it during. If you want to come back to it two weeks later to see whether it's lost anything because of load cycles or thermal cycles or something, then you have to, the machine nowadays keeps a log of what the initial length of the bolt was or the initial acoustic length.

MR. LEWIS: Do you do reflection from the open end?

MR. BICKFORD: We can do it from either end. We have to have reasonably flat and parallel surfaces, but we can work with most conventional bolts. But it's a hard and fast technology that's been around now for quite a while.

MR. LEWIS: But the two effects, the increase in length and the slowing, the sound speed are additives, and that's what you measure?

MR. BICKFORD: Yes. And they are both linears, a function of average stress.

MR. LEWIS: And they are in the same direction?

MR. BICKFORD: And they are in the same direction, right.

MR. MICHELSON: How much degradation does it take to be detectable?

MR. BICKFORD: You mean wastage?

MR. MICHELSON: Yes.

MR. BICKFORD: This system is designed to ignore things like threads and cracks and so forth. We're just looking for changes in length. I can measure change in length to the nearest hundredth of a thousandth of an inch.

MR. SHEWMON: Let me come back and ask the question we both thought he was asking the first time. And that is, relaxation or change in length. What sort of sensitivity?

MR. BICKFORD: Hundredth of a thousandth of an inch, generally speaking, which usually comes out to, something like a couple of hundred psi in a bolt. As a rule of thumb, you get, if you take these kinds of bolts, these low-alloy quenched and tempered bolts, we're talking about the yield, you're getting something like three mils of stre~:h at yield for each inch of grip length. That varies with material and so forth. It's that kind of a number. And we can measure those. And in your case, you're dealing with several inches, usually, so you're looking at maybe ten miles of stretch and we can measure that easily to a tenth of a mil and we can measure it to a hundredth of a mil, if you need to. And you normally don't bother to do that. But these kinds of accuracies are possible.

MR. LEWIS: It lends itself to having portable tension measures.

MR. BICKFORD: These are battery powered things that hang around your neck. We've developed a bolting service which was based on this. We then sold the license to that to Westinghouse who has since sold it to Fermanite.

But that's all based on ultrasonic measurement of bolts. Most of their work is nuclear. They do manways and things a lot. Equipment can be used remotely so that the operators of the equipment are not exposed to the radiation as these bolts are being struggled with by the mechanics and so forth.

There is a fair amount of nuclear use of this stuff.

MR. LEWIS: There is in all these deals some Piezo Magnetism isn't there? Isn't there some magnetic way to measure the stress?

MR. BICKFORD: Work has been done on using hysterisis and eddy current losses to measure stress level. There's a guy in Japan --

MR. LEWIS: I was just thinking of ferromagnetism.

MR. BICKFORD: The Navy uses changes in permeability, for example, to look at tension in propeller shafts and this has been tried on mine roof bolts, but it requires very close gap control and you have to have your pickups adjacent to a very uniformly stressed region.

There's nothing practically available on the market, but the other magnetic things, like I say, like hysterisis and eddy current losses have been tried and we have some of this equipment, but the ultrasonic has been taken --

MR. LEWIS: That kind of activity, that's harder.

MR. BICKFORD: The permeability thing, or the magnetic property thing is really the only true stress related changes that were not, so it will come some day, I think.

MR. LEWIS: That's very interesting.

MR. SHEWMON: I think I have enough guidance to talk with the staff then.

MR. LEWIS: I've got to say one thing: I got a report that this wonderful long equation that Richard was kind enough to pass out to us, I recognize as a dispersion relation calculation of an elastic scattering amplitude in terms of the matrix elements for the inelastic branches and the denominators do go through zero so it will diverge unless you're careful along the branch points. I had to put that on the record.

MR. JOHNSON: I'm glad we have that down for posterity.

MR. SHEWMON: Thank you. Unless you can find nothing else to do, I want only the erosion/corrosion and anybody else who is interested for general interest, but we're through with this issue for the day.

[Whereupon, at 12:05 p.m., the meeting was recessed for lunch, to be reconvened at 1:05 p.m.]

AFTERNOON SESSION

[1:05 p.m.]

MR. SHEWMON: First, we hear about erosion/corrosion.

[Slide.]

MR. KOSCIELNY: Good afternoon. My name is Steven Koscielny with the Materials and Chemical Engineering Branch and this is a presentation on the erosion/corrosion aspects. A brief overview of what erosion/corrosion is: it's really a flow assisted damage mechanism where the oxide layer is washed away from carbon steel components and piping systems in both single phase and two phase systems.

In two phase systems, it also includes an impingement portion of the aspect where the metal is actually fatigued away from the surface. The effects of temperature are described in this diagram here.

As the temperature increases, the effect drops off. At about 250 degrees Centigrade, it's very nominal and not a very predominant temperature effect. Looking at the effects of pH on --

MR. MICHELSON: Let me ask you this: you're talking about erosion/corrosion. Erosion alone, of course, can occur at any temperature.

MR. KOSCIELNY: That's correct.

MR. MICHELSON: Okay.

MR. LEWIS: Is there a simple way for me to understand why it goes down at higher temperatures?

MR. KOSCIELNY: if there is, I don't have a good answer for you.

MR. LEWIS: Fine.

MR. SHEWMON: Why does it go down at low temperatures.

MR. LEWIS: Because --

MR. SHEWMON: Hush.

MR. KOSCIELNY: My understanding is that it has to do with the dissolution rate of the oxide layer back into the liquid phase, into the liquid that's passing through it or across it. As the temperature drops, the reaction rate drops also.j

MR. SHEWMON: So something makes the oxide more stable at high temperatures?

MR. KOSCIELNY: Yes, that's my understanding.

[Slide.]

MR. KOSCIELNY: The higher the pH, the better the oxide layer tends to stay in place and there's less effect of erosion/corrosion because of pH as pH increases. If you increase the amount of -- if you change the pH control agent, you also have an effect on the erosion/corrosion rate.

If you use morpholine versus all volatile chemistry or morpholine as opposed to a phosphate chemistry system or if you maintain a higher pH in your condensate and feedwater systems, you will minimize the amount of erosion/corrosion that will occur.

MR. MICHELSON: Apparently, it's still erosion related although in your previous slide, you said the predominant was the liquid chemical action. If there were any erosion occurring, this type of corrosion would not occur; is that correct?

MR. KOSCIELNY: The erosion aspects of it -- well, there is always going to be some kind of erosion occurring, strictly erosion. As far as the erosion/corrosion aspects of it, the flow assisted corrosion portion of it, that is a strong function of seven variables which I am going to get into.

There are two distinct mechanisms that are occurring.

MR. MICHELSON: I guess it will become clear later. Thank you.

[Slide.]

MR. KOSCIELNY: Alloying elements are also a strong function of the erosion/corrosion rate. Small amounts of chromium will make the material much less susceptible to erosion/corrosion. Most carbon steels that power plants are built out of are A106 Grade B carbon steel for the piping components and the fittings are normally manufactured out of APV2-334 and those two materials have very small or negligible amounts of chromium.

The only chromium that is normally in those two alloys or those two materials is residual amounts.

MR. LEWIS: These two are two different investigators measuring the same thing?

MR. KOSCIELNY: Yes.

MR. LEWIS: At the upper levels, they differ by more than a factor of ten from each other?

MR. KOSCIELNY: Yes, according to this graph which I pulled out of a previous presentation.

MR. LEWIS: Does that impair one's willingness to believe either of them?

MR. KOSCIELNY: I would have to find out more information about these two specific investigators.

MR. LEWIS: Well, the fact that they agree at zero chromium doesn't mean anything because that's the normalization, but out where they're doing measurements, they differ from each other by a factor of ten. I normally don't put a lot of credence in such things. Maybe I'm wrong.

MR. SHEWMON: Everyone knows that physicist do precise measurements, so go ahead.

MR. LEWIS: If they measure at all.

[Slide.]

MR. KOSCIELNY: Now I would like to discuss some of the regulatory efforts that have been taken in order to address the erosion/corrosion issue. Back in 1982, failure occurred at the steam extraction line at Oconee. That resulted in Information Notice 82-22.

In 1986 in December, the failure at Surrey Unit 2 occurred and that resulted in a feedwater line break and Supplements 1, 2, and 3. The significant unexpected erosion of feedwater lines at Trojan resulted in 87-36 and those were summarized -- the response of Bulletin 87-01, thinning of pipe walls in nuclear power plants, was summarized in 87-17.

One bulletin was issued which is 87-01, which requested licensees to provide information about erosion/corrosion programs and the issue was further discussed in the Generic Letter 89-08 which required licensees to establish a long term erosion/corrosion program.

MR. SHEWMON: Now, the 87-01 result of these couple of deaths that occurred just south of here?

MR. KOSCIELNY: Yes, that's correct.

MR. SHEWMON: Okay.

MR. KOSCIELNY: As part of Generic Letter 89-01, NUREG 1344 was an attachment to that generic letter. That describes some of the findings in the investigation conducted as part of the erosion/corrosion issue.

MR. SHEWMON: Let's back up to the first part of your slide. Was this failure in the turbine exhaust lines, erosion/corrosion or erosion?

MR. KOSCIELNY: Steam water mixture erosion/corrosion.

MR. SHEWMON: Okay, so that's a different -- that's two phased.

MR. KOSCIELNY: Damage, that's correct.

MR. SHEWMON: All of those in that first set are two phased?

MR. KOSCIELNY: In 82-22? No. The information notices?

MR. SHEWMON: Yes.

MR. KOSCIELNY: They contain both single phase and the two phased events. The first one, 82-22, was a two phase steam water event.

86-106 was a single phase water event at Surrey and the other two -- or 87-36 was also a single phase water event at Trojan.

MR. SHEWMON: Okay, then Surrey was the place where the people were killed and where they first rediscovered single phase erosion/corrosion?

MR. KOSCIELNY: Well, I wouldn't say rediscovered it. That would be the first discovery.

MR. SHEWMON: Well, it sure wasn't anything the NRC had any interest in or the utility until then.

MR. FOSCIELNY: That's true.

MR. SHEWMON: Go ahead.

MR. MICHELSON: How you do you define -- locally, where you are getting corrosion, you may very well be getting localized two-phased, although the bulk stream is single phase. How do you sort that sort of thing out?

MR. KOSCIELNY: You'd have to rely on the computer codes that are available, namely the EPRI or Checkmate computer codes.

MR. MICHELSON: When you say it's single phase, it means in the bulk stream, not necessarily in the corroded area. It might have been two phased in the corroded area, depending upon how much steam voiding was occurring.

MR. KOSCIELNY: If you had flashing occurring at a level control valve, for example?

MR. MICHELSON: For instance.

MR. KOSCIELNY: Yes. But the EPRI computer code check will tell you flashing is probable to occur.

MR. MICHELSON: Let me ask my question again. When you say that the 86-106 was single phase, did that mean that single phase in the vicinity of the corrosion, or single phase in the bulk stream?

MR. KOSCIELNY: My understanding was that it was in both locations.

MR. MICHELSON: In other words, there was no -- well, what war the erosion occurring then? What was causing erosion if there was no void formation. The void would obviously be steam if they were in a liquid circuit.

MR. KOSCIELNY: There was, to my understanding, no steam in the location. It was an elbow downstream of a --

MR. SHEWMON: The temperatures are relatively low and --

MR. MICHELSON: 200 or 300 Centigrade is not relatively low. These were in feedwater and steam lines.

MR. SHEWMON: Where is the peak on this thing?

MR. MICHELSON: A couple hundred degrees.

MR. SHEWMON: 150 Degrees C.

MR. MICHELSON: Yes, that's feedwater line temperatures.

MR. SHEWMON: Fine, but people have looked at this and to the best of their knowledge and the best of their calculations, there was no cavitation.

MR. MICHELSON: What is the erosion effect?

MR. SHEWMON: It takes off the oxide as it forms.

MR. MICHELSON: Just the fluid in the bulk stream flowing?

MR. SHEWMON: Yes. It dissolves. It has a certain solubility and these things that he listed earlier which have to do with pH and temperature and oxygen all influence the solubility of it.

MR. MICHELSON: No cavitation was occurring?

MR. SHEWMON: It's more dissolution and that's why the turbulence is so important --

MR. MICHELSON: Oh, yes.

MR. SHEWMON: -- and where it is. Go ahead.

MR. KOSCIELNY: 1344 gives a lot of background information on the overall issue of erosion-corrosion. It also describes the findings of the inspection of ten power plants conducted by the NRC back in 1988.

MR. SHEWMON: Now that is what we were primarily interested in learning about with this presentation was what had been learned about erosion-corrosion, what kind of a problem was it and how well do we have it under control.

I trust the rest of your presentation will get there.

Go ahead.

MR. KOSCIELNY: In addition to the NUREG there's been continued work between the ASME Section 11 and the NRC to establish erosion-corrosion rules for single phase systems in Class I, 2 and 3 pipings, piping systems.

[Slide.]

MR. KOSCIELNY: Some of the industry guidelines --

the industry guidelines were established by the NUMARC Technical Committee back in 1987. They require analysis to be conducted in a limited but thorough baseline inspection of components, determine the extent of thinning occurring and repair or replace and continue to perform follow-up inspections.

The generic letter guidelines or the NRC guidelines were established in the generic letter by endorsing the NUMARC guidelines.

The generic letter requires a long term erosion-corrosion monitoring program which meets the intent or meets the requirements of the NUMARC program or another equally effective program established by the utility.

The NRC program also requires that all high energy piping systems both single and two phase carbon steel manufactured systems being included in the licensee's program.

MR. SHEWMON: Does the NUMARC program recommend the check program or how does it define places to be looked at?

MR. KOSCIELNY: It does recommend use of the check program.

[Slide.]

MR. KOSCIELNY: Systems that are susceptible to erosion-corrosion are feedwater, condensate, extraction steam, auxiliary steam, moisture separator drains, moisture separator reheater drains, feedwater cascading drains, feedwater heater drain pump discharge piping, high pressure HPCI from BWR systems, main steam in some plants, and turbine crossover and crossunder piping.

MR. SHEWMON: Main steam has an erosion-corrosion problem?

MR. KOSCIELNY: Depending on the amount of moisture in the main steam line and where in the main steam line you are analyzing it could be a problem.

It's not normally considered a problem because of the dry amounts of steam --

MR. SHEWMON: We're mixing two phase, we're calling two phase erosion-corrosion now, is that right?

MR. KOSCIELNY: Yes.

MR. SHEWMON: You don't have solid water normally in steam lines anyplace, do you?

MR. KOSCIELNY: No but depending on the amount of two phase and the moisture in that two phase, it is also considered erosion-corrosion.

MR. SHEWMON: I'd not thought that was called erosion-corrosion and I guess I am mildly bothered to see that that's picked up because it seems to me you have now lost any distinction you had between single phase and two phase erosion.

MR. KOSCIELNY: As far as the computer codes that are available, the EPRI CHECMATE computer code handles two phase erosion-corrosion.

MR. SHEWMON: Fine. That doesn't --

MR. KOSCIELNY: So there really isn't a distinction. It can be utilized from both single phase and two phase because the one factor for the two phase portion --

MR. SHEWMON: The way I can tell two phase erosion-corrosion is you use those words and what people call single or two phase erosion?

MR. KOSCIELNY: No.

MR. SHEWMON: That's an impact problem whereas the erosion-corrosion problem single phase is not an impact problem.

MR. KOSCIELNY: It's a dissolution problem, yes.

[Slide.]

MR. KOSCIELNY: Some of the plants that have exhibited erosion-corrosion problems in feedwater and condensate lines are listed in this handout and the locations and when the plant was put in service.

MR. SHEWMON: Are those -- they're all single phase?

MR. KOSCIELNY: Feedwater and condensate, yes.

MR. SHEWMON: How does the NRC learn of these or who generated this list?

MR. KOSCIELNY: This list came out of the 1344 NUREG.

MR. SHEWMON: Fine. Who generated that?

MR. KOSCIELNY: The author was Paul Wu.

MR. SHEWMON: And he works for the NRC?

MR. KOSCIELNY: He no longer works for the NRC. He worked for the NRC.

MR. SHEWMON: Who did he work for when he put this together? The NRC?

MR. CHENG: Yes.

MR. SHEWMON: So my question again is how does the NRC learn about these things? There is not a reporting requirement, is there?

I understand EPRI collects this data regularly or somebody does but the NRC does not require that failures of this part be submitted to them?

MR. KOSCIELNY: That's true.

MR. SHEWMON: So the NRC learns about this by word of mouth or does this come from EPRI or where does this table that's up there -- do you know?

MR. KOSCIELNY: Do I know where specifically this table came from?

MR. SHEWMON: Yes.

MR. KOSCIELNY: I do not, other than it came from that NUREG.

MR. LEWIS: What is the date?

MR. SHEWMON: How did he get it and do we have any indication that it is complete?

If you only hear from people who happen to send you the information then it's not as complete as if you got it from EPRI where indeed apparently there is a requirement or at least a tradition that failures of this sort will be handed in there.

MR. KOSCIELNY: That's true.

MR. SHEWMON: One of the things I am interested in is what fraction of what is going on out there do we know about? How large a problem is it?

If you can't tell me how this data was assembled then there is no way of telling whether this is 10 percent of it or this is 99.5 percent of it.

MR. CHENG: I understand, yes.

MR. WITT: This is Frank Witt. There are no LERs required but a lot of this information comes from morning reports on pipe failures which cause a shutdown of a plant and that is how Millstone III was picked up from that and AIT was formed to investigate.

A lot of these are picked up on the daily morning reports.

MR. SHEWMON: So somebody in your division at least when they know that they are going to have to write a report like this, put together a list, and after he leaves the NRC does somebody else pick it up? What can we say?

MR. WITT: Yes.

MR. SHEWMON: We can say?

Somebody else does pick it up and start making a list or continuing the list?

MR. WITT: Yes, that's right.

MR. SHEWMON: Okay, and who's he?

MR. WITT: Steve.

MR. CHENG: Steve, yes.

MR. KOSCIELNY: Wait a minute. I don't collect all the data.

MR. WITT: No, but you're aware of when plants --

MR. KOSCIELNY: I know -- I don't see all the morning reports which is what I believe Mr. Shewmon is asking.

There is not a tracking mechanism right now for every single pipe failure within the Commission

MR. SHEWMON: So Wu was interested and Wu did this so you think it's probably fairly complete for the time that Wu was with the NRC and assigned to this?

MR. WITT: That's right.

MR. SHEWMON: Okay, thank you.

MR. MICHELSON: Is an LER required for every time somebody finds a pipe wall thinned? It didn't break or even leak.

It just was found thin.

MR. WITT: No.

MR. MICHELSON: So the pipe thinning is not reported as LERs.

The pipe leak I guess depends on which system is leaking as to whether it's even reported in an LER.

MR. WITT: If the pipe ruptures and shuts down the plant --

MR. MICHELSON: Oh, yes. That clearly is reported.

I am just thinking if I walk up to a service water pipe and it's dripping -- well, it won't be a service water pipe.

It'll be a warm water or hot water pipe.

MR. WITT: If the inspection shows that the pipe wall is thinned, the utility would go ahead and replace it without its knowing about it.

MR. MICHELSON: No, but it doesn't require a LER though.

MR. WITT: No.

MR. MICHELSON: Okay, so only certain types of events resulting from thinning would even be reported so it is a small set, a smaller set.

MR. KOSCIELNY: The utilities according to the NUMARC guidelines are supposed to report any findings, thinning or replacements to NUMARC. As part of the NUMARC guidelines it states that in there.

MR. SHEWMON: That's why I said EPRI when I probably meant NUMARC but whether this had come from an industrial group who said this is -- they do report to us, this is the list of what they found -- but you don't have that information knowingly, is that right?

MR. KOSCIELNY: That's correct.

[Slide.]

MR. KOSCIELNY: Looking at the formulation of the CHEC computer code for determining the erosion corrosion rate, the CHEC code looks at geometry, ph, oxygen effect, mass transfer effect, alloy content, temperature. For the CHECMATE computer code, there's a 7 factor for the void fraction. It sums up all the parts of the equation and then come out with the determined predicted erosion corrosion rate.

MR. MICHELSON: Now, how does it determine the void fraction, do you know?

MR. KOSCIELNY: It uses a -- it determines that from input data from the engineer who's running the code, which he uses pressure and temperature in that particular line. In addition, there's a flow module within the

CHECMATE computer code which can be utilized to accurately monitor the pressure dropped through that line that you've modeled from the extraction --

MR. MICHELSON: Of course, I'm sure you understanding that local cavitation, local flashing occurs because of velocity changes, pressure changes, which are highly localized. Flashing occurs and the bubble recondenses as it goes on downstream. So, it's a very localized phenomenon --

MR. KOSCIELNY: True.

MR. MICHELSON: -- and you have to use a very localized code to predict whether that phenomenon is occurring or not.

MR. KOSCIELNY: The CHECMATE computer code takes into account not only the geometry of each piping component, but it also takes information from the valve itself. You'll have to input the size of the valve, CV of the valve and that will give you an indication of whether you're having flashing at that valve. Because it will show you -- as one of the outputs of the code, it shows you the void fraction.

MR. MICHELSON: It does the same on elbows and so forth?

MR. KOSCIELNY: Elbows, teeth, it goes through each particular component in that piping stream that you've modeled.

MR. MICHELSON: But it does it on a micro basis then?

MR. KOSCIELNY: Component-by-component. Elbow, T-valve, pipe --

MR. MICHELSON: I can get no flashing through a component and yet I get localized flashing within the component?

MR. KOSCIELNY: That -- the code will not show you that.

MR. MICHELSON: In the localized flashing within the component, is where maybe the erosion, the corrosion is occurring. As it was a case a couple of --

MR. SHEWMON: It is my impression that the code does not look for cavitation or flashing, it's a correlation which has a set of factors and they then back out how much --

MR. MICHELSON: Yes, it's good for distance but not good locally. But the corrosion has been very localized in these valves and it's been showing them up. Whether its erosion corrosion or what, I don't know. But the code wouldn't necessarily tell me whether it was advised or not.

MR. LEWIS: At the risk of sounding like a physicist, is there a basis for believing that these various effects are independent of each other so that they can be factored in a simple way? That is, I can imagine mechanisms in which the composition would determine the temperature dependents of the effect and things like that. So, it wouldn't be a matter of simple factors. Is there evidence that it really is that simple?

MR. KOSCIELNY: It's a synergistic effect. They are interrelated and you can't just eliminate the possibility of erosion/corrosion based on only 1 or 2 variables.

MR. LEWIS: If they're interrelated then this formula is wrong. Is that what you're telling me?

MR. KOSCIELNY: What I'm saying is you can't discount this formula based on the temperature effect being zero, assumed to be zero.

MR. LEWIS: The question I'm raising is whether the -- just take composition and temperature, whether factoring the effects into the product of temperature effect times the composition effect is really a decent approximation to what's happening? Just asking. I don't know. That's what's assumed in writing this down?

MR. KOSCIELNY: Yes. This is the best tool that I know of.

MR. SHEWMON: Is it really entirely a product of all those functions?

MR. LEWIS: That's the question I'm asking.

MR. KOSCIELNY: Yes, it comes out in mils per year or mils per year.

MR. SHEWMON: No. What you've got up there is it's a temperature factor times a mass transfer factor times an alloy content. So I guess the -- every one of those factors would have to be one, unless there was a reason to make it different from 1. Because if any one of them is zero, then the effect is zero.

MR. KOSCIELNY: This isn't -- the computer code generates the erosion/corrosion rate, and this is an explanation as to how it does that.

MR. LEWIS: But somebody generates the computer code?

MR. KOSCIELNY: Yes.

MR. SHEWMON: It is the function of those, it's not the product.

MR. LEWIS: Oh, it's written as a product. You mean, I shouldn't believe that formula?

MR. MICHELSON: Yes, that's the idea. I don't think that formula is right.

MR. LEWIS: Where did that formula come from?

MR. KOSCIELNY: That's from an EPRI hand-out.

MR. LEWIS: Well, they're the ones who wrote the code.

MR. SHEWMON: But they consider the code proprietary?

MR. KOSCIELNY: That is true.

MR. LEWIS: You must be joking. Surely you're joking?

MR. SHEWMON: No.

MR. KOSCIELNY: No, it is considered a proprietary code.

MR. LEWIS: It makes it kind of hard to understand.

MR. SHEWMON: I assume the staff was aware of the true formulation.

MR. KOSCIELNY: To my knowledge, that is still considered proprietary and the staff has not got the internals of the code.

MR. MICHELSON: Do you use any of this in making regulatory judgments?

MR. KOSCIELNY: No.

MR. MICHELSON: You don't?

MR. LEWIS: Oh, I'm sorry, you showed one a minute ago in which you said that people have to show that they have something which is -- did I misunderstand it?

MR. KOSCIELNY: Meets the intent of the NUMARC guidelines, or meets the NUMARC guidelines. Now, within those NUMARC guidelines, they recommend use of the CHEC computer code.

MR. LEWIS: Right. But then you have a regulation

which says you've got to follow those guidelines or
something equally effective.

MR. KOSCIELNY: Yes.

MR. LEWIS: How can you judge whether something is equally effective if you don't even know what this is? It does have a regulatory impact?

MR. MICHELSON: Yes. I had assumed that they really knew what the true formulation was.

MR. KASSNER: It was my understanding that NRC or regulatory does have this code that they ask that -- EPRI made it available. They couldn't show it to us, for example. We wanted to use it and see it ourselves.

MR. MICHELSON: But they have the document, the code?

MR. KASSNER: They have the whole code. They can run test cases.

MR. MICHELSON: Well, the documentation of the code is what's important, not -- not a tape that you run. Understanding the formulation, the models and all that that is the important part.

MR. KASSNER: Well, there's an awful lot of data that went into developing the code and this just reflects the -- pulling together a very large data base and --

MR. WITT: Yes, that's what I wanted to say -- that this program has been verified from plant data and loop data from all over the world. It's a large mass of data that substantiated this.

MR. SHEWMON: If you find one that doesn't fall within that, they'll change the code so it will.

MR. WITT: I think they -- well they keep revising it, yes, to --

MR. LEWIS: But that's always the problem with the computer code, that if it's completely up to date, then it has no predictive value, because it just describes the past. The questions that are being asked, as I understand them, have nothing to do with whether the data base supports the precise functions here, but the underlying assumption -- whether the underlying assumption is that these factors are independent or if they're put together -- if that's really just, as Paul suggested, a way of saying that it depends on all of these things, then we're talking about a function of 6 variables, and you don't unscramble that from a large data base. Well, not with any predictive value.

MR. SHEWMON: Well, you know, it's a correlation which fits all known data. It has certainly some predictive -- it has good retrodictive value.

MR. MICHELSON: It doesn't help you much with knowing the contribution of all these various phenomenons and material compositions and so forth. You can't -- you don't know what's going on and you just know what the bottom line answer is.

MR. SHEWMON: I understand, from having attended a Section XI meeting and actually sitting in for a while with the sub-group there, which is putting together something for Section XI on how people will do erosion/corrosion inspections, that at least one utility, and I think it was Wisconsin Electric, does not pay the tab for a check, but has some other way of deciding what they'll look at. Are you familiar with that?

MR. CHENG: They have not submitted their program to us.

MR. SHEWMON: They have or have not?

MR. CHENG: They have not. Isn't that right?

MR. KOSCIELNY: That's correct.

MR. CHENG: Yes.

MR. KOSCIELNY: Fine.

[Slide.]

MR. KOSCIELNY: With regard to the examination of components this is a sample grid type inspection recommended in the NUMARC guidelines where the data is taken at the intersections and a scan of the wall thickness is conducted within the area bounded by the four corners of a rectangle in this example.

That is then recorded and the data is evaluated for the amount of wall loss or wall thinning that has or has not occurred.

Now I would like to discuss some of the recent pipe failures that have occurred.

[Slide.]

MR. KOSCIELNY: Surry Unit 1 lost a pipe in the low pressure heater drain system in March, 1990.

Lovisa, a finished power plant, had a feedwater line break in May.

Recently Millstone Unit 3 in its moisture separator drains had a failure on New Year's Eve.

MR. SHEWMON: Pardon me. As a metallurgist I am a lousy plumber but a drain to me is a hole in the floor where the shower water runs out.

[Laughter.]

MR. SHEWMON: It's tough to see how you could get erosion-corrosion there.

Could you enlighten me on what a drain really is?

MR. KOSCIELNY: Certainly. If I could have a pen to write on this drawing I would be more than happy to do that.

MR. MICHELSON: There's a board up there, a white board.

MR. KOSCIELNY: Can I use the white board?

MR. SHEWMON: White board behind the recorder -- no, no, on your left.

MR. KOSCIELNY: Oh, this thing.

MR. MICHELSON: That's a white board. That's it. You got it.

MR. KOSCIELNY: Okay. In your heat balance diagram you have a moisture separator. It also has a reheater associated with it. The first part is called the moisture separator and that will come off your main steam line.

Some of the main steam will be routed through the moisture separator to provide the heat and drive off the steam -- pardon me, drive off the moisture, which is then collected in the bottom of the moisture separator.

In the case of Millstone, that drained into what is called the moisture separator drain tank.

The moisture separator drain tank had a pump associated with it which then took a suction on the drain tank and pumped that to the suction of the steam generator feed pump.

MR. MICHELSON: Are you going to put the valves in there?

MR. KOSCIELNY: Sure.

MR. MICHELSON: To break down the pressure.

MR. KOSCIELNY: There is a pressure control valve here, an isolation valve there and an isolation valve there, as I recall.

There was also one associated with the suction side of the pump.

MR. MICHELSON: No breakdown to the drain tank from the separator?

MR. KOSCIELNY: Breakdown?

MR. MICHELSON: Is there a breakdown valve between the separator and the drain tank?

MR. KOSCIELNY: I believe there was.

MR. MICHELSON: Okay.

MR. KOSCIELNY: In the case of Millstone 3 the failure occurred downstream of the level or the pressure control valve there.

MR. SHEWMON: So the drain refers to the whole line?

MR. KOSCIELNY: Yes, that is correct. It's the moisture separator drain.

MR. SHEWMON: Turbulence below the pressure control line that made that more prone than other parts, presumably?

MR. KOSCIELNY: Yes.

MR. MICHELSON: Was that thought to be two phase then, erosion-corrosion?

MR. KOSCIELNY: It is thought to be single phase.

MR. MICHELSON: Well, now, how can you have single phase out of a high pressure steam system into a drain line?

MR. KOSCIELNY: This is a drain tank.

MR. MICHELSON: Yes. That's still a pressure. You haven't broken down all the pressure at the drain tank.

MR. KOSCIELNY: Well, this pressure is at about 170 pounds.

MR. MICHELSON: Well, that's a lot of pressure.

MR. KOSCIELNY: It is about 300 pounds here at the suction of the pump, as I recall, the suction of the second pump at the steam generator feed pump.

MR. SHEWMON: Which way is the flow going? It's going up a pressure gradient?

MR. MICHELSON: You put a pump in there.

MR. KOSCIELNY: There is a pump here.

This is the moisture separator drain pump.

MR. SHEWMON: Okay, fine. I'm with you.

MR. MICHELSON: See, the discharge of that pump is probably considerably higher than the feedwater line and he has to control his pressure back with that final control valve and that's where he is going to get the flashing.

There is no way to prevent it if you -- just read your steam table. You can't prevent flashing.

You're not controlling flashing. That's what is happening and to call that single phase is a little bit of strange terminology.

It is going to be locally two phase now but the bulk will be single phase further on down probably.

MR. SHEWMON: Well, if it was two phase, I suspect it would more properly be called cavitation than erosion because it would be collapsing.

MR. MICHELSON: Yes, that's what I -- and I always try to figure out which phenomenon is occurring.

MR. SHEWMON: If you shoot BB's against something, that's erosion. If you collapse bubbles on it, that's cavitation.

MR. MICHELSON: But collapsing bubbles is just like shooting BB's locally.

MR. SHEWMON: No.

MR. MICHELSON: I think you'll find in implosions of steam bubbles they are very erosive.

MR. SHEWMON: That's true but that doesn't mean the mechanism is the same as shooting BB's.

MR. MICHELSON: No, no. No, no. I didn't mean to infer that.

MR. SHEWMON: Okay. Onward.

Now if I look at your earlier table, I could come to the erroneous conclusion that we have the problem well under control because nobody's reported hardly anything in the last three or four years and if I look at this it says that indeed we have had at least three events in the last year.

MR. MICHELSON: That was a big event, by the way, I think at Surry. Wasn't that the one that went back and screwed up the security system again and so forth?

MR. KOSCIELNY: Just about any time you start with steam --

MR. MICHELSON: It was a big release. It wasn't a little trivial --

MR. KOSCIELNY: A security system doesn't like moisture.

MR. MICHELSON: And, see, they thought they had fixed the whole security system from the other pipe break they had and they got another pipe break and not in the same location but in the same room, and this one screwed up the security system again.

Also it set off the halon this time instead of the CO_2 in the electrical board rooms.

MR. SHEWMON: So these were the three which were SERs last year, is that a fair statement or is that just three out of many you could have brought in?

MR. KOSCIELNY: Well, the Lovisa one occurred in Finland, so there is no U.S. reporting requirement.

Surry Unit 1 was a voluntary LER.

Millstone Unit 3 occurred a little over a week and a half ago and there was an inspection team dispatched to the site.

MR. MICHELSON: Why was Surry voluntary when it interfered with the switch gear? It released the halon in the switch gear room and I thought that would be enough of a basis to make it a mandatory.

MR. KOSCIELNY: I'd have to look at the LER again.

MR. MICHELSON: But I won't argue with it. I know they -- I read the LER and they said it was voluntary. I said, hell, you --

MR. SHEWMON: Why was Millstone worse than Surry?

MR. KOSCIELNY: Millstone was a larger pipe rupture. It took out both trains of the moisture separator drain system and it caused a steam leak within the turbine building and the plant had to shut down.

MR. SHEWMON: I guess I haven't read that one yet.

MR. IGNE: Is it my understanding that CHEC predicted the failure at Millstone Unit 3 but they didn't check it yet?

MR. KOSCIELNY: I am getting to that, to the whole story of the Millstone 3.

That is part of the discussion.

The first one I would like to discuss is the failure at Surry Unit 1.

[Slide.]

MR. KOSCIELNY: This is the geometry at Surry Unit 1. It is coming off a fourth point feedwater heater through the low pressure drain pump and then it ties back into the main feed heater.

Again the failure was downstream of a level control valve in a short section of pipe less than one foot long.

The pipe went from four inches through a six by four expanding elbow through an isolation through a flow venturi and that level control valve controlled the level in the drain in this fourth point feedwater heater and the oscillations essentially through the throttling effects were what gave you the turbulence causing properties downsteam of that level control valve.

MR. MICHELSON: Which direction was the expanding elbow m[illegible]ted?

MR. KOSCIELNY: This is the four inch end here.

MR. MICHELSON: Okay.

MR. KOSCIELNY: It's expanding to a six inch pipe.

When this was analyzed by Virginia Power that small section of pipe was not analyzed.

This particular stream of feedwater heater drains was analyzed but that pipe was not included in the model due to an oversight.

MR. MICHELSON: When they went back and checked it again after they realized that they had an oversight, how did the model predict it, or did the model predict it?

MR. KOSCIELNY: The model did predict it.

MR. MICHELSON: It did. Okay.

MR. KOSCIELNY: It showed that that was a high probability location.

MR. MICHELSON: Okay.

MR. KOSCIELNY: Are there any other questions on this particular slide?

MR. LEWIS: I have to say I am confused by the 4,065,108 pounds per hour.

I bet it is probably closer to nine -- never mind.

MR. SHEWMON: Nine million pounds?

MR. LEWIS: No, no. Nobody measures flow rates to seven significant figures.

MR. SHEWMON: But you can read your hand calculator to seven figures.

MR. LEWIS: Not I. I have bad eyes.

[Slide.]

MR. KOSCIELNY: The next one I want to discuss is the failure at Lovisa. The failure at Lovisa was downstream of one of the feedwater pumps. It occurred at an orifice in the feedwater train. Again, the orifice was the flow-turbulence causing device.

[Slide.]

MR. KOSCIELNY: The piping downstream of the orifice looked like this as far as the damage that occurred.

The piping did not exhibit much damage once it became the CT-20 material, which is a Soviet material which contains some small amounts of chromium. This small pump piece here, this was manufactured out of German material, an ST-45.8 material, and it had very, very little chromium. Essentially it was carbon steel. And the flange was also manufactured out of German carbon steel with very little chromium.

So in this case, the materials were really the strong point of the Soviet piping, the small amounts of chromium.

Now, I'm going to discuss the problem that occurred recently at Millstone 3.

[Slide.]

MR. KOSCIELNY: This is a schematic diagram of what I've drawn up on the board here. Again, pump discharge with a 10-inch line, elbows, et cetera, a reducer to a 10 by 6 to put in a six-inch isolation valve, a six-inch schedule 40 downstream pipe, the flow control valve, a six-inch schedule 40 piece of piping, a six-inch isolation valve and a 10 by 6 expander, and it ties into the header to go back to the suction of the steam generator feed pump.

MR. SHEWMON: It saves them enough money in valve costs to go down to a lower diameter for their valving and then back up; is that right? This is what happened at the

Surry, also; it was 6 by 4 there instead of the 6 by 10.

MR. KOSCIELNY: That was, apparently, from my discussions with the licensee when I was there, this was the only pipe in the system or the only place in their plant where they left it at the six-inch schedule 40. Every other place they have noticed that Stone & Webster's design puts an expander, a reducer in expanding configuration, to get you back up to the ten-inch size, the higher size, so that the velocity would be lower. In this case, the velocity was someplace between 17 and 20-some-odd feet per second.

MR. MICHELSON: Where was the failure, though; have you told us yet?

MR. KOSCIELNY: The failure occurred right at the level control valve, or the flow control valve.

MR. MICHELSON: Now, what difference would it make whether they'd used a 10-inch valve or a six-inch valve? They have to throttle to a certain extent. Probably you'd have to throttle a little more if you had used a 10-inch valve instead of a six. The damage is from the throttling action, which is a mandatory action. You have to throttle.

MR. KOSCIELNY: You have to throttle, that's right.

MR. MICHELSON: Yes. And it's the throttle that's doing it.

MR. KOSCIELNY: And allowing the velocity to drop would mitigate some of the consequences of that throttle.

MR. MICHELSON: The velocity through the valve is extremely high, and that's a function of where you set the throttling position in the valve.

MR. KOSCIELNY: But the valve body was not damaged.

MR. MICHELSON: Well, yes, but the turbulence is created by the throat of the valve, and it's going to show up somewhere downstream.

MR. KOSCIELNY: It shows up right in the straight section of thee pipe.

MR. KOSCIELNY: Yes, that's about where it should be.

MR. SHEWMON: It would be interesting to see what the CHEC code does say with regard to if you changed that to a 10-inch pipe it would make any difference.

MR. MICHELSON: Yes. It would be very interesting to see if it realizes that.

MR. SHEWMON: So was that your conclusion page?

MR. KOSCIELNY: There are no conclusions at this point. As a result of this recent failure, it's time to discuss what the NRC should do next.

MR. SHEWMON: A very timely meeting. What is your guess about what they will do next?

MR. KOSCIELNY: My initial guess is that there needs to be some more investigation as to what requirements we need to lay on licensees of inspections conducted of licensees' programs.

MR. SHEWMON: If somebody comes back and says gee, this was messy, but it's not a safety issue, then what do you say?

MR. KOSCIELNY: I need some horsepower.

MR. MICHELSON: How far downstream do you require the bolt inspection?

MR. KOSCIELNY: Nominally, it's done for one diameter.

MR. MICHELSON: Just one diameter from where?

MR. KOSCIELNY: From for example an elbow, you would go one diameter downstream.

MR. MICHELSON: In the case of a throttling valve, how far?

MR. KOSCIELNY: The damage is noted within two diameters of the throttling valve, according to the EPRI publication.

MR. MICHELSON: Isn't that though a function of the configuration downstream of the throttling valve?

MR. KOSCIELNY: Yes, it does, it fills --

MR. SHEWMON: That is assumed a straight pipe.

MR. MICHELSON: Yes, but it may not be. Also it's assumed to be the same diameter as the valve, I guess, although it may be larger or smaller, or there may be an expander there, and so forth.

MR. KOSCIELNY: In the event the computer code tells you to look at the valve, the guidance is to look at the downstream component, the pipe, the elbow, or whatever is attached to it.

MR. MICHELSON: Yes. That's the place to look, all right. The code is probably not that good.

MR. SHEWMON: What happened as a result of this?

MR. KOSCIELNY: An augmented inspection team was sent to Millstone 3.

MR. MICHELSON: What did it do to the plant when it failed?

MR. KOSCIELNY: It knocked out a ventilation duct, it knocked out both --

MR. MICHELSON: This was in the turbine building, now?

MR. KOSCIELNY: Yes.

MR. MICHELSON: Was the ventilation duct in the turbine building?

MR. KOSCIELNY: Yes, it was.

MR. MICHELSON: Physically damaged --

MR. KOSCIELNY: Physically nearby.

MR. MICHELSON: Just moved it away or something?

MR. KOSCIELNY: It blew the piece, blew that section --

MR. MICHELSON: What else, what happened to the steam that was released? Did any of it get back into vital equipment?

MR. KOSCIELNY: It knocked out a couple of electric switchgear motor controllers and did some damage to some supports that were associated.

MR. MICHELSON: Now, were these located in the turbine building or elsewhere?

MR. KOSCIELNY: Turbine building, directly below the failed piping.

MR. MICHELSON: But it didn't get back into essential switchgear or didn't get into the security system or any of the other funny things?

MR. KOSCIELNY: Not to my knowledge. I wasn't involved in that particular accident.

MR. MICHELSON: Did it release the fire protection in that area?

MR. KOSCIELNY: Not to my knowledge. But I wasn't involved in that --

MR. MICHELSON: See, in Surry it kept setting off fire protection. Maybe there's no fire protection in this area. We'll read the book.

MR. SHEWMON: Okay. Thank you very much.

Any other questions?

[No response.]

MR. CHENG: Frank Witt is next.

MR. SHEWMON: Fine.

[Slide.]

MR. MICHELSON: Are you going to start out now by telling us what MIC is? My main interest is, what is MIC, as opposed to what are all the manifestations of it.

MR. WITT: Yes. I have a very informative videotape on which you can actually see it.

MR. MICHELSON: That would be helpful. But an explanation before the tape would probably be helpful, too, so I know what I'm looking for.

MR. WITT: MIC is microbiologically-influenced corrosion. And this is corrosion that is accelerated by the presence of certain microbes that form colonies on the surface of the piping. And they generate enzymes which accelerate corrosion, acids, or sulfates, and it's just an accelerated corrosion process.

MR. MICHELSON: How do they generate these enzymes? How do they generate them?

MR. WITT: It's part of their metabolism.

MR. MICHELSON: It's an effluent from the microbe?

MR. WITT: Yes. And there are all different types.

MR. SHEWMON: These can be aerobic or anaerobic?

MR. WITT: That's right. They can be either one. They start off as, they require oxygen in the beginning, and then when the tubercles form on top of them, they change to one that doesn't require oxygen. That's where it really gets into the metal, and in no time it could form a pit right through the metal.

MR. MICHELSON: The microbes are following the track of the penetration of the metal then; is that right? They're going right along with them.

MR. WITT: That's right. They're part of it.

MR. MICHELSON: Well, that's a big difference. Do they stay on the surface?

MR. WITT: Oh, no, they go right into the cavity.

MR. MICHELSON: Into the crack in the cavity.

MR. SHEWMON: That's what I meant. They stay on the surface of the metal, and as the metal recedes -

MR. WITT: That's right.

MR. SHEWMON: -- they stay on that receding surface.

MR. MICHELSON: I didn't view this as a big pit. I understand it's almost a microscopic crack, and they're way down inside already.

MR. SHEWMON: Does this go through as a, if it's a carbuncle or whatever your word was, I assume it's round?

MR. WITT: Yes. You'll see it on the videotape.

MR. MICHELSON: Okay.

MR. SHEWMON: And it's round, it goes through as a cylindrical hole, roughly.

MR. WITT: It's a small hole at the surface, and then you have tunnelling under the surface, and you can form big cavities.

MR. MICHELSON: Yes.

MR. WITT: Especially in stainless steel welds.

MR. MICHELSON: Yes.

MR. WITT: Then when it breaks through the surface, it's really only a mil in diameter, and the water passing through it could actually plug up the leak after a while. So it will heal itself up, because of the debris in the water, and it just plugs up the hole.

MR. SHEWMON: And the love chrome and nickel?

MR. WITT: Pardon me?

MR. SHEWMON: They love chrome and nickel?

MR. WITT: Chrome, yes.

MR. SHEWMON: It happens faster in stainless than carbon steel?

MR. WITT: It's a different type of corrosion. In carbon steele, it's a general type corrosion. The tubercles form all over the surface, and they are very large, and they could plug up small bore piping in no time.

MR. MICHELSON: What do they live on? What keeps them going?

MR. WITT: They live on nutrients in the water.

MR. MICHELSON: Yes, but if I envision now a crack or a hole form which they entered the cavity and then you tell me even the hole got plugged, how do they continue to metabolize?

MR. WITT: There are always nutrients present.

MR. MICHELSON: In that microscopic cavity inside the pipe, there's plenty to keep them, all they need to keep corroding all the way through a half an inch of pipe or more?

MR. SHEWMON: The metal is part of the metabolism?

MR. WITT: Yes.

MR. MICHELSON: Well that I didn't realize.

MR. WITT: Well, the enzymes that are formed form acids or sulfates, and that's what accelerates the corrosion.

MR. SHEWMON: So it's actually a dissolution rather than a metabolism of the metal.

MR. WITT: Right.

MR. MICHELSON: They don't eat the metal?

MR. WITT: I don't think so, not really.

MR. SHEWMON: Tom, are you going to --

MR. KASSNER: They have to get rid of the products. But as far as I was led to believe, they can incorporate the metallic ions into the compounds or chemicals that they are metabolizing. In other words, it becomes incorporated in their tubes, or whatever.

MR. LEWIS: I had the impression -- obviously wrong -- that their life process was completely independent of their corrosive influence, that they were living off the water, but that their excrement, if you like, was corroding the metal. But I'm not quite clear. Is that correct? Or do they in fact ingest metal?

MR. WITT: I thought it was the metabolism forms the acids and sulfates which corrode the metal.

MR. LEWIS: The question is, Paul asked why they prefer stainless steel. Is the question that they love the chrome, or that their exudates are more corrosive to the chrome material? They are separate questions.

MR. WITT: In stainless steel, they only attack the weld area, or the heat-affected zone. They don't attack the straight section necessarily.

MR. SHEWMON: But it's a dissolution of all the metal?

MR. WITT: Yes.

MR. SHEWMON: So there's an awful lot of chrome that has to get involved, and the welds have chrome just like the base metal. There may be a percent less or something to get you some ferrite number in there, but actually a percent more to get your ferrite, less nickel.

MR. WITT: Well, why don't we take a look at --

MR. SHEWMON: -- a good way to change the subject.

MR. LEWIS: It would be nice, though, to know what's happening.

MR. MICHELSON: I heard several stories, including the eating the metal versus the effluents attacking the metal. That's why I was curious to get it sorted out by the experts.

I'd heard the horror stories associated with what they do to the pipe.

[Whereupon, a video presentation followed.]

MR. SHEWMON: My impression is that this has been more of a problem in the South than in the North; is that right?

MR. WITT: No. It's a problem in practically every plant.

MR. MICHELSON: Well, apparently, they do live on iron as well. They can do it both ways.

MR. LEWIS: Well, those were dirty pictures.

MR. WITT: MIC is of concern to the NRC, as it can adversely affect the performance of safety-related systems.

Many systems in nuclear facilities may be susceptible to MIC during construction, operation and also during outages. Susceptible components may include storage tanks, tendons used in pre-stressed concrete and containment structures, condenser hot well casings, heat exchangers, fan coolers and piping.

These tendons, that was Fort St. Rain, where there was a microbe that grew in the grease and formed some organic acid and actually broke the tendons.

In operating plants, MIC problems occur predominantly in service water systems. These systems provide cooling water for the -- from the ultimate heat sink to remove heat from plant auxiliaries which are required for safe reactor shut-down and perform required cooling functions following a loss of coolant accident.

Systems and components adversely effected by service water system failures of degradation include: the component cooling water system, emergency diesel generators, emergency core cooling pumps and heat exchangers, residual heat removal systems, containment spray pumps, containment fan coolers, control room chillers and reactor building cooling units.

MR. MICHELSON: Now, it's only on the service water side of those systems that you have the problem; is that right?

MR. WITT: That's right.

MR. MICHELSON: It's not on the -- not on the closed systems themselves?

MR. WITT: This is the raw water coming in from the river or --

MR. MICHELSON: Because you can control the chemistry to keep it out of the other system.

MR. WITT: Well, they also have it in enclosed water systems, if it's not treated -- chemically treated.

MR. MICHELSON: Yes.

MR. WITT: They have that too.

MR. MICHELSON: Okay.

[Slide.]

MR. WITT: Well, what I'd like to review is the prevention, detection, monitoring, mitigation measures and replacement and talk a little bit more about what the video showed.

[Slide.]

MR. WITT: Prevention -- actually it should really start in the design. If the system can be designed so that the flow rate is greater than 3 feet per second, you wouldn't have this problem. At 3 feet per second, the colonies can attach and remain on the surface of the piping. Unfortunately, in service water systems are not operating all the time. Most of the time they shut off and they're only turned on once a month during surveillances. So they're just excellent areas where MIC can occur.

MR. MICHELSON: Fire protection must be in the same category.

MR. WITT: Fire protection is very seriously effected by MIC.

Material selection is another area. A lot of plants started of with carbon steel and service water systems and very soon after operation, the small bore piping were either -- the flow was reduced to such levels that it did not provide enough flow to perform the function in the cooler, or it actually plugged the whole piping.

Like at Limerick plant, after a year or two, they had to replace all their 2-inch piping to the coolers with the stainless steel piping. Stainless steel piping is not the answer either because the MIC attached the weld area and heat infected zone and actually forms cavities under the surface and finally penetrate the weld and cause leaks.

But there are materials which are less susceptible to corrosion. One of them is Allegheny Ludlum 6XN alloy, it's a 6 percent moly and 24 percent nickel. The high-nickel alloys are also less susceptible.

I think the best material is titanium. But, that's pretty expensive. I think it's being used in service water systems.

The Salem plant is replacing all their service water system piping with this 6 moly material. It's pretty expensive, but that's what they're doing.

Also, you should make provisions for cleaning and water treatment. Cleaning is very important. You have to clean off the corrosion products, the tubicles and also clean out the colonies and then after that's cleaned properly, then you could go into a water treatment program. But if it's not cleaned properly, water treatment isn't going to help that much either.

In the design you should minimize low points and the areas of local stagnation, crevices, well backing rings, any place where you can have localized area of low flow, where these colonies can attach itself and generate very rapidly and accelerate corrosion.

In fabrication and construction of the plant, a lot of this occurs at that time too. A lot of piping is left out wet and the piping should actually be stored dry or inside a building and all the systems should be drained after they're used and dried.

During hydrostatic testing, the water should be treated with a biocide. After hydrostatic testing, the system should be dried and drained in dry lay-up. Okay, or you could use corrosion inhibitors and biocides during the lay-up period.

For operation, again, a clean and well-maintained system is very important. If it's cleaned properly, then a water treatment system would be effective.

Also, a relatively high fluid velocities are important, but that is not possible in service water systems, which I just use for intermittent use.

MR. MICHELSON: In the case of boiling water reactors, the RHR heat exchangers, for instance, might be cooled by service water, but they have reactor grade water on the other side --

MR. WITT: Right.

MR. MICHELSON: -- untreated, of course.

MR. WITT: Right.

MR. MICHELSON: How do these things behave under those circumstances? Is it -- is the fact that it's essentially neutral and so forth, keep the bacterial growing or do they grow in an RHR system?

MR. WITT: They do grow in an RHR system.

MR. MICHELSON: But on the RHR -- on the --

MR. WITT: On the service water side.

MR. MICHELSON: No, no, on the other side? On the reactor water side? That's not treated water of course?

MR. WITT: No. I -- well, I suspect that when they go through the monthly surveillances, that there's hot water that passes through that side and that would be --

MR. MICHELSON: Not necessarily, no, not at all.

MR. WITT: No?

MR. MICHELSON: Not necessarily. Now, when they go to shut down cooling, of course, then there's hot water. Well, let's take the case of the suppression chamber, another good example, and a boiler. I don't believe that's treated water at all?

MR. WITT: No, but there are coatings on the suppression -- on the torus.

MR. MICHELSON: Yes, but they aren't coating in the piping. Only the torus is coated. There's no way to coat the piping effectively.

MR. WITT: Well, it's an inert atmosphere, too.

MR. MICHELSON: Well, that's what I'm wondering.

MR. WITT: I haven't heard of any evidence in a primary side.

MR. MICHELSON: Yes. That's true, that's an inert atmosphere. I guess you could argue that there's a lack of oxygen then and, therefore, a non-problem? Is that the way you do it?

MR. WITT: I -- that could be because I have never heard of any -- of this type problem on the primary side --

MR. MICHELSON: I hadn't either --

MR. WITT: -- just on the service water.

MR. MICHELSON: -- but I wondered why not, since you don't treat the water.

Now, the water in the suppression chambers used to get pretty rusty.

MR. WITT: Yes. They have to be cleaned out periodically too. They vacuum clean those out.

MR. MICHELSON: Where is that coming from? Well, there's some --

MR. WITT: Well there's --

MR. MICHELSON: -- kind of a natural corrosive attack, if nothing else.

MR. WITT: -- corrosion from the piping I guess.

MR. MICHELSON: But, do you think that if it's a non-oxygenated atmosphere you're okay?

MR. WITT: Yes. I'm not aware of any -- of MIC problems on primary sides.

MR. MICHELSON: Okay.

MR. WITT: In operation, we talked about water treatment and high fluid velocities and regular maintenance, so this includes routine inspections and thorough cleaning of the systems.

[Slide.]

MR. WITT: Detection, monitoring and diagnosis on the video, we could see by just the color and the shape of the tubercle and the smell of the hydrogen sulfide and the touch of the slime. Those are ways of identifying that MIC is present.

Actually, the NDE can detect the pitting in the piping. This is done periodically in service water systems.

It's being done more now than before.

MR. MICHELSON: But, how -- you don't do that on the bolt metal, do you? You usually do that in --

MR. WITT: This is in welds.

MR. MICHELSON: In welds, yes. But the bulk metal can be attacked as well, since that's all carbon steel.

MR. WITT: Yes. Most -- I think, all the TVA plants had such serious problems with the service water systems that they replaced their carbon steel with 316. They've inspected all the welds.

MR. MICHELSON: I'm not sure. Are you sure all the service water piping has been replaced, or just the small bore stuff?

MR. WITT: The essential raw water for the emergency service water. No, the large piping, too.

Also, water sampling from chemical and microbiological constituents, that's done to find out just how many colonies there are.

MR. MICHELSON: Excuse me, though. If you're replacing the piping isn't the whole answer, because you've got a large number of heat exchangers and so forth. What do you do in that case? You're not putting in stainless steel heat exchangers.

MR. WITT: Well, I know at Surry, they replaced their recirc's, heat exchanger, their three big ones, and --

MR. MICHELSON: Let's take the RHR heat exchangers which you use raw water on.

MR. WITT: They were all corroded because of MIC, and they replaced them with titanium heat exchangers.

MR. MICHELSON: Well, how about in the case of TVA?

MR. WITT: I don't know about TVA.

MR. MICHELSON: Those are carbon steel construction, of course.

MR. WITT: I'm going to Watts Bar tomorrow. I'll try to find out about that.

MR. MICHELSON: Well, Watts Bar won't tell. I was thinking of Browns Ferry, which we'll do in February.

MR. SHEWMON: You've got one more question, now.

MR. MICHELSON: What?

MR. SHEWMON: You've got one more question now.

MR. MICHELSON: Oh, I know. That's why we're getting the education today.

MR. WITT: Okay. And there is also sampling of the solid deposits for a chemical analysis and microbiological analysis. They are also done after failure, and metallurgical evaluations.

Another thing that is done is routine monitoring of system flows, temperatures and pressures, to see whether the effects of MIC are causing a reduction in flow.

MR. MICHELSON: Let's take the case of a pump, for instance, which might only be started once a month for surveillance and -- you know what I'm thinking of, service water pumps.

MR. WITT: Yes.

MR. MICHELSON: Clearly, at the time the pump is running, the velocities and everything are such that there's no problem with the pump casing. But is that pump casing susceptible to MIC in between usages? How fast does this come on, in other words? Usages might be a month apart, or whatever the surveillance might be.

MR. WITT: Pretty rapid. I saw corrosion rates of half an inch a year, or three to five eighths of an inch.

MR. MICHELSON: So, even though you start the pump and you sweep out what was in there, you start new colonies as soon as you shut the pump down?

MR. WITT: It really is necessary to treat these systems.

MR. MICHELSON: Has anybody looked at pump casings, for instance?

MR. WITT: I'm quite sure they've looked at the emergency service water pumps.

MR. MICHELSON: The casings?

MR. WITT: They actually go into a pit, I think, and suck the water up, I believe.

MR. MICHELSON: That's right. Yes. The casing is emerged in the intake structure.

MR. WITT: Right.

MR. MICHELSON: Yes. But that doesn't prevent MIC from growing, the fact that they are submerged. They are stagnant inside.

MR. WITT: Most of the failures that I've seen are in heat exchanger tubes and in piping.

MR. MICHELSON: Yes, but see, if the casing is failing you have no way to know that until it falls down.

MR. WITT: Yes, well that's probably the case.

MR. MICHELSON: You don't see leaks. You might see a flow rate reduction and wonder why it don't pump quite as well as it used to. But it would take a lot of leakage before it would do that.

MR. WITT: We haven't seen any failure of any pumps because of MIC.

MR. CHENG: But the pump casing that, let's say, from in-out stock, you can measure it. You know, any vibrations of thickness

MR. MICHELSON: Well, these are immersed pumps. These are down in the intake filter. You can't see them. You don't know even what's happening to them until the casing falls down. It's supported by its own strength.]

What does this do to the seismic qualification, these kinds of devices?

MR. WITT: Well, even with pits in piping, not our through-wall pits, but there are quite a few pits, say, in a stainless steel weld around the circumference. There are analyses done to show that it still has structural integrity. I'll talk about it later on.

We have a generic letter which addresses repair.

MR. MICHELSON: This doesn't precipitate any circumferential cracking or that sort of thing, it just is a hole?

MR. WITT: Just a hole, right. A pit.

MR. MICHELSON: So, you can get quite a few holes before it --

MR. WITT: Yes. There's still enough strength in the weld.

We also have corrosion monitoring where there's a side stream where coupons are exposed to the water. This is the approach that Watts Bar is using. Other plants are using electro-chemical corrosion probes to determine what's going on, or try to determine.

[Slide.]

MR. WITT: Mitigation measures. Again, water treatment with biocides and, again, effective only when the surfaces are clean.

Typical biocides are sodium hyperchloride, and

Watts Barr is using a mixture of sodium hyperchloride and sodium bromide. But all these biocides have to get a permit from the state so you can discharge this back into the river. Sometimes this is difficult to do.

Other plants, like Duane Arnold, uses sodium hyperchloride, and you can't inject that back into the river, so you have to add something to the sodium hyperchloride to convert it to chloride ions. I think they use sodium thiosulfate, and so that's acceptable. But all these biocide treatments have to get a permit from the state before it can be used in the plant.

MR. MICHELSON: Is there a MIC problem in cases where piping is exposed to excessive moisture, but is not water-filled pipe?

MR. WITT: Yes.

MR. MICHELSON: It doesn't require -- it has to be absolutely dry or you couldn't --

MR. WITT: It's moisture -- moisture and dirt.

MR. MICHELSON: So the fire protection systems, even where they're dried pipe systems, if you've got leaky emission valves or anything of that sort, could provide enough moisture?

MR. WITT: Very significant problems with fire protection systems with MIC.

MR. MICHELSON: Now when you do have a fire and, you know, you open one of the sprinklers, does that tend to tear off these carbuncles and send them down to the nozzle and plug the nozzles or --

MR. WITT: I don't know.

MR. MICHELSON: How lose are they, in other words? How lose is that material that's around this cubicle or whatever you call it?

MR. WITT: I think that they're removed by hydrolazing. I think you need higher velocity flows.

MR. MICHELSON: Yes. That's what I wondered, if you just needed high velocity or you needed to do something -- hydrolazing?

MR. WITT: Not that easily removed.

MR. MICHELSON: Okay. So, they're fairly tenacious, in other words.

MR. WITT: So, cleaning could be done either mechanical, and this is by hydrolazing or some plants send scrapers down the pipes, mechanical scrapers or PIGS, they call them PIGS, they just ream out the piping, and some of them use some sponges to go through heat exchanges to scrub out the inside of heat exchangers. Chemical treatment is also effective.

One thing I wanted to say about biocides. You have to be careful about the biocides, because some of the biocides may be corrosive to the materials in your service water system. So you have to check out your corrosion of your materials in the plant with that biocide before it should be used.

MR. MICHELSON: Now, some people use concrete or glass-lined piping for some of the service water.

MR. WITT: Concrete.

MR. MICHELSON: Does that tend to aggravate the problem? If you get a crack in your concrete and a little moisture gets into the iron concrete interface --

MR. WITT: Cracks or caulking is removed and the concrete is a serious area. That's where these colonies can form an cause corrosion.

MR. MICHELSON: Then they just go on through the metal.

MR. WITT: There are a number of plants that have protective coatings, like coal tar epoxy coatings. Like Surry has coal tar epoxy. Some of the newer coatings are epoxy coatings. Provided that the coating is applied right, that you have a good surface that you apply it to and also that you don't have any holidays. If you have holidays, that's where your colonies are going to form. It's just -- you have to have a good coating and it has to be applied right.

They've had problems with protective coatings where they delaminated from the piping and they wound up on a sheet of -- on a heat exchanger. So, you have to be very careful with that approach too.

Operational controls. When -- during shut-downs, systems should be dry, drained and dry. When they're filled up with water, they should be treated with a biocide.

MR. MICHELSON: But, you can't -- you can't lay by like an RHR heat exchanger, you have to have the service water ready to go on instant notice any time.

MR. WITT: That's right.

MR. MICHELSON: So, you can't drain it and dry it.

MR. WITT: No, no that's right. You can't do it with service water systems. But --

MR. MICHELSON: And you can't treat the water because it gets dumped into the river.

MR. WITT: They take one -- one of the loops out of service for repair to be drained and dried to repair it.

MR. MICHELSON: Yes, true. But that's just a small amount of time you're saving there.

MR. WITT: And to establish flow on a daily basis; that is, jogging the pump daily. But that can't be done on service water systems. And by increasing the temperature above 140 degrees would be effective in killing off some of the colonies. Ultraviolet treatment, ozone is used in some cases, and also cathodic protection has been used in some cases.

MR. SHEWMON: What does cathodic protection protect you from? It doesn't kill the bugs does it?

MR. WITT: Well the -- it's an electrochemical process -- it's --

MR. SHEWMON: I'm some familiar with the electrochemical processes there, that's why I'm asking. You raised the potential or changed the potential, I'm -- how does this -- it inhibits the corrosion?

MR. WITT: It's the same as for normal corrosion, that -- the cathodic protection --

MR. SHEWMON: Will this stop it once it's going, or is it more prevention?

MR. WITT: It's prevention, yes.

MR. MICHELSON: Why does it even prevent it?

MR. LEWIS: I still haven't understood exactly what the process is, but I didn't think it was electrochemical.

MR. WITT: I have some source books here which go into the electrochemical process in detail, which you can take a look at later.

MR. LEWIS: I guess I'm still slightly confused about what these bugs are eating to live on. If one filled these tanks with clean water, would this still happen? Would the bugs still grow? These are bacilli, I guess. You showed them earlier.

MR. WITT: Yes. If we fill it with clean water, the air that's in contact with the water is going to bring the bugs into the water. They're dissolve into the water and the water won't remain clean.

MR. LEWIS: Bugs need more than air to live on, they need something to eat. I'm still unclear about what it is they eat. By clean water, you know, suppose -- if you fill it with distilled water, will these bugs colonize in distilled water?

MR. WITT: No, you need a nutrient.

MR. MICHELSON: Well, I thought the irons ions was what they were eating, according to that movie.

MR. LEWIS: So they actually do eat ions?

MR. MICHELSON: Of course, if you got air in -- even distilled water, gee, that will corrode like mad.

MR. WITT: Well, they can, you know -- forgive me. They may -- they may include iron in their diet, after all, so do we. But that doesn't mean you can live on an iron diet. We sometimes chew nails at these meetings, but it doesn't help a great deal.

MR. MICHELSON: But the inference was they were living on F2 plus.

MR. LEWIS: In the film it showed that they were using -- that the iron was included in their diet, but it did not show that they live on the iron.

MR. MICHELSON: Do they need other things?

MR. LEWIS: I can't believe that they don't require some combustible material to live on. That's sort of the nature of life. So, I'm still bewildered on that point. That sounds like an early course I once took as a matter of fact. And, you know, if you keep it out of the water, I don't see how these bugs can grow.

[Slide.]

MR. WITT: Our replacement, refurbishment, this is being done quite frequently at the plants and a lot of times it's replaced with the same material, but it's recommended that increased tension should be done during the fabrication, keeping materials clean and dry. Then you have proper maintenance, surveillance and water treatment.

MR. MICHELSON: Now, a lot of the service water piping is buried in the ground. How do we know the condition of the buried piping? Browns Ferry is buried in the ground, for instance.

MR. WITT: Yes, I kn ome of it is yes.

MR. MICHELSON: And it's stagnate.

MR. WITT: If it's large enough, they inspect it. They'll crawl through these pipes and --

MR. MICHELSON: Well, no, they aren't large enough to crawl through. They aren't that big.

MR. SHEWMON: If there's a pipe constriction, they think maybe those tubercles got on it.

MR. MICHELSON: If there's enough -- yes, if you could measure -- if you had a good monitoring of your frictional coefficient for that length of piping and you watch it change, and you conclude that it's coming either from asiatic clams or from bacteria growing or something else growing in there.

MR. WITT: There are T.V. monitors that go into the pipes and crawl up to inspect.

MR. MICHELSON: That would be good, yes.

MR. LEWIS: I assume you could culture a sample of the water, if these are bacilli?

MR. MICHELSON: Yes. But that won't tell you how bad off the pipe might be, although it would give you a good hint, I guess.

MR. LEWIS: It would tell you whether you have an infestation.

MR. MICHELSON: Which I guess you always have. I gather they're there ready to go if they find the right environment.

MR. WITT: Right.

Okay. We talked a little bit about coatings and linings.

Epoxy coatings are being used and, in older plants, concrete liners are used.

Replacement for carbon steel. A lot of plants have placed, mostly the small bore piping to stainless steel. The TVA plants -- the -- all the essential grow water piping has been replaced with 316 stainless steel and this was replaced in the early '80s, I think, in most plants. Those have developed leaks too, at the welds.

So, Browns Ferry and Sequoyah and Watts Bar have developed extensive programs to -- to take care of MIC. This involves water treatment and surveillance, maintenance. In the case of Browns Ferry and Sequoyah, their programs are submitted to NRC for approval. We've prepared SERs to approve their program on MIC.

MR. MICHELSON: What's the largest leak that you're aware of that was witnessed from this kind of mechanism? I'm talking about a leak, through-wall leak. What's the biggest one?

MR. WITT: Most of them are real small leaks --

MR. MICHELSON: Yes.

MR. WITT: -- but they spray all over the place, and that's -- that could be a problem, if the spray hits electrical control cabinet that has safety function.

MR. MICHELSON: But have you seen more than one come through at a time on a pipe? Several at once?

MR. WITT: Several places.

MR. MICHELSON: If you get a water hammer or something, I suppose that pops them lose?

MR. WITT: Could be.

MR. MICHELSON: All right.

MR. WITT: I don't think there have been any real severe leaks.

MR. MICHFLSON: From the mechanism you described to me, I didn't see how there could be real severe, since they don't precipitate cracking and gross fractures.

MR. WITT: They usually walk down the service water piping to look for leaks, because the know that one is going to develop sometime or other. So, I think they do that on a weekly basis.

MR. LEWIS: You can do "what if's" all day but in your document there is an estimate somewhere that this kind of leaking is occurring -- two times seven to the minus to per plant year or something like that, so .t's sort of once a year in some plants, roughly, and it also says that the estimate of core melt probability due to this effect is between ten to the minus three and ten to the minus five.

That means that somebody is estimating that when one of these leaks springs there is a chance of between one in ten and one in a thousand of causing a core melt. That seems amazingly high to me for pinhole leaks in service water tanks.

Who made that estimate?

MR. WITT: That came out of an AEOD document.

MR. LEWIS: Out of who ?

MR. WITT: AEOD.

MR. LEWIS: Uh-huh!

MR. SHEWMON: That must have been out of Carl's period.

MR. MICHELSON: No, no.

[Laughter.]

MR. LEWIS: Carl is a well known expert on PRAs.

MR. WITT: I think it was a study on service water systems.

MR. LEWIS: That seems very high to me.

MR. MICHELSON: It does if the mechanism is as described and you never get more than a small pinhole and if you don't get several at a time -- you could get several at a time I guess but you'd have to do some kind of hydraulic disturbance.

MR. LEWIS: One way people sometimes get these large numbers is by lumping things together. That is, they might say that a pinhole leak is a service water failure and then ask what the conditional probability of core melt is in the event of a service water failure and mix this up with real service water.

MR. MICHELSON: That wouldn't be right, yes.

MR. SHEWMON: Well, but in addition to the pinhole leaks he and the movie showed both the filling up of the tube and so the failure may be that if there was enough flow restriction that it can only put out a fraction of what it was rated at.

MR. WITT: I think that's it.

MR. MICHELSON: Well, we have got another program.

MR. WITT: The flow in the heat exchangers was not checked.

MR. MICHELSON: Well, there is a program for that.

MR. LEWIS: But that is not happening in a ten to the minus two probability.

MR. MICHELSON: And there is a program to determine whether or not that is happening -- that service water generic letter.

MR. WITT: There have been an awful lot of heat exchangers, safety related heat exchangers where it was found that there was not sufficient flow to them because of this problem.

MR. LEWIS: Well, you know, you can be overly conservative and you can do a PRA very wrong by calling a flow restriction a failure and then going on from there.

One simply has to see the details.

MR. WITT: Now the replacement for stainless steel is Allegheny Ludlum, six percent moly, 24 percent nickel and this is being done at one by Hope Creek -- the Salem plant, right.

MR. MICHELSON: Now it's attacked also but slower, was that what I thought I heard? This new material, it is susceptible to attack but at a much slower rate, or is it just immune to attack?

MR. WITT: It's the best material that they found so far.

MR. MICHELSON: What does that mean?

MR. WITT: Well, it has --

MR. SHEWMON: It means it's at least a factor or two better than stainless steel so they'll pay twice as much for it if they can sell it.

MR. WITT: Titanium is the best material but nobody is replacing service water systems except for condenser tubes.

MR. MICHELSON: How about gold, while you're at it? Wouldn't gold be pretty good protection?

MR. SHEWMON: Not as strong as titanium.

MR. MICHELSON: No.

[Slide.]

MR. WITT: Here are some of the service water system problems -- flow reduction and also there is actually flow blockage in case of two inch lines for coolant.

Now fouling of heat exchanger tubes, this is another problem. The MIC corrosion causes a corrosion film on the service water heat exchangers.

Through-wall pitting and heat exchanger tubes, one problem was in lube oil cooler for diesel generator where it perforated the walls of the tubes so the water was going into the lube oil and that made the diesel generator inoperable.

For piping, many cases of piping failure, the sprays from the failure can hit safety-related electrical equipment.

Some plants actually put boots around the leaks before they get a chance to repair it so they direct the spray into a drain and prevent it from spraying all around the local area.

MR. MICHELSON: Now some water systems have expansion problems so they have used a number of expansion bellows to take care of some of their problems.

How do these things go after expansion bellows in a service water system? I notice you are talking about pretty thin wall if anything goes wrong.

MR. WITT: I haven't seen anything on that.

MR. MICHELSON: You haven't run into expansion bellows or have you just not looked for them?

They are there.

MR. WITT: I haven't heard of any MIC problems.

MR. MICHELSON: It may be the material is not susceptible to attack.

MR. WITT: What material?

MR. MICHELSON: I don't know. I don't recall what the material was for those bellows.

MR. WITT: It wouldn't attack that. It would only attack the weld areas.

MR. MICHELSON: As I say, it may be that the bellows are okay because they are good material, however depending on whether they're form or welded bellows too. You could have a lot of weld area --

MR. SHEWMON: Is it primarily in the sensitized zone or will the weld metal itself be --

MR. WITT: Both areas, in the weld material itself and the heat affected zone.

MR. MICHELSON: Now it is still much better though than the old carbon steel pipe.

MR. WITT: From the standpoint of not reducing the flow to the heat exchangers below what's required for the safety function.

MR. MICHELSON: From the viewpoint of attack, biological attack, is it less susceptible?

MR. WITT: You don't get as much corrosion products to reduce the flow so you don't have sufficient flow for safety.

MR. MICHELSON: No, but how long does it take to make a hole in the weld, compared with carbon steel?

MR. WITT: Oh, it's fast too. It's half inch per year.

MR. MICHELSON: Oh, you mean there is no difference in the rate of penetration?

MR. WITT: I don't think so.

MR. MICHELSON: Between stainless and carbon?

MR. SHEWMON: The safety issue is plugging the line, not spraying the countryside.

MR. MICHELSON: Or spraying the electrical equipment on the outside.

I can think of several places where there's small bore water piping running around very sensitive electrical equipment.

Well, you have got to get to cooling the small devices on the generators and so forth.

[Slide.]

MR. WITT: Yes, I talk about the generic letter on service water problems and where MIC was addressed.

One of the requirements is for a program to preclude biofouling.

That's both the macro and the micro biofouling by using biocides.

Also there's a test program to verify the heat transfer capability of safety-related heat exchangers and also it requires a routine inspection-maintenance program to remove excessive accumulations of corrosion products and biofouling agents and silt and also requires the repair of defective protective coatings and corroded piping and components.

MR. MICHELSON: Are there biocides effective in open cycle systems?

MR. WITT: Yes. You have to keep injecting them.

MR. MICHELSON: And there are biocides you can put in that you can feed back to the river?

MR. WITT: Yes. You have to get a permit for it, still.

MR. MICHELSON: Because there was always a problem with the Asiatic clams and how much chlorine you could put in.

MR. WITT: You can't use chlorine. Yes, right. You only could do it for a certain time.

MR. MICHELSON: There was another biocide that was very effective, too. But it turned out that was not good for the environment, either.

MR. SHEWMON: A biocide inside your plant, I can imagine might be a biocide outside of it, too.

MR. MICHELSON: Yes.

[Slide.]

MR. WITT: Okay. We have a generic letter out, 90-05, for guidance and performing temporary non-code repair for Code Class 1, 2 and 3 piping.

This generic letter says the temporary non-code repair is acceptable until the next reviewing, the next scheduled outage exceeding thirty days, but no later than next refueling outage.

That's provided that the structural integrity is maintained or ensured.

MR. MICHELSON: What's a non-code repair? Does that mean just plug the hole itself?

MR. WITT: It could -- it doesn't have to be a welded repair. It could be a clamp.

MR. MICHELSON: Okay.

MR. WITT: On Class 3, it could be a clamp arrangement or something.

Temporary non-code repair unacceptable without specific relief from NRC. So, it actually has to be a submittal to NRC to grant relief. Non-welded repairs may be considered. That's for Class 3 piping.

Along with this, augmented inspection is required. That means you have to look at the piping more frequently to see that you're not springing any more leaks. The ASME code committee, which is presently considering this non-code repair of Class 3 pipes.

MR. MICHELSON: How well can you determine wall thicknesses on piping that has a whole lot of junk on the inside surface, and so forth?

MR. WITT: I think ultrasonics does a good job. I think --

MR. MICHELSON: Still, no problem with the roughness of the inside surface?

MR. SHEWMON: I think it's a discontinuity and mass.

MR. MICHELSON: Yes. That's all you -- it's pretty -- so there's no problem in measuring wall thickness.

Now, does the ultrasonics pick up these pinholes? The detector would have to be right on top of them, somehow, wouldn't they?

MR. WITT: Yes. The radiography is better for that. That's what TVA has been using, radiography.

MR. MICHELSON: I see.

MR. LEWIS: There is a comparable problem that DOE has, that they didn't publicize a lot. Finding how much plutonium has been deposited in the duct work at Rocky Flats. It's a comparable problem. Thin steel ducts with plutonium on the inside.

The only way it could, in the end, be done was to poke a hole in it and put in a camera and take pictures. They tried all sorts of external testing techniques.

MR. SHEWMON: There was no radiation that comes through there?

MR. LEWIS: No. They just couldn't find any way of doing it.

MR. SHEWMON: Onward.

[Slide.]

MR. WITT: So, this is what industry is doing. This is a service order working group which was established in 1988. Fifty utility experts, 28 utilities, and EPRI is deeply involved in it. They meet three times a year.

[Slide.]

MR. WITT: These are the objectives. To provide timely resolution or input to industry on service water systems. Improve technology transfer, and provide input to EPRI R&D.

MR. SHEWMON: When was this working group set up?

MR. WITT: In 1988.

MR. SHEWMON: Do they go on until people quit wanting to come, or is there a particular set of documents they're committed to get out?

MR. WITT: There's enough work in the service water system to keep them working for years, I think.

MR. SHEWMON: Okay.

MR. WITT: The video tape that you saw is a product of that working group.

MR. SHEWMON: You've got a list of more of them here.

MR. WITT: Yes. Seminars and workshops. I have two documents that I put out. One is a source book for microbiologically Influenced Corrosion. Nuclear Power Plants is another one on detection and control of MIC.

This one goes into electro-chemical reactions involved in the MIC process.

MR. MICHELSON: Does this same working group deal with all service water problems, or just this biologically related?

MR. WITT: All service water.

MR. MICHELSON: All service water problems.

MR. WITT: I think they started up when they found out we were working on a generic letter on service water systems.

MR. MICHELSON: So, it's just a continuation of that kind of --

MR. WITT: Yes.

MR. MICHELSON: Okay.

MR. WITT: But this is one of the main topics.

MR. MICHELSON: Uh-hum. So, they are the outfit that will deal with the Asiatic clams and other kinds of growth?

MR. WITT: That's right. They just had a symposium in Orlando in macrofouling, in December.

MR. MICHELSON: Yes.

MR. WITT: That's about all that I have.

MR. SHEWMON: Okay. Thank you very much.

MR. MICHELSON: I thought that was real interesting.

MR. SHEWMON: I remember Joe Danko called me a year or two ago and said, have you heard about microbiologically induced fouling? He says, you guys ought to be looking at it. It's a big problem.

MR. WITT: Yes. I met him last October. I gave a paper at an international symposium on MIC, and he was one of the chief organizers from the University of Tennessee.

MR. SHEWMON: Yes. He's gotten quite interested in it.

MR. MICHELSON: TVA supporting him?

MR. WITT: He was asking me, when is NRC going to write a Reg Guide on this? So I said, why don't you start working on an ASTM committee to start working on it. And that's what he is going to do in March, I think. There's one in Cincinnati, a meeting that they're going to start something up on MIC, on one of the ASTM committees, corrosion committees.

MR. MICHELSON: What effect does silt have on this corrosion phenomenon? What does it do? Because it tends to end up in the lower parts of the building when you're using service water, and it settles out and it tends to plug pipes too. But does it have any effect on the rate of growth, or anything of that sort? Or, do we know that much?

MR. WITT: I don't know.

MR. SHEWMON: It would cut down local flow, if that would help you.

MR. MICHELSON: On the other hand, you can argue that you sandblast the pipe whenever you do have flow.

MR. LEWIS: Can't you just pasteurize the stuff? Can't you just keep the water to 200 degrees for a day or two, and then be done with it? There shouldn't be any live bugs left. I'm serious.

MR. MICHELSON: There would be a lot of clam shells around if you do. Because the clams are growing in there.

MR. SHEWMON: If heating to 140 degrees was enough to do it, and that's one of the options here.

MR. WITT: But I haven't heard of anybody doing it, though.

MR. SHEWMON: Fine. I guess that does it. Thank you very much for coming down.

MR. CHENG: Do we want to come back tomorrow?

MR. SHEWMON: No, I don't think so. This is for the information of the subcommittee.

MR. CHENG: How about erosion and corrosion? I thought that you wanted to ask us to come back tomorrow?

MR. SHEWMON: No. For what?

MR. CHENG: For erosion and corrosion.

MR. SHEWMON: No.

MR. MICHELSON: That TV film was nice, if they brought it in at noontime or something for those that are interested. I found it kind of fascinating.

MR. SHEWMON: Could we keep that for a day and send it back to you?

MR. WITT: Yes.

MR. SHEWMON: Okay, fine.

MR. MICHELSON: Maybe it would be useful to show at noontime for those that want to stick around. I'd like to see it again so I'll remember it. I missed a few things.

MR. SHEWMON: Okay. Meeting adjourned.

[Whereupon, at 3:00 p.m., the meeting was adjourned.]

REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission

in the matter of:

NAME OF PROCEEDING: ACRS Materials and Metallurgy

DOCKET NUMBER:

PLACE OF PROCEEDING: Bethesda, Maryland

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

Marilyn Estep

Official Reporter
Ann Riley & Associates, Ltd.

GI-29, BOLTING DEGRADATION OR FAILURE IN NUCLEAR POWER PLANTS

- o SUMMARY (R. Baer)
- o INDUSTRY PROGRAM (R. Johnson)
- o PAST AND ONGOING NRC EFFORTS ON BOLTING (T. Y. Chang)
- o SURVEY OF BOLTING DEGRADATION/FAILURE (J. Davis)
- o PROPOSED RESOLUTION (R. Baer)

SUMMARY OF INDUSTRY RECOMMENDED PROGRAM

- EPRI ORGANIZED THE DEVELOPMENT OF A GENERIC PROGRAM
- BROAD PARTICIPATION BY MANY INDUSTRY GROUPS
- OUTPUT
  - EPRI NP-5769, VOLS 1&2
  - EPRI GOOD BOLTING PRACTICES MANUALS
  - VIDEO TAPES (PARTS I, II, & III)
- EPRI RECOMMENDS DEVELOPMENT AND IMPLEMENTATION OF A PLANT-SPECIFIC BOLTING INTEGRITY PROGRAM
  - STAFF HAS SOME QUALIFICATIONS AND EXCEPTIONS, BUT BASICALLY AGREES WITH THE RECOMMENDED PROGRAM

SUMMARY OF NRC ACTIVITIES ON BOLTING

- RELATED GENERIC COMMUNICATIONS
  - 7 BULLETINS, 2 GENERIC LETTERS, 1 CIRCULAR, AND 11 INFORMATION NOTICES
  - BULLETIN 82-02
  - BULLETIN 87-02
  - GENERIC LETTER 88-05
  - GENERIC LETTER 89-02
- USI - A46
  - ADDRESSES ADEQUACY OF EQUIPMENT ANCHORAGES
  - SAFE SHUTDOWN REQUIRED FOR SSE
- INDIVIDUAL PLANT EXAMINATION FOR EXTERNAL EVENTS
  - WILL ADDRESS ADEQUACY OF EQUIPMENT ANCHORAGES
  - SEISMIC EVENTS BEYOND SSE TO BE CONSIDERED

BOLTING DEGRADATION OR FAILURE - GSI-29

PRESENTATION TO THE ACRS

RICHARD E. JOHNSON
EIB/DSIR/RES/NRC

JANUARY 9, 1991

<u>OUTLINE</u>

1. HISTORY OF GSI-29
2. EPRI RESEARCH RESULTS
3. NUREG-1339 HIGHLIGHTS

HISTORY

1. BOLTING: ORIGINALLY PART OF USI A-12 (1978)
   STRUCTURAL INTEGRITY
   - "POTENTIAL FOR LOW FRACTURE TOUGHNESS AND LAMELLAR TEARING IN PWR STEAM GENERATOR AND REACTOR COOLANT PUMP SUPPORTS"
   - ALSO SEPARATED: GSI-15, "RADIATION EFFECTS ON REACTOR VESSEL SUPPORTS"
   - BOLTING NAMED A SEPARATE G.I. MAY, 1981
   - IDENTIFIED AS GSI-29 APRIL 25, 1983
   - PRIORITIZED HIGH NOVEMBER 30, 1983

2. AIF COMMITTEE CHARTERED TO ADDRESS BOLTING WITHIN USI A-12 PER NUREG-0577, FOR COMMENT (OCT., 1979)

3. UNDER EPRI, INDUSTRY PROGRAM EVOLVED INTO 19 TASKS
   - STATED GOAL: PROVIDE BASIS FOR GSI-29 RESOLUTION
   - PRODUCTS:
     (1) R. E. NICKELL, "DEGRADATION AND FAILURE OF BOLTING IN NUCLEAR POWER PLANTS," EPRI NP-5769, VOLS. 1 AND 2, APRIL, 1988
     (2) EPRI VIDEO TRAINING TAPES, "PRESSURE BOUNDARY BOLTING PROBLEMS," PARTS I, II AND III (1987)
     (3) BOLTING MANUALS, LARGE (VOL. I, 1987) AND SMALL (VOL. II, 1990) BOLTS

EPRI RESULTS

1. TASKS

(1) PRIORITIES/SAFETY SIGNIFICANCE
(2) CORROSION LITERATURE SURVEY
(3) STRESS-CORROSION CRACKING
(4) HARDNESS DATA ASSESSMENT
(5) BOLTING DATABASE
(6) NUCLEAR SPECS./STDS.
(7) ASME CODE REQUIREMENTS
(8) DEVELOP FIELD NDE
(9) INFORMATION EXCHANGE
(10) SCREENING/CORRECTIVE ACTION
(11) RECOMMEND SEC. XI CHANGES
(12) RECOMMEND RESEARCH
(13) ALTERNATIVE MAT'LS./COATINGS
(14) SUPPORT BOLTING SCREENING CRITERIA
(15) ASSESS INTEGRITY BASED ON F.M.
(16) PRELOAD EVALUATION
(17) UT FOR HIGH-STRENGTH INSP.
(18) HIGH-STRENGTH BOLTING
(19) OWNER'S GROUPS LIAISON

EPRI RESULTS (CONT'D)

2. EPRI NP-5769

VOLUME 1

1. INTRODUCTION
2. INDUSTRY RESOLUTION OF THE BOLTING ISSUE
3. PRESSURE BOUNDARY BOLTING
4. STRUCTURAL AND COMPONENT SUPPORTS
5. OWNERS' GRP. SUMMARY
6. ASME & ASTM CODES/ STANDARDS
7. NDE OF BOLTING
8. LUBRICANTS AND SEALANTS
9. ALTERNATIVE MAT'LS.
10. TRAINING PACKAGE
11. CONCLUSIONS/ RECOMMENDATIONS

VOLUME 2

1. UTILITY RECOMMENDATIONS AND GUIDELINES ...
2. STANDARD TEST METHOD (EQUOTIP HDN)
3. EVAL. OF BOLTING EXPERIENCES IN PRIMARY PRESSURE BOUNDARY CLOSURES
4. SAMPLING INSP./ACCEPT. CRITERIA
5. NUCLEAR STRUCTRUAL BOLTING PRELOAD EVAL.
6. THE BOLTING DATABASE
7. ASSESSMENT OF FIELD HDN (MIDLAND)
8. GOOD BOLTING PRACTICES
9. ASME CODE BOLTING RULES
10. CRITIQUE OF CODE PRELOAD (ASME/AISC)
11. EVAL. PROCEDURE FOR SUPPORT BOLTING
12. ALTERNATE ALLOYS
13. ASTM STD. FXXX FOR NUCLEAR FASTERNERS
14. THE BOLTING TECHNOLOGY COUNCIL

<u>NUREG-1339</u>

"RESOLUTION OF GENERIC SAFETY ISSUE 29:
BOLTING DEGRADATION OF FAILURE IN NUCLEAR POWER PLANTS,"
NRC, JUNE, 1990

1. INTRODUCTION
   1.1 THE BOLTING SAFETY ISSUE
   1.2 PROBLEM
2. INDUSTRY RESOLUTION
   (AN EXECUTIVE SUMMARY OF EPRI NP-5769)
3. CONCLUSIONS
   - BASIS FOR RESOLUTION AT HAND
   - NRC DISAGREEMENTS
     (1) EXPAND SEC. 11, VOLUME 2
     (2) SPECIFY Y. S. LESS THAN 150 KSI RE: SCC
     (3) AUDIT HARDNESS CONVERSIONS
     (4) EMPHASIZE MoS_2 AVOIDANCE
     (5) EMPLOY UP-TO-DATE F.M. ANALYSES
4. NUREG-1339 GIVEN TO ASME CODE COMMITTEE; AGENDA NUMBER ASSIGNED

BOLTING DEGRADATION OR FAILURE - GSI-29

PRESENTATION TO THE ACRS

T. Y. CHANG
EIB/DSIR/RES/NRC

JANUARY 9, 1991

OUTLINE

1. PAST AND ONGOING NRC EFFORTS
2. PAST AND ONGOING INDUSTRY EFFORTS

PAST AND ONGOING NRC EFFORTS ON BOLTING

- o NRC ISSUED BULLETINS, GLs AND INs ON BOLTING-RELATED ISSUES. BULLETINS AND SOME GLs REQUIRED ONE-TIME ACTIONS AND CONTINUING PROGRAMS

- o IMPLEMENTATION OF NRC PROGRAMS (USI A-46 AND IPEEE) PROVIDES FURTHER BASES THAT ACTIONS CONCERNING DEFICIENT SUPPORTS/BOLTING ARE ADEQUATE

  - WALKDOWN REVIEW OF BOTH PROGRAMS WILL ADDRESS INADEQUACIES OF SUPPORTS (AND THEIR BOLTING) DUE TO DESIGN AND INSTALLATION

  - USI A-46 WILL EVALUATE FOR SSE LEVEL

  - IPEEE WILL EVALUATE FOR GREATER THAN SSE LEVEL

NRC EFFORTS (CONTINUED)

RCPB BOLTING DEGRADATION IN PWRs

Document	Contents	Actions Req'd/ Recommended	Actions (one-time/ continuous program)	Close-out Document	Conclusions of Close-out Document
IEB 82-02 (also, IN 80-27, IN 82-06)	o Described experience (Wastage & SCC) o Req'd actions	o Devel. & Implement Maint. procedures o Inspect when joints opened o Identify & report problems	C C O	NUREG-1095 (5/85)	o Evaluated responses from 41 licensees o 10% bolted connections showed leakage, but decreases as plants age o Improper lubricant seems to be a common reason for bolting degradation
GL 88-05 (50.54f) (also, IN 80-27, IN 86-108)	o Described wastage exp. from past INs, IEB o Request assurances that program exists	Program should include: o Determination of principal leakage locations with rate less than tech spec limits o Procedures to locate leak o Methods for exam. and eval. o Corrective actions	C C C C	NUREG/CR - 5576 (6/90)	o Responses from 50 licensees, audited 10 o Plants have varied wastage prevention programs o All plants have wastage prevention programs and training programs for inspectors o All plants (except one) kept relatively clean o Most plants cleaned leakage quickly or drained/contained leakage

NRC EFFORTS (CONTINUED)
NON-CONFORMING, MISREPRESENTED, COUNTERFEIT, FRAUDLENT BOLTING

Document	Contents	Actions Req'd/ Recommended	Actions (one-time/ continuous program)	Close-out Document	Conclusions of Close-out Document
NRC CB 87-02 & Suppl. 1&2 (also, SECY 90-057)	o Testing bolting to determine conformance with mat. specs	o Report receipt inspection & internal controls program o Test & report 10 SR, 10 NSR bolts/nuts o Describe further actions needed to meet requisite specs & requirements	C O C	NUREG-1349 (6/89)	o Out of spec: 8% SR - 2% significant 12% NSR o Results did not indicate safety concern regarding counterfeit/mismarked bolts o Should improve QA/ receipt inspection (SECY 90-057)
GL 89-02 (for info)	o Actions to improve detection of counterfeit & fraudulent products	Recommended actions o Eng. involv. in procurement process o Proper receipt insp. & test criteria, effective vender audits o Commercial-grade dedication process	C C C	-	-

NRC EFFORTS (CONTINUED)

NON-CONFORMING, MISREPRESENTED, COUNTERFEIT, FRAUDULENT BOLTING

Document	Contents	Actions Req'd/ Recommended	Actions (one-time/ continuous program)	Close-out Document	Conclusions of Close-out Document
IN 86-25	o Alert licensees to defic. in mat. traceability & control. espe. fasteners	Recommend to o Review IN o Emphasize proper receipt insp. & qualified personnel	O C	-	-
IN 89-22 IN 89-56	o Alert licensees to Questionable cert. of fasteners/ materials	Recommend to o Review IN & Consider Actions as needed	C	-	-
IN 89-59 & Suppl. 1&2	o Inform licensees of names of suppl./manuf. from NRCCB 87-02	Recommend to o Review IN & Consider Actions as needed	C	-	-
IN 89-70 & Suppl. 1	o Provide info to detect misrepresented vender products	Recommend to o Review IN & Consider Actions as needed	C	-	-

NRC EFFORTS (CONTINUED)

STRESS CORROSION CRACKING OF COMPONENT INTERNALS BOLTING

Document	Contents	Actions Req'd/ Recommended	Actions (one-time/ continuous program)	Close-out Document	Conclusions of Close-out Document
NRCB 89-02	o Alert licensees to SCC of internal bolting in certain types of swing check valves	o Identify, disass. & inspect certain types of CV that may have Type 410 S.S. retaining block studs	O	N/A	-
	o Req'd actions	o Take approp. actions if Type 410 S.S. bolting of suff. high hardness (prone to SCC)	C		
IN 90-68	o Alert PWR licensees of potential IGSCC of S.S. RC pump bolts fastening turning vanes	Recommend to o Review IN & Consider Actions as needed	C	-	-

NRC EFFORTS (CONTINUED)

MISCELLANEOUS BOLTING PROBLEMS

Document	Contents	Actions Req'd/ Recommended	Actions (one-time/ continuous program)	Close-out Document	Conclusions of Close-out Document
IN 88-11	o Alert licensees to potential failure to bolts splicing bus bars in MCC & Switchboards o Prob. was over-torquing of silicon bronze bolts	Recommend to o Review IN & consider actions as needed	C	-	-
IN 90-79	o Alert licensees to potential stud failure in certain types of MS isolation CV resulting in disc separation o Prob. was high-cycle, low-stress fatigue of stud connecting disc to swing arm	Recommend to o Review IN & consider actions as needed	C	-	-

INDUSTRY EFFORTS

- o AIF/MPC/EPRI TASK GROUP
- o OUTPUTS
  - EPRI NP-5769, V. 1&2
  - EPRI GOOD BOLTING PRACTICES MANUAL (V. 1&2)
  - VIDEO TRAINING TAPES (3 PARTS)
- o REFINEMENTS IN CODES AND STANDARDS
  - ASME B&PV CODE
  - ASTM (E.G. COMMITTEE F16 on FASTENERS)
- o INPO ISSUED A NUMBER OF DOCUMENTS, NOTABLY SOER 84-5, AND RECOMMENDED ACTIONS IN RESPONSE TO BOLTING DEGRADATION
- o NUMARC ISSUED A LETTER TO MEMBERS (7/6/89)
  - INFORMING THEM OF PUBLICATION OF EPRI NP-5769
  - STATING THAT EPRI PUBLICATIONS (NP-5769, GOOD BOLTING PRACTICES MANUAL) PROVIDE INDUSTRY'S TECHNICAL BASIS FOR RESOLUTION OF GSI-29

PROPOSED RESOLUTION OF GSI-29

- REGULATORY ANALYSIS RESULTS PROVED TO BE INCONCLUSIVE REGARDING A MANDATORY PROGRAM ON SAFETY-RELATED BOLTING FOR OPERATING PLANTS

- WITH SOME EXCEPTIONS AND QUALIFICATIONS, RES AND NRR BOTH ENDORSE THE INDUSTRY PROPOSED BOLTING INTEGRITY PROGRAM AS BASIS FOR RESOLUTION OF GSI-29

- INDUSTRY TO CONTINUE COMMITTED ACTIONS IN RESPONSE TO NRC BULLETINS AND GLs

- A NEW SRP SECTION OF "SAFETY-RELATED BOLTING" TO BE DEVELOPED BY NRR FOR FUTURE PLANTS

- RES PROPOSES ISSUING GL FOR INFORMATION (INCLUDING NUREG-1339)

  - INFORMS INDUSTRY
  - MAKES SUGGESTIONS
  - DOES NOT REQUIRE SPECIFIC ACTION

- NRR PROPOSES ISSUING 50.54(f) TYPE GL

- STAFF SEEKS ACRS ADVICE

LEAK - BEFORE - BREAK PROPOSAL

1. IN NP-5769, VOL. 1, SEC. 3, "PRESSURE BOUNDARY BOLTING," EPRI PROPOSED LBB TO ENSURE CLOSURE INTEGRITY.

2. BOLTED CLOSURE/WELDED JOINT SIMILARITIES:
   MAT'L. SELECTION; DESIGN, PSI AND ISI REQUIREMENTS; MANUFACTURING/CONSTRUCTION CONTROLS.

3. BOLTED CLOSURES FEATURE REDUNDANCY.

4. NECESSARY CONDITIONS CITED (P. 3-2)
   - PLANT CONDITIONS ENSURE LBB
   - LEAKAGE IS SAFETY-ACCEPTABLE
   - MARGIN (LEAK DETECTION TO BREAK) IS SUFFICIENT

5. NOTE: G. L. 88-05 (BORIC ACID/WASTAGE) SET LEAKAGE BELOW T. S. ALLOWABLES.

6. EPRI PROPOSED A LBB STRATEGY (P. 3-15)

7. EPRI PROPOSED ACCEPTANCE CRITERIA (P. 6-3)

8. CODE CASE PREPARED AND SUBMITTED TO ASME CODE, SEC. XI; UNDER STUDY BY COMMITTEE WITH NRC PARTICIPATION.

9. NRC STAFF IN SUBSTANTIAL AGREEMENT.

NRR STAFF PRESENTATION TO THE ACRS

SUBJECT: GENERIC ISSUE 29
BOLTING ISSUES AND PROBLEMS

DATE: JANUARY 9, 1991

PRESENTER: JAMES A. DAVIS

PRESENTER'S TITLE/ BRANCH/DIVISION:

MATERIALS ENGINEER
NRR/ DET

DIVISION PRESENTER'S NRC TEL. NO:

(301) 492-0713

SUBCOMMITTEE: MATERIALS AND METALLURGY

OUTLINE

- Boric Acid Corrosion
- Stress Corrosion Cracking
- Safety Significance
- NRR Action Plan

BORIC ACID CORROSION

- First Occurrence - 1968
- Latest Occurrence - 1989
- Corrosion Of Carbon And Low Alloy Steel Caused By Leaks From Pressure Boundary Systems - Borated Water

STRESS CORROSION CRACKING
HIGH STRENGTH STAINLESS STEELS

- 410 ss Valve Stems and Valve Internals
- Improper Tempering - Excessive Hardness
- 17-4 PH ss Shows Similar Behavior
- Proper Tempering Temperatures Are
  410 ss - 1125 TO 1350 F
  17-4 PH ss - >1100 F
- Avoid Contact With, Cu, S, Cl-, F, Boric Acid
- All Anchor Darling Valves Inspected

GENERIC ISSUE 29
SAFETY SIGNIFICANCE

- Bolting in Structural Applications-Highly Loaded Under Faulted and Accident Conditions. Degraded, Loose, or Missing Bolts May Result in System Failure.
- Bolting with Manufacturing Defects May Cause System Failure. (Broken Ice Condenser U-Bolts Could Result in Ejection of Ice Basket)
- Counterfeit Bolts- From a Small Sample, No Counterfeit Bolts were Found, but 10% Were out of Spec., 1% Seriously out of Spec.

GENERIC ISSUE 29
SAFETY SIGNIFICANCE

- A Given Type of Bolting May be used in a Number of Components: i.e., Over-Hardened 410 SS in Anchor Darling Check Valves.
- Severe General Corrosion of Bolts Caused by a Leak Could Result in "Unzippering."

GENERIC ISSUE 29
NRR ACTION PLAN

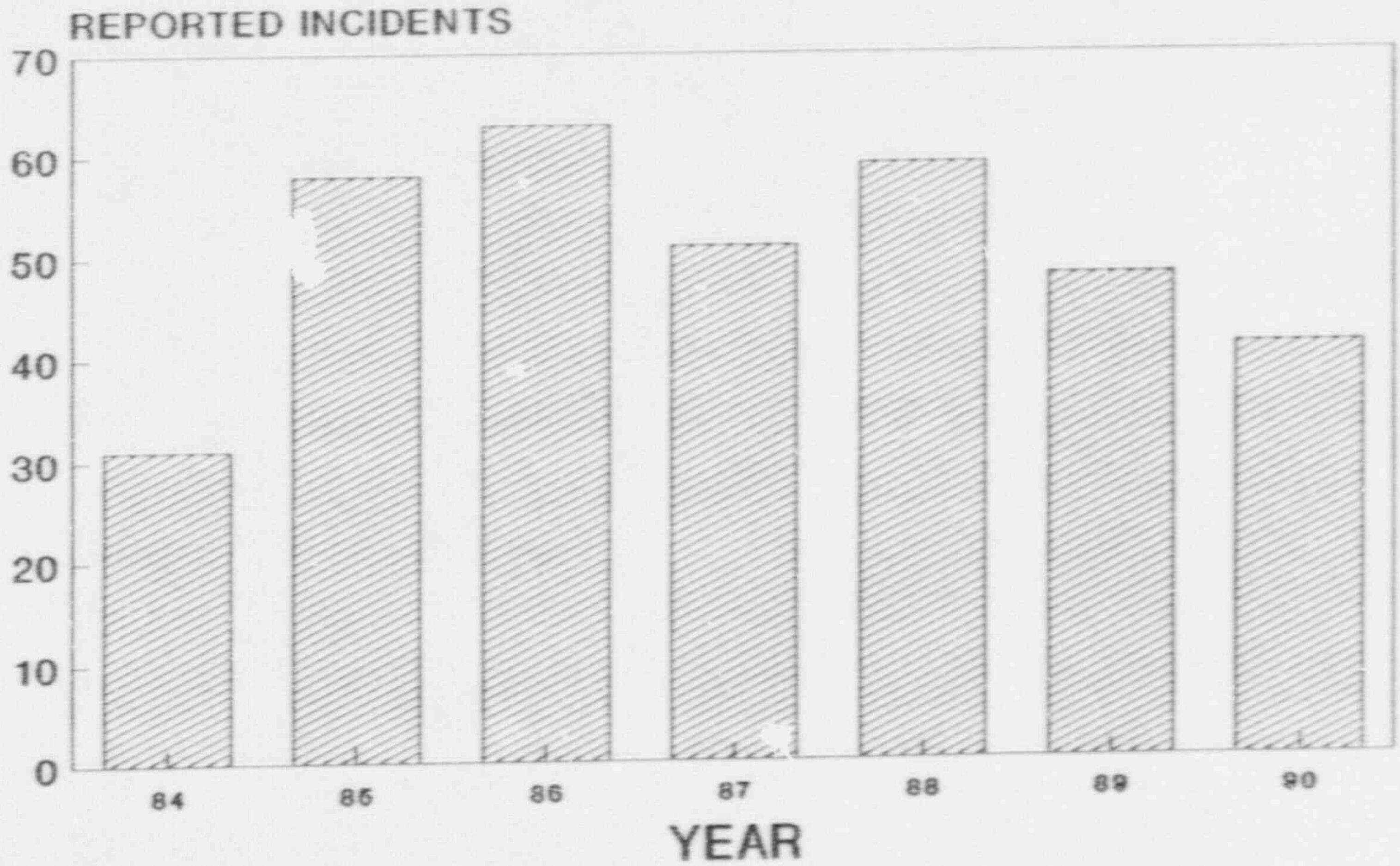
ACTION	CONTACT
LER Search	M. Poore ORNL
Receiving Inspections	R. McIntyre RVIB
Generic Letter to Assess Industry Implementation of EPRI Bolting Manuals	
Assess Need for Future Action	

GENERIC ISSUE 29
LER SEARCH

- Oak Ridge Searched LER's - 1984 to Sept., 1990
  349 Incidents Reported.

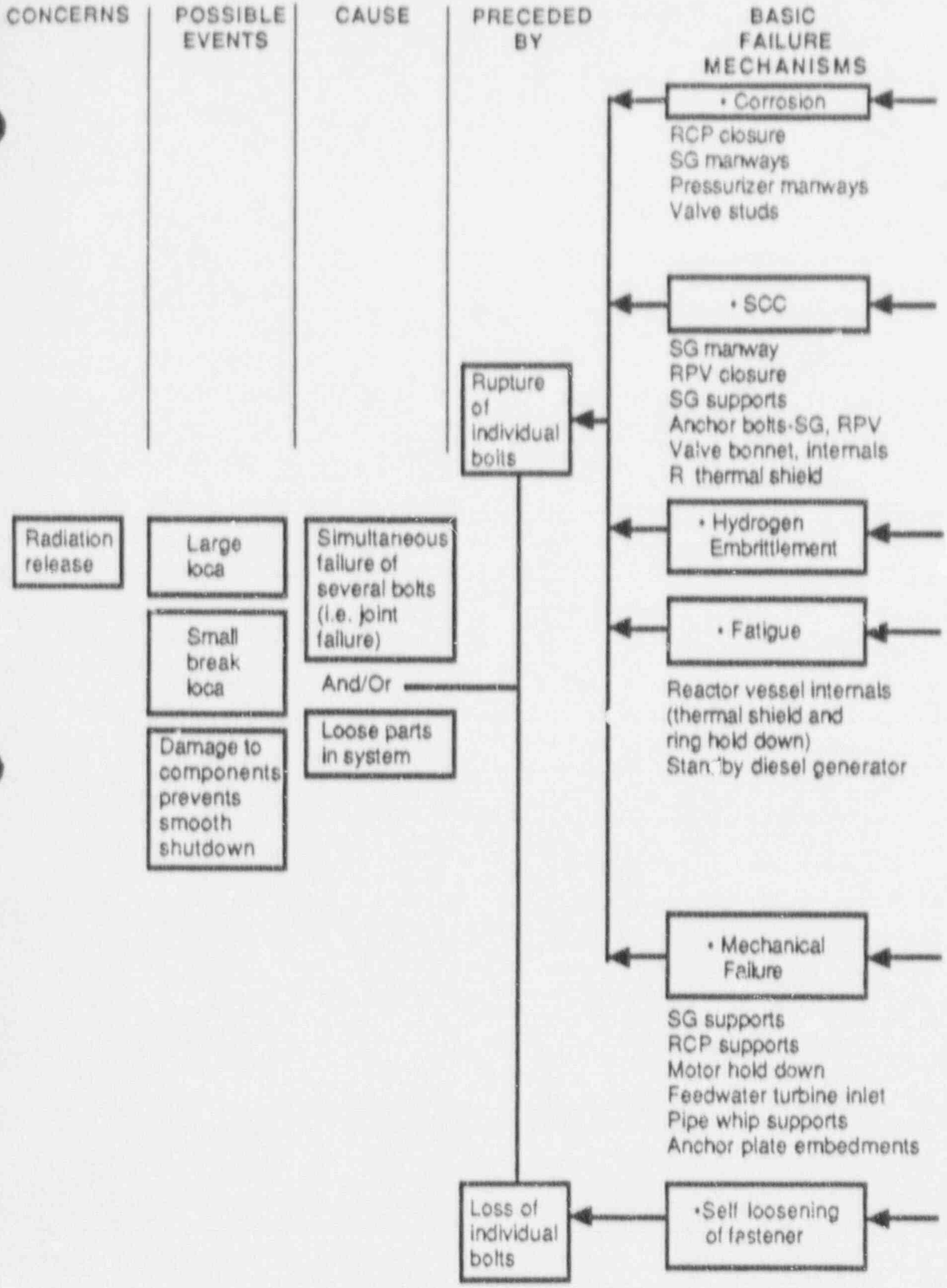
- Common Incidents
  - ✓ Stress Corrosion Cracking
  - ✓ Boric Acid Corrosion
  - ✓ Vibration Loosening
  - ✓ Loose Nuts-Improper or no Torquing Instructions
  - ✓ Missing Bolts-Improper or No Installation or Inspection Requirements
  - ✓ Improper Design or Material
  - ✓ Counterfeit Bolts

BOLT/FASTNER FAILURES
1984 TO SEPT 1990

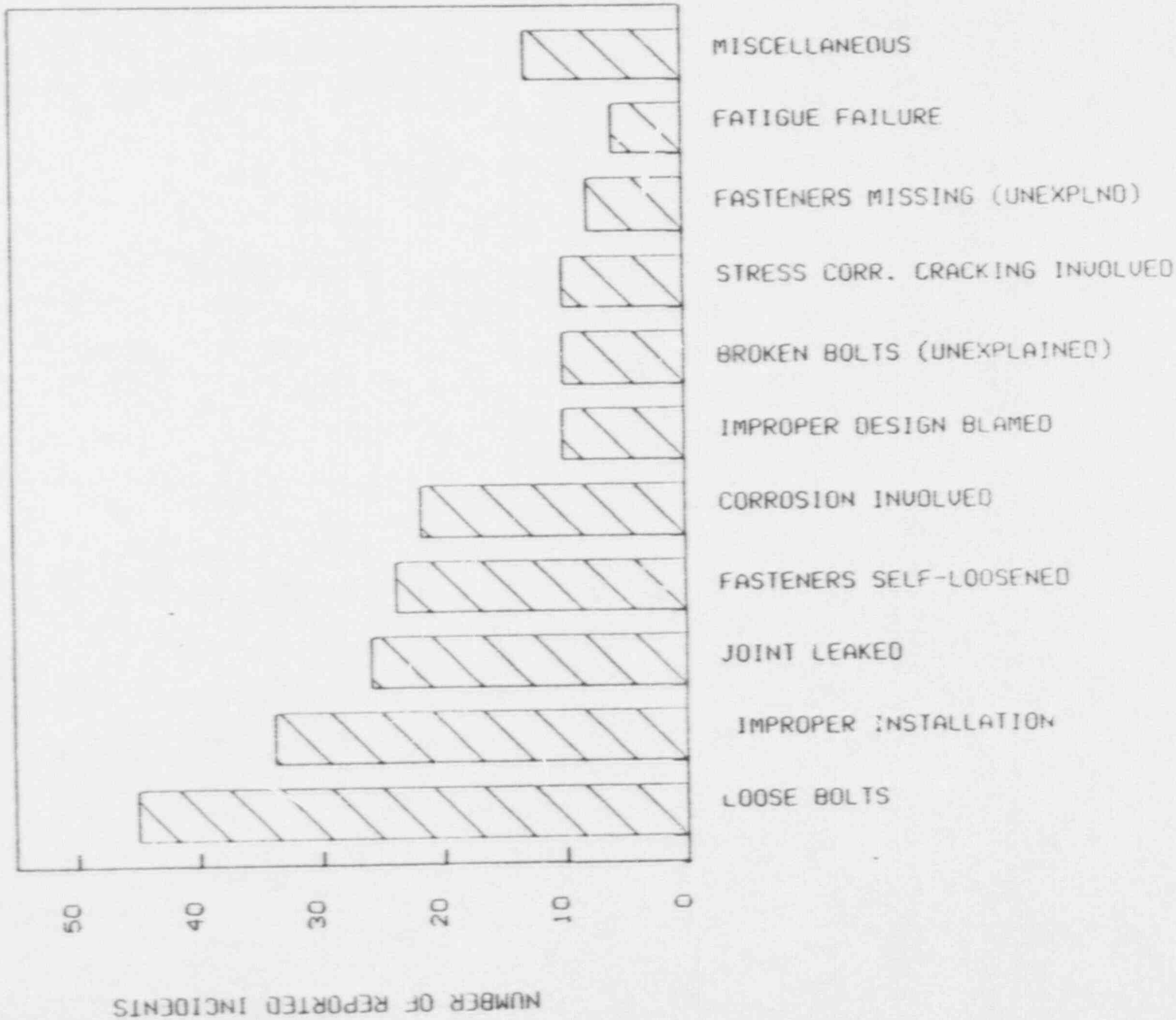


GENERIC ISSUE 29
NRR PROPOSED SCHEDULE

Action	DUE DATE
Prepare Draft Generic Letter	02/01/91
Management Review	03/01/91
Meet With CRGR	04/01/91
Issue Generic Letter	05/01/91
Review Responses	09/01/91
Determine Future Action	09/15/91


CONCERNS
POSSIBLE EVENTS
CAUSE
PRECEDED BY
BASIC FAILURE MECHANISMS
• Corrosion
RCP closure
SG manways
Pressurizer manways
Valve studs
• SCC
SG manway
RPV closure
SG supports
Anchor bolts-SG, RPV
Valve bonnet, internals
R thermal shield
Rupture of individual bolts
• Hydrogen Embrittlement
• Fatigue
Reactor vessel internals
(thermal shield and
ring hold down)
Standby diesel generator
Radiation release
Large loca
Small break loca
Damage to components prevents smooth shutdown
Simultaneous failure of several bolts (i.e. joint failure)
And/Or
Loose parts in system
• Mechanical Failure
SG supports
RCP supports
Motor hold down
Feedwater turbine inlet
Pipe whip supports
Anchor plate embedments
Loss of individual bolts
•Self loosening of fastener

ESSENTIAL CONDITIONS (ALL REQUIRED)	POSSIBLE CONTRIBUTORS
-Anode -Cathode -Electrolyte -Connector	-Material not as specified -Borated water -Gasket leakage -Insufficient preload -Elevated temperatures -High velocity electrolyte
-Susceptible material -Stress levels above threshold -Electrolyte -Initial flaw	-Material not as specified -Poor choice of material (too strong) -Wet or humid environment -Use of moly or furmanite -Unnecessarily high preload -Gasket leakage (borated water) -Improper heat treatment -Differential thermal expansion -Concrete joint member -High temp (decomposes moly, etc.)
-Same as SCC plus -Hydrogen	-Same as SCC plus - poor plating practices
-Cycle stress -Susceptible material -Stress levels above endurance limit -Initial flaw	-Material not as specified -Poor choice of material -Excessive preload (high mean) -Insufficient preload (increases stress excursions) -Improper heat treatment -Poor fastener design (fillets, runout, threadroots, etc.) -Fastener dimensions poor (thread fits, thread length) -Relaxation (low residual preload) -Flow induced vibration -Thermal cycles -Decarburization during manufacture -Creep damage -Electrolyte
-Stress levels exceeding static strength.	-Material not as specified -Poor choice of material -Improper heat treat (including quench cracks) -Excessive preload -Shear, bending or torsion stress -Creep damage -Abnormal loads (water hammer, seismic shock, loca) -Poor fastener dimensions (e.g., thread fit) -Elevated temperatures -Construction procedures
-Cyclic transverse loads -Relative motion (slip) between Nut-Bolt-Joint members	-Insufficient preload -Tranverse vibration or slip -Thermal cycles -Lubricant on threads -Washers or helicoil inserts -Relaxation (embedment, creep, elastic interaction, etc.) -Poor fastener design -Poor fastener dimensions

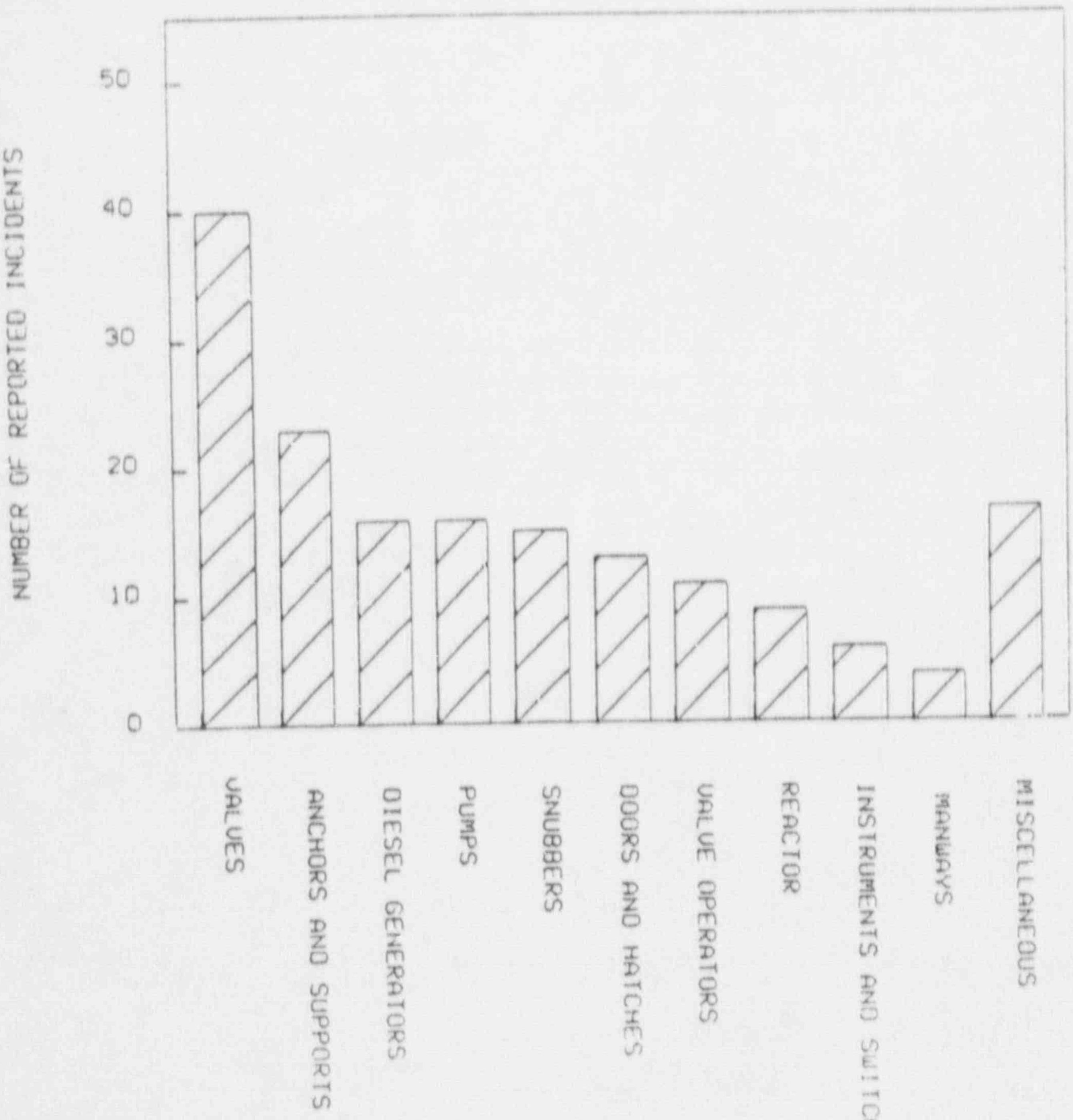


REASONS FOR FAILURES

Fig. 1

LOCATION OF PROBLEMS

Fig. 2



NRR STAFF PRESENTATION TO THE ACRS

SUBJECT: EROSION/CORROSION

DATE: JANUARY 8, 1991

PRESENTER: STEPHEN KOSCIELNY

PRESENTER'S TITLE/BRANCH/DIV: CORROSION ENGINEER
MATERIALS AND CHEMICAL ENGINEERING BRANCH
DIVISION OF ENGINEERING TECHNOLOGY

PRESENTER'S NRC TEL. NO.: X20726

SUBCOMMITTEE: MATERIALS AND METALLURGY

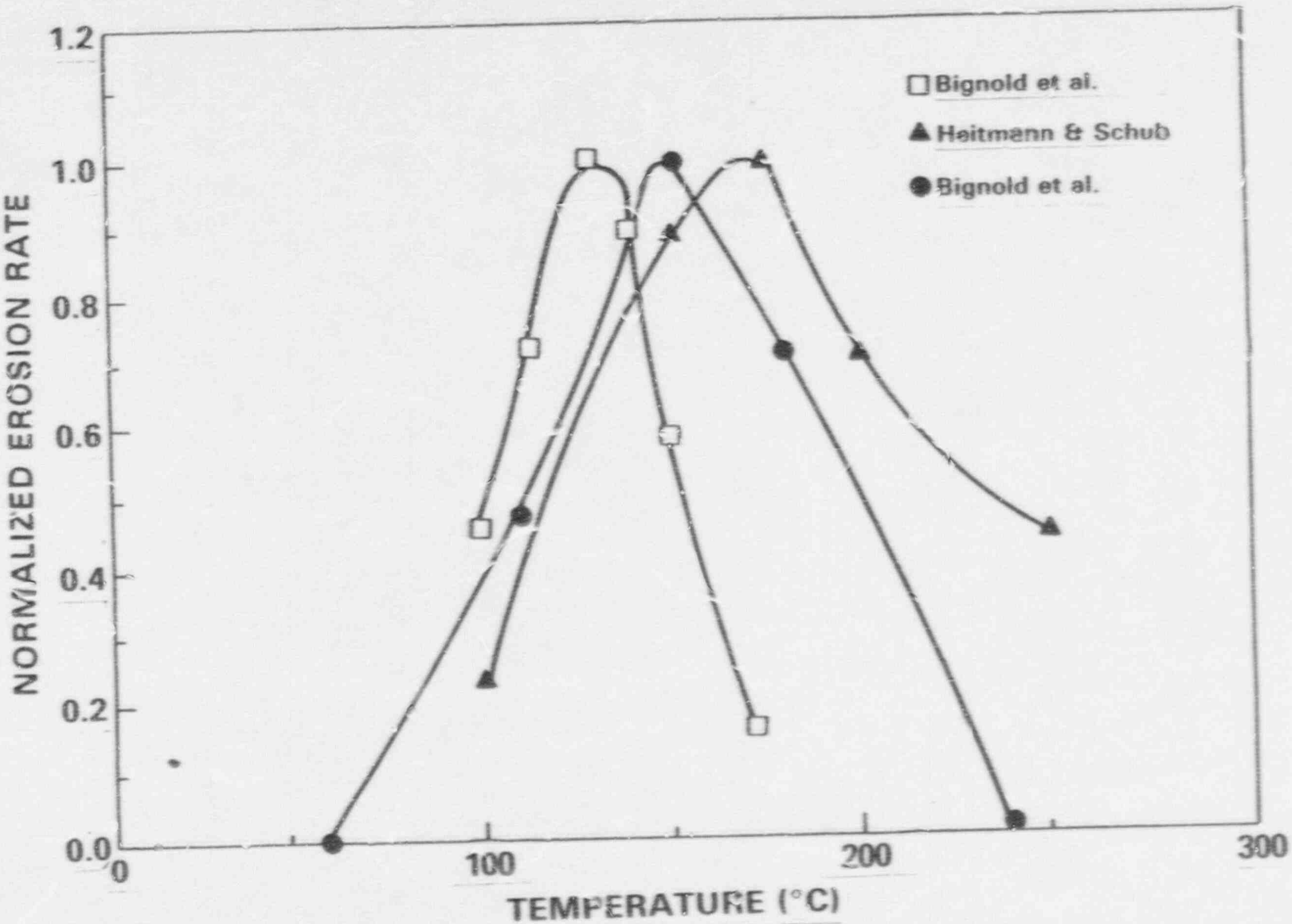
Nature Of The Erosion/Corrosion Damage Process

- Metal Removal Is Predominantly Chemical/Electrochemical And Not Mechanical
- Flow Assisted Corrosion Is A More Accurate Description

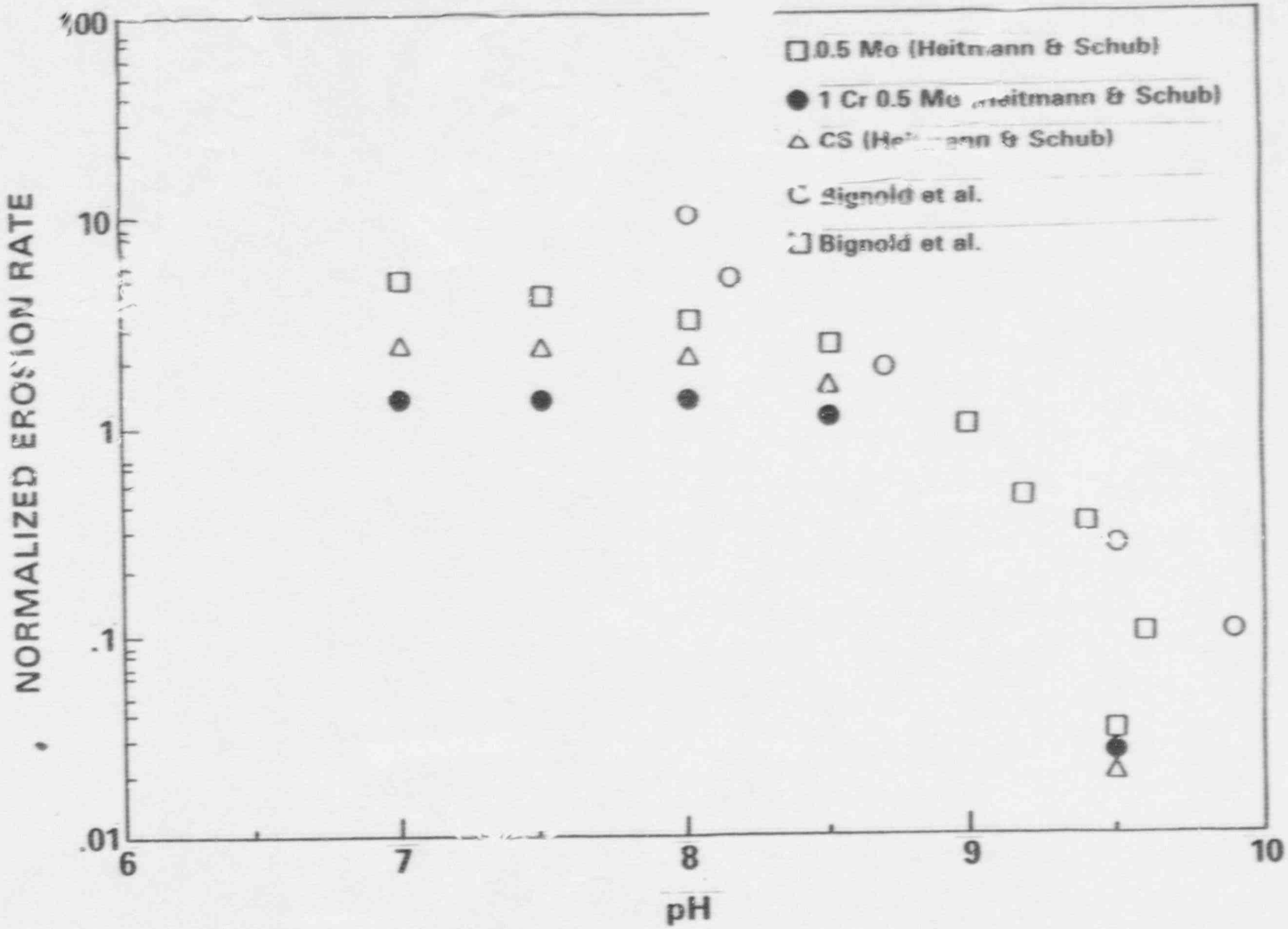
Critical Variables

- Material-Chemical Composition, Especially Cr
- Environment
  - ph - Affected By Control Agents, Impurities
  - Dissolved Oxygen
  - Temperature
- Hydrodynamic
- Turbulent Mass Transfer - Velocity, Flow Geometry, Vold Fraction

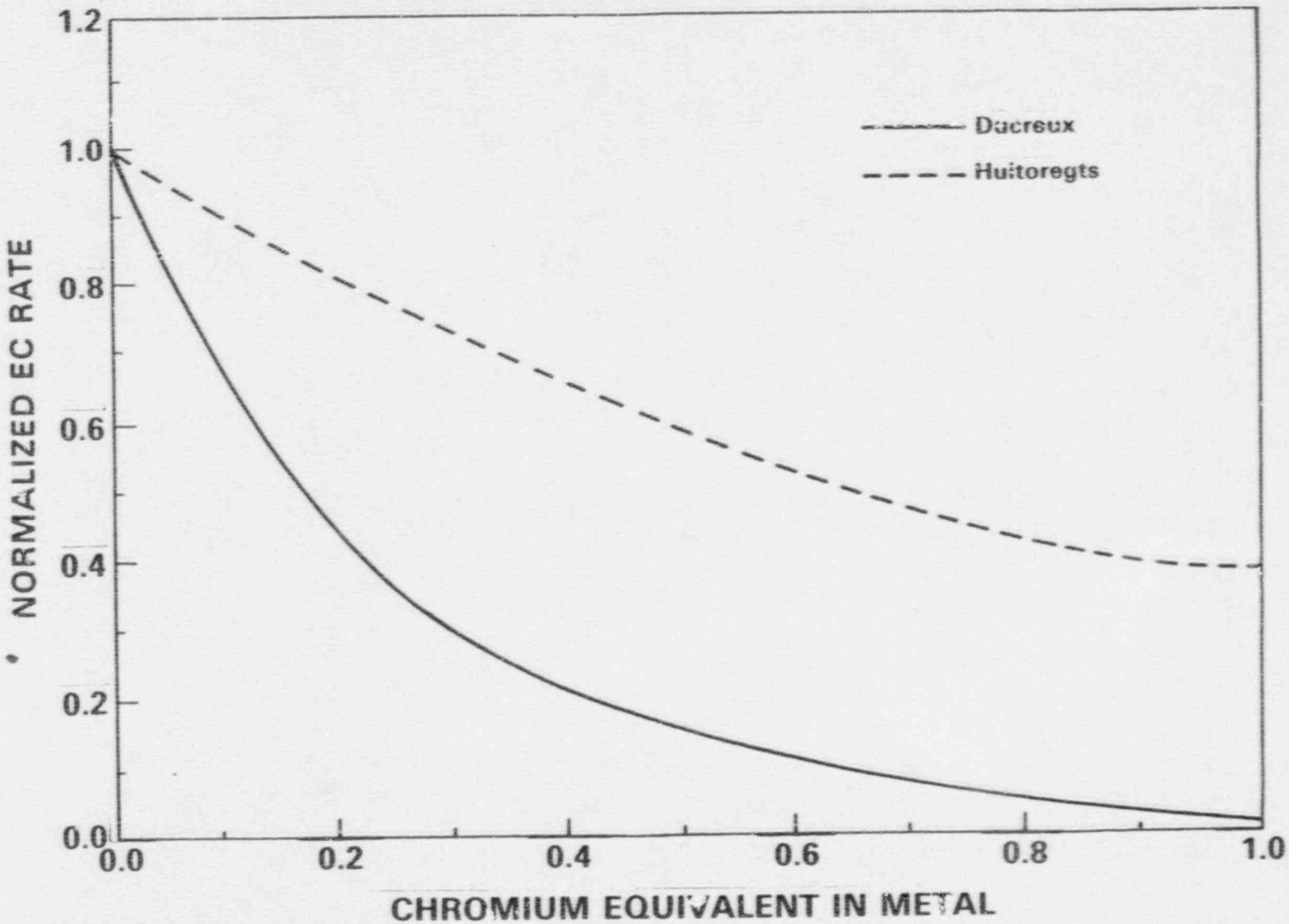
EFFECT OF TEMPERATURE ON EROSION/CORROSION



EFFECT OF pH OF COOLANT ON EROSION/CORROSION



EFFECT OF METAL COMPOSITION ON EROSION/CORROSION



REGULATORY EFFORTS TO ADDRESS THE ISSUE OF FLOW ASSISTED CORROSION

NRC INFORMATION NOTICES

82-22	FAILURES IN TURBINE EXHAUST LINES
86-106	FEEDWATER LINE BREAK AND SUPPLEMENTS 1,2,3
87-36	SIGNIFICANT UNEXPECTED EROSION OF FEEDWATER LINES
87-17	SUMMARY OF RESPONSES TO NRC BULLETIN 87-01, "THINNING OF PIPE WALLS IN NUCLEAR POWER PLANTS"

NRC BULLETIN

87-01	THINNING OF PIPE WALLS IN NUCLEAR POWER PLANTS

NRC GENERIC LETTER

89-08	EROSION/CORROSION INDUCED PIPE WALL THINNING

NRC NUREG

1344	EROSION/CORROSION-INDUCED PIPE WALL THINNING IN U.S. NUCLEAR POWER PLANTS

NRC/ASME SECTION XI

REQUIREMENTS FOR EXAMINATION OF CLASS 1, 2, AND 3 SYSTEMS FOR DETECTION OF PIPE WALL THINNING DUE TO SINGLE PHASE EROSION-CORROSION.

INDUSTRY GUIDELINES

- ESTABLISHED BY NUMARC TECHNICAL SUBCOMMITTEE JUNE 1987
- REQUIRE: (1) APPROPRIATE ANALYSIS AND LIMITED BASELINE INSPECTION

  (2) DETERMINE EXTENT OF THINNING AND REPAIR/REPLACE

  (3) PERFORM FOLLOW-UP INSPECTIONS
- NRC GUIDELINES
  - REQUIREMENTS ESTABLISHED IN GENERIC LETTER 89-08
  - LONG TERM EROSION/CORROSION MONITORING PROGRAM
  - NUMARC PROGRAM OR ANOTHER EQUALLY EFFECTIVE PROGRAM BE IMPLEMENTED
  - APPLIES TO ALL HIGH-ENERGY (TWO PHASE AS WELL AS SINGLE PHASE) CARBON STEEL SYSTEMS

SYSTEMS SUSCEPTIBLE TO EROSION/CORROSION

- FEEDWATER
- CONDENSATE
- EXTRACTION STEAM
- AUXILIARY STEAM
- MOISTURE SEPARATOR DRAINS
- MOISTURE SEPARATOR REHEATER DRAINS
- FEEDWATER HEATER CASCADING DRAINS
- FEEDWATER HEATER DRAIN PUMP DISCHARGE
- HPCI (BWR)
- MAIN STEAM
- TURBINE CROSSOVER AND CROSS-UNDER PIPING

Table 1 **Plants experiencing wall thinning in the feedwater condensate system**

Plant/Unit	Type of Reactor	Initial Criticality Date	Degraded Components, Fittings, or Straight Runs
Dresden 2	BWR	January 1970	elbows
Duane Arnold	BWR	March 1974	elbows, reducers, straight runs
Pilgrim 1	BWR	June 1972	elbows
Oyster Creek 1	BWR	May 1969	elbows
River Bend 1	BWR	October 1985	recirculation line
Perry 1	BWR	June 1986	straight runs
Arkansas 1	PWR	August 1974	elbows, drain pump discharge piping
Arkansas 2	PWR	December 1978	undefined
Calvert Cliffs 1	PWR	October 1974	elbows, reducers, straight runs
Calvert Cliffs 2	PWR	November 1976	elbows, reducers, straight runs
Callaway 1	PWR	October 1984	recirculation line elbows
Diablo Canyon 1	PWR	April 1984	elbows, straight runs
Diablo Canyon 2	PWR	March 1978	elbows
Ft. Calhoun 1	PWR	August 1973	elbows, straight runs
Haddam Neck	PWR	July 1967	recirculation line
Harris 1	PWR	October 1986	recirculation line
Millstone 2	PWR	October 1975	elbows, heater vent piping
North Anna 1	PWR	April 1978	elbows, straight runs
North Anna 2	PWR	June 1980	elbows, straight runs
Robinson 2	PWR	September 1970	recirculation lines
San Onofre 1	PWR	June 1967	reducers, heater drain piping
San Onofre 2	PWR	July 1982	heater drain piping
San Onofre 3	PWR	August 1983	heater drain piping
Salem 1	PWR	December 1976	recirculation line
Salem 2	PWR	August 1980	recirculation line
Surry 1	PWR	July 1972	fittings
Surry 2	PWR	March 1973	fittings
Sequoyah 1	PWR	July 1980	elbows, straight run
Sequoyah 2	PWR	November 1981	elbows
Trojan	PWR	December 1975	elbows, reducers, straight runs
Turkey Point 3	PWR	October 1972	feedwater pump suction line fittings
Fort St. Vrain	HTGR*	January 1974	straight run in emergency feedwater line
Rancho Seco 1	PWR	September 1974	straight runs downstream of main feedwater (MFW) loop isolation valve or MFW pump miniflow valve

*high-temperature gas reactor

CHEC

FORMULATION

$$E = F_1(T) \cdot F_2(A.C.) \cdot F_3(M.T.) \cdot F_4(O_2) \cdot F_5(pH) \cdot F_6(G)$$

Geometry effect
(Type, T, Re, L, Upstream

pH Effect
pH_{25c}, T, Amine

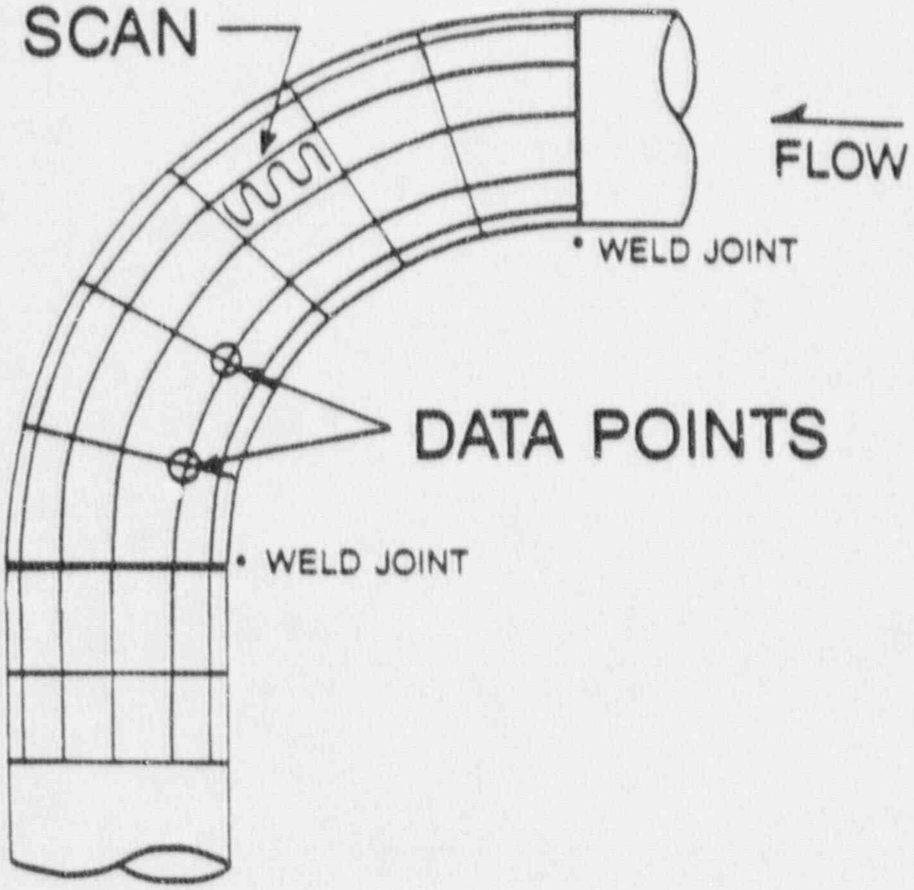
Oxygen Effect
O_2 in ppb)

Mass Transfer Effect
(V, D, T)

Alloy Content Effect
(Cr, Cu, Mo)

Temperature Effect
(T)

EPRI



Grid-Type Inspection

NOTE: SIMILAR PHILOSOPHY SHOULD BE APPLIED TO OTHER COMPONENTS (i.e. REDUCER / EXPANDER, TEE, etc.)

RECENT PIPING FAILURES

° SURRY UNIT 1	LOW PRESSURE HEATER DRAINS	(3/23/90)
° LOVIISA UNIT 1	FEEDWATER LINE BREAK	(5/28/90)
° MILLSTONE UNIT 3	MOISTURE SEPARATOR DRAINS	(12/31/90)

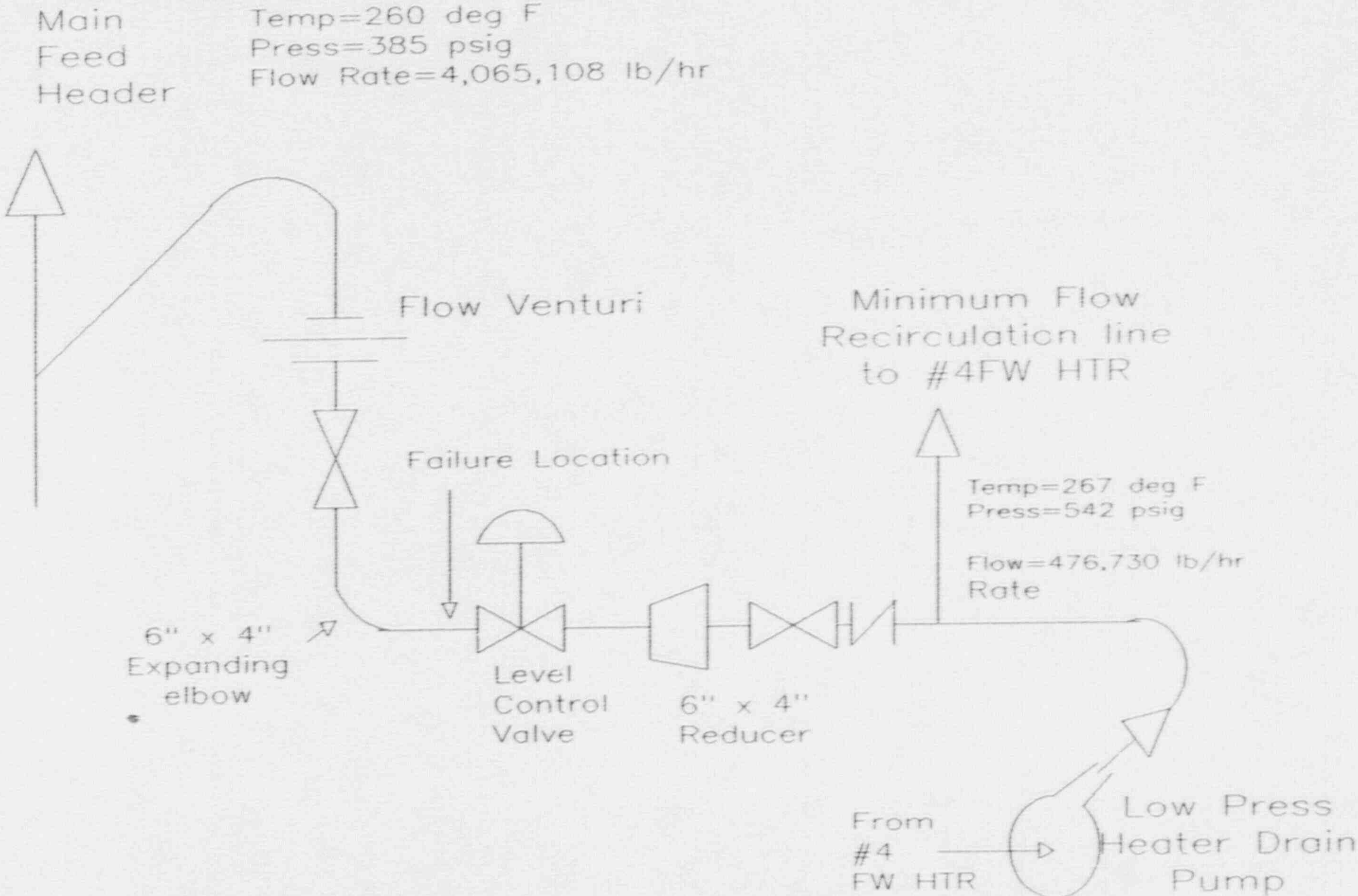


Figure 1 : Surry Unit 1 Low Pressure Heater Drain System

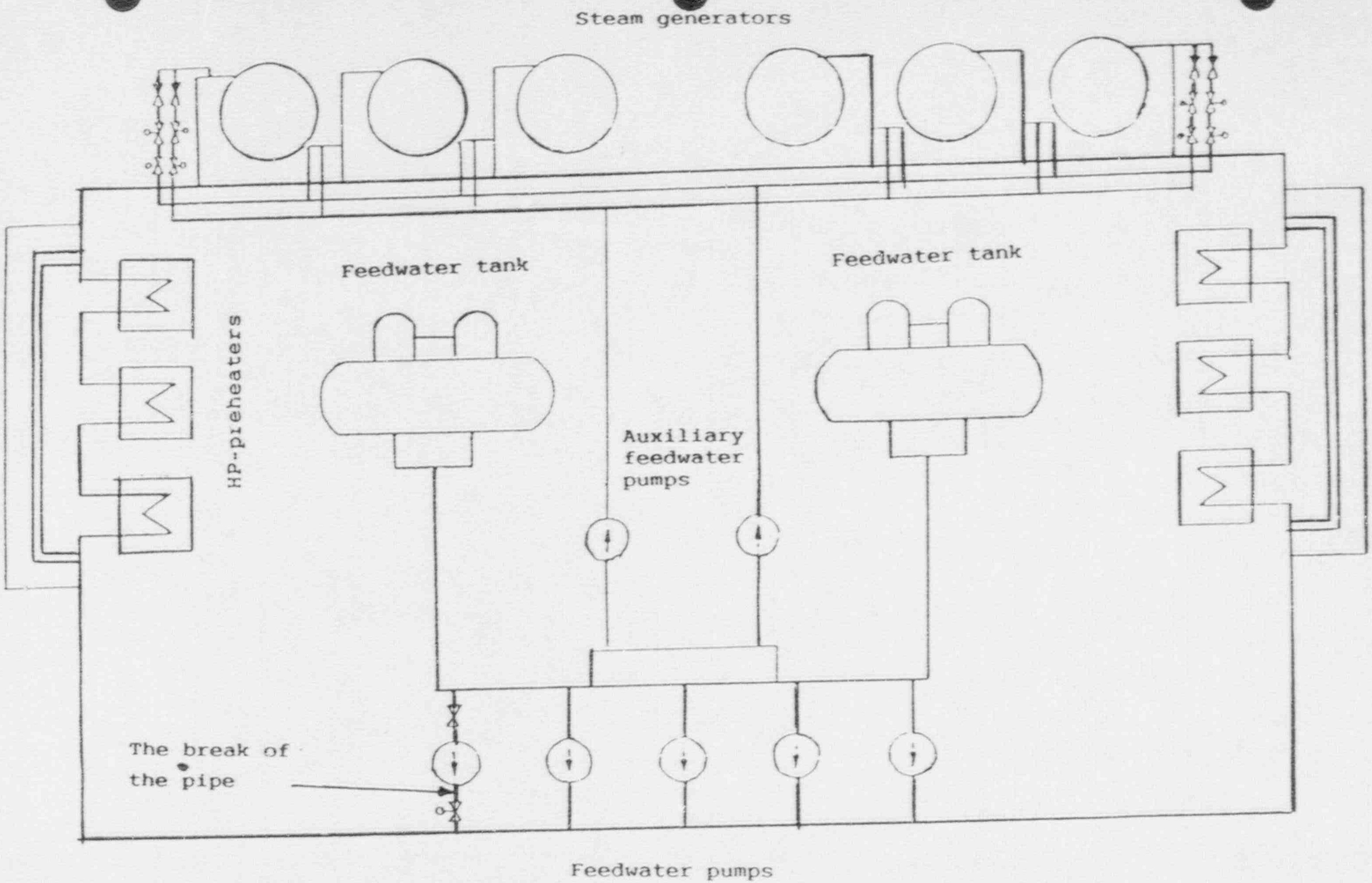


Figure 2 Feedwater system of the Loviisa 1

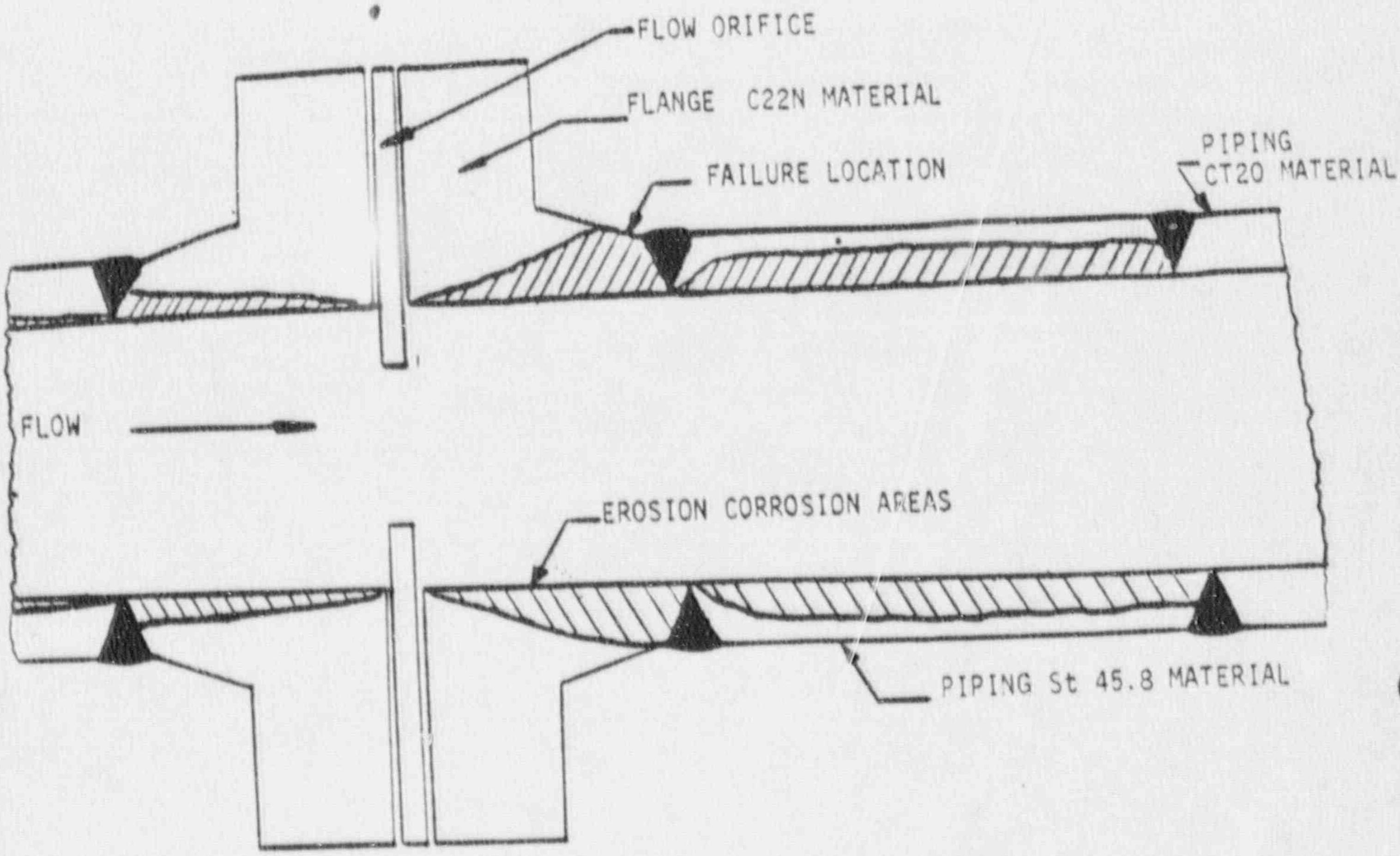


FIGURE 3 LOVIISA UNIT 1 FLANGE EROSION/CORROSION AREAS

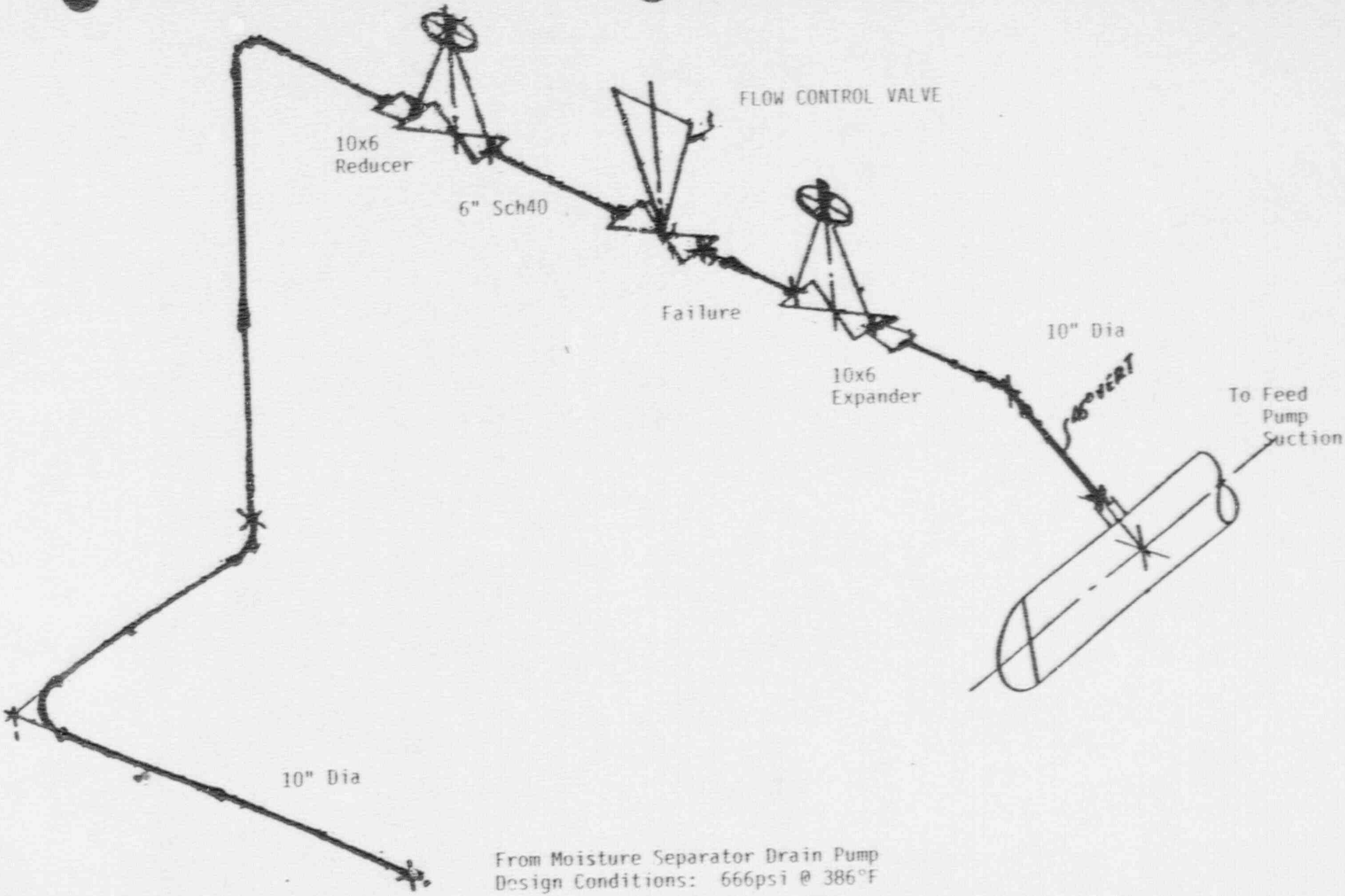


FIGURE 4 MILLSTONE UNIT 3 MOISTURE SEPARATOR DRAIN SYSTEM

NRR STAFF PRESENTATION TO THE ACRS

SUBJECT: MICROBIOLOGICALLY INFLUENCED CORROSION

DATE: JANUARY 9, 1991

PRESENTER: FRANK J. WITT

PRESENTER'S TITLE/ BRANCH/DIVISION:
CHEMICAL ENGINEER
MATERIALS AND CHEMICAL ENGINEERING BRANCH
DIVISION OF ENGINEERING TECHNOLOGY

DIVISION PRESENTER'S NRC TEL. NO:
(301) 492-0767

SUBCOMMITTEE: MATERIALS AND METALLURGY

MICROBIOLOGICALLY INFLUENCED CORROSION (MIC)

- PREVENTION
- DETECTION, MONITORING AND DIAGNOSIS
- MITIGATING MEASURES
- REPLACEMENT

PREVENTION

- DESIGN
  - CONTINUOUS FLOW > 3 FPS
  - MATERIAL SELECTION
  - PROVISION FOR CLEANING AND WATER TREATMENT
  - MINIMIZE LOW POINTS, AREAS OF LOCAL STAGNATION, AND CREVICES
    - STUBS, BLIND FLANGES
    - WELD BACKING RINGS
- FABRICATION
  - CLEANLINESS DURING FABRICATION AND PRESERVICE TESTING
  - SYSTEMS SHOULD BE DRAINED AND DRIED
  - BIOCIDE TREATED WATER FOR HYDROSTATIC TESTING
  - ADDITION OF CORROSION INHIBITORS AND BIOCIDES DURING LAY-UP
- OPERATION
  - CLEAN AND WELL MAINTAINED SYSTEM
  - WATER TREATMENT
  - RELATIVELY HIGH FLUID VELOCITY
  - REGULAR MAINTENANCE
    - INSPECTION
    - CLEANING

DETECTION, MONITORING AND DIAGNOSIS

- SIGHT, SMELL, AND TOUCH
- NDE: RADIOGRAPHY, ULTRASONICS, OR EDDY CURRENT
- WATER SAMPLING FOR CHEMICAL AND MICROBIOLOGICAL CONSTITUENTS
- SOLIDS SAMPLING FOR CHEMICAL AND MICROBIOLOGICAL ANALYSIS
- METALLURGICAL EVALUATION
- ROUTINE MONITORING OF SYSTEM TEMPERATURES, PRESSURES, AND FLOW RATE
  - REDUCTIONS IN EFFECTIVE FLOW AREA
  - FOULING OF HEAT EXCHANGERS
- CORROSION MONITORING
  - COUPON EXPOSURE
  - ELECTROCHEMICAL CORROSION PROBES

MITIGATION MEASURES

- WATER TREATMENT WITH BIOCIDES (EFFECTIVE ONLY WHEN SURFACES ARE CLEAN)
- CLEANING
  - MECHANICAL
  - CHEMICAL
- OPERATIONAL CONTROLS
  - DRAIN AND DRY
  - TREAT THE WATER
  - ESTABLISH FLOW ON A DAILY BASIS
  - THERMAL TREATMENTS > 140°F
  - ULTRAVIOLET TREATMENT
  - CATHODIC PROTECTION

REPLACEMENT/REFURBISHMENT

- REPLACEMENT IN KIND
  - INCREASED ATTENTION TO FABRICATION, MAINTENANCE, MINIMUM FLOWS, WATER TREATMENT

- COATING AND LINING

- REPLACEMENT FOR CARBON STEEL
  - STAINLESS STEEL

- REPLACEMENT FOR STAINLESS STEEL
  - AL-6X ALLOY 6% Mo 24% Ni
  - TITANIUM

SERVICE WATER SYSTEM PROBLEMS

- FLOW REDUCTION FROM TUBERCLES AND MASSIVE CORROSION PRODUCT DEPOSITS
- FOULING OF HEAT EXCHANGER TUBES
- THROUGH-WALL PITTING
  - HEAT EXCHANGER TUBES
  - PIPING
- STRUCTURAL INTEGRITY REDUCTION

RECOMMENDED ACTIONS IN GENERIC LETTER 89-13,

"SERVICE WATER PROBLEMS AFFECTING SAFETY-RELATED EQUIPMENT"

° PROGRAM TO PRECLUDE BIOFOULING

  - BIOCIDES

° TEST PROGRAM TO VERIFY HEAT TRANSFER CAPABILITY

° ESTABLISH ROUTINE INSPECTION AND MAINTENANCE PROGRAM

  - REMOVE EXCESSIVE ACCUMULATIONS

    - - BIOFOULING AGENTS

    - - CORROSION PRODUCTS

    - - SILT

  - REPAIR DEFECTIVE PROTECTIVE COATINGS AND CORRODED PIPING AND COMPONENTS

GENERIC LETTER 90-05, "GUIDANCE FOR PERFORMING TEMPORARY NON-CODE REPAIR OF ASME CODE CLASS 1, 2, AND 3 PIPING"

- TEMPORARY NON-CODE REPAIR IS ACCEPTABLE
  - UNTIL NEXT SCHEDULED OUTAGE EXCEEDING 30 DAYS
  - NO LATER THAN NEXT REFUELING OUTAGE
    - PROVIDED STRUCTURAL INTEGRITY IS ASSURED
- TEMPORARY NON-CODE REPAIR UNACCEPTABLE WITHOUT SPECIFIC RELIEF GRANTED BY THE NRC
- NON-WELDED REPAIRS MAY BE CONSIDERED
- AUGMENTED INSPECTION PART OF RELIEF ACCEPTANCE CRITERIA
- ASME CODE COMMITTEE PRESENTLY ADDRESSING NON-CODE REPAIR OF CLASS 3 PIPING

SERVICE WATER WORKING GROUP (SSWG)

BACKGROUND

- ESTABLISHED JUNE 1988
- 50 UTILITY EXPERTS FROM 28 UTILITIES
- 5 EPRI PROJECT MANAGERS
- 9 TECHNICAL ADVISORS
- CONSULTANTS/CONTRACTORS AS NEEDED
- THREE MEETINGS PER YEAR

SERVICE WATER WORKING GROUP (SSWG) (CONTINUED)

OBJECTIVES

- PROVIDE TIMELY RESOLUTION OR INPUT TO INDUSTRY ISSUES RELATED

  TO SERVICE WATER SYSTEMS

- IMPROVE TECHNOLOGY TRANSFER

- PROVIDE INPUT FOR EPRI R&D

SERVICE WATER WORKING GROUP PRODUCTS

- RECOMMENDED PRACTICES AND GUIDELINES
- TRAINING MODULES AMD AIDS
- COMPENDIUMS OF EXPERIENCE AND METHODOLOGIES
- SEMINARS AND WORKSHOPS