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UNITED STATE NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

DATE: February 13, 1992

The contents of this transcript of the proceedings of the United States Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards, (date) February 13, 1992, 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

JOINT MATERIALS AND METALLURGY/MAINTENANCE PRACTICES

AND PROCEDURES SUBCOMMITTEE

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

Thursday, February 13, 1992

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

PRESENT FOR THE ACRS SUBCOMMITTEE:

David A. Ward, Member
Charles J. Wylie, Member
Carlyle Michelson, Member
Thomas Kress, Member
E. Igne, Cognizant Federal Official

PARTICIPANTS:

R. Fraley	R. Bosnak
R. Art	T. Vo
B. Gore	F. Simonen
L. Smith	C. Tomes
B. Wendland	

P R O C E E D I N G S

[8:30 a.m.]

MR. SHEWMON: The meeting will now come to order. This is a joint meeting of the Advisory Committee on Reactor Safeguards Subcommittee on Materials and Metallurgy and Maintenance Practices and Procedures.

I am Paul Shewmon, Subcommittee Chairman for Materials and Metallurgy. Jay Carroll is Subcommittee Chairman for Maintenance Practices and Procedures, and he didn't make it in from California. I guess I get to Chair it alone. ACRS members in attendance are Dave Ward, Charlie Wylie, Carlyle Michelson, and Tom Kress is someplace and will appear soon.

The purpose of this meeting is to discuss the ASME risk-based inspection guidelines. Mr. Elpidio Igne, on my right, is the Cognizant ACRS staff member for this meeting. The rules for participation in today's meeting have been announced as part of the notice of this meeting, previously published in the Federal Register on January 29, 1992. A transcript of the meeting is being kept and will be made available as stated in the Federal Register Notice.

It is requested that each speaker first identify himself or herself, and speak with sufficient clarity and volume that he or she can be readily heard. The meeting is being recorded. We have received no written comments or requests to make oral statements from members of the public.

I don't know that I have any opening remarks to make, so we will proceed. I will call on Bob Bosnak to introduce things.

MR. BOSNAK: Good morning. I am very pleased that you asked our team to be present to explain exactly what we mean by our project on risk-based inspection guidelines. In effect, I am wearing two hats this morning. I am going to be representing Ray Art who is an employee of ASME, the Center for Research and Technology Development. Also, I am the Deputy Director of the Division of Engineering in the Office of Research. We are the division that is sponsoring the research that is going on, and we will get into the details of that particular project.

[Slides.]

MR. BOSNAK: First of all, if Ray were here he could do a much better job than I with respect to the Center for Research and Technology Development. As you see here from the logo, it is a bringing together of industry, academia and government. What the Center has tried to do since its inception, which was approximately 1985, was to acquire the resources that are available and particularly within this area. That's another reason why the Center is located in Washington rather than in New York, where a lot of the activities of the society take place.

They have gotten together people from the National Science Foundation, from the Nuclear Regulatory Commission, Department of Energy, Department of Transportation and academia. Of course, the people that are interested in getting the results are often times industrial firms.

ASME's functions, and they serve -- the projects that the Center has taken on have done a lot and also in the process have a peer review taking place. This has become very important, particularly in some of the projects that we have worked on and others as well. The last thing that I think Ray wanted to show you is the organization that the Center has.

The Board of Research and Technology Development is here. This is the group that oversees the operation of the Center. Currently, the Vice President of Research is Ward Wiener from Georgia Tech. They have several technical divisions and groups and, of course, as they have highlighted here the main area that we are talking about is the Codes and Standards Research Planning Committee. This particular group takes direction from the Council codes and standards which is up here, and the Board on Research which reports to the Council on Engineering.

They are the two major Council's within ASME for performing engineering of standards and engineering research work.

MR. MICHELSON: Excuse me, Bob. Perhaps you mentioned it and I missed it, but where is this Center located?

MR. BOSNAK: The Center is located on L Street, 1828 L Street, Washington, D.C.

MR. MICHELSON: It's headquartered here, in Washington?

MR. BOSNAK: Yes. That was the point that I tried to make earlier. They are not in New York, they are here. Maybe Ray doesn't want to say it, but this is a source of research particularly the National Science Foundation. They have gotten a lot of work with that organization.

MR. MICHELSON: Could you tell me roughly how many people are involved locally in that?

MR. BOSNAK: At the Center the technical staff area there are about five people.

MR. MICHELSON: Most of this is people -- the Center really functions with people coming in from industry and elsewhere and leaving again.

MR. BOSNAK: Yes.

[Slides.]

MR. BOSNAK: With respect to putting on my other hat, this is with respect to what the NRC has been doing in trying to organize this particular project. As you see here for the first bullet, there are many complex structures -- I am not just speaking of nuclear power plants -- that cost billions of dollars. They are very difficult to inspect. In fact, some of them when they were built, were practically un-inspectable. So, as these things age and you need to assess what is going on with respect to the overall plant, and we are not just talking about a section of piping. We are talking about, again, a complex plant with systems, components and now best to go about it.

As you know currently, there is only one section of the ASME Boiler and Pressure Vessel Code at least, that deals with inservice inspection. That is Section XI. Section XI is based on Section III. Section III has five classifications for construction. Two of the five are really the same as -- let me tell you exactly what they are. They are Class 1, Class 2, Class 3, Class MC which is metal containment, and Class CS which is core support structures. Core support structures is very much the same as the Class 1. Class MC is very much like Class 2.

So, in effect, there are three ways of building a system. While they are not inherently talking about risk, the regulatory actions have directed people to build the more risk sensitive structures to the higher classifications. Section XI, of course, has done the same thing. We are talking about implicit recognition of risk through engineering judgment and qualitative methods.

It would be a lot better if there were a methodology that one could follow that would explicitly recognize risk and could, in a systemized way, come up with procedures for what to inspect, when to inspect, how to inspect, that would recognize again the consequences of a failure. The Codes and Standards Research Planning Committee and the Board on Research and Technology Development, the Council Codes and Standards, this is back in -- you will see a slide here on chronology -- in about the 1986, 1987 timeframe endorsed the project.

Some of you may know Ernie Damen. He was the initial Chairman of the Codes and Standards Research Planning Committee from Foster Wheeler.

MR. SHEWMON: Bob, you know more about the Code than I do, but there certainly are some -- you must inspect primary systems within ten years and so much at periodic intervals. There are things of that sort, yet you talk about Codes and Standards that cover periodic inspections are practically non-existent. Are we going to get into what you --

MR. BOSNAK: What I am talking about, I am talking about not just nuclear. I am talking about our broad-based complex structures, petrochemical.

MR. SHEWMON: Okay.

MR. BOSNAK: If you will, bridges, transportation, all of that. The only thing that we have -- that's why I say it's practically non-existent, with the exception of Section XI.

MR. SHEWMON: Okay.

MR. MICHELSON: While you are interrupted, let me ask a couple of more questions. This ASME Center, how many years has it been in existence?

MR. BOSNAK: Since 1985.

MR. MICHELSON: Since 1985. I assume that motor operated valves in an integral part of what this Center is going to be handling?

MR. BOSNAK: Right now, it is not.

MR. MICHELSON: I was going to ask then, what the relationship is to the activity up in Philadelphia on motor operated valves at the Eddie Stone Plant.

MR. BOSNAK: You are talking about -- there are several organizations, EPRI as you know, the check valve group. MR. MICHELSON: Let me tell you what bothers me a little bit. If I were worried about risk and I wanted to pick out components that were particularly troublesome in that regard, I would pick out all the valves in the plant.

MR. BOSNAK: We know.

MR. MICHELSON: Yet, that big piece of risk is not in your program.

MR. BOSNAK: That's correct.

MR. MICHELSON: Is there a good reason for that?

MR. BOSNAK: The scope of the program is such that we are talking about what I would call passive components.

MR. MICHELSON: Section XI, of course, talks about the valves and so forth. Part of your Section XI --

MR. BOSNAK: We do only for the pressure boundary. The things that you and I know that we are talking about, valve testing, have now been moved. We are not trying to --

MR. MICHELSON: It's not a part of Section XI any longer?

MR. BOSNAK: No longer.

MR. MICHELSON: I didn't realize that. Where has it moved to?

MR. BOSNAK: It has moved to the Code on Operation and Maintenance.

MR. MICHELSON: It's O&M what, nine?

MR. BOSNAK: O&M, six and ten.

MR. MICHELSON: Six and ten. It has been officially moved then?

MR. BOSNAK: That's correct.

MR. MICHELSON: The risk that you are talking about here is just the risk of steel girders and pressure boundaries, I guess.

MR. BOSNAK: You will hear from our presenters later, that this system could in effect, even though we are not handling risk due to valves now, it could. It could do that.

MR. MICHELSON: As I say, I was caught a little by surprise. I thought it was going to, and it's a little bit of a disappointment to find that probably the biggest risk contributor in the plant is not in the program.

MR. BOSNAK: We recognize exactly that. You will hear about that later.

MR. MICHELSON: Okay.

[Slides.]

MR. BOSNAK: I want to go through these rather quickly. The initial objectives and in the initial objectives, as Mr. Michelson has recognized, we are talking about inspection guidelines for passive components. We wanted to come up with a program to be able to recommend not only the ASME but perhaps ASCE, IEEE. IEEE has been involved in reliability. Here is a method that could be used.

The chronology quickly, and I have covered a lot of this, so I am not going to dwell on that.

MR. MICHELSON: Before you leave that, we are really concerned here I guess, about risk-based methods, and I assume we are also worried about risk that these passive components might present. Is there any part of this program that is going to get at the issues of probabilities of pipe breaks and that sort of thing?

MR. BOSNAK: Yes, you will hear about that.

MR. MICHELSON: Thank you.

MR. BOSNAK: Some of you may have heard of the Risk Analysis Task Force that started about in the 1985, 1986 timeframe. That, now, has become the Safety Engineering and Risk Analysis Division. Here again, you see the process that they went through. In 1988 the Task Force members were established, and they developed this detailed work plan. The funding by the sponsors commenced in 1988. Again, NRC was one of the sponsors. We are talking here about Phase I.

Phase I is now complete or will be complete with the publishing of Volume 2, Part 1. All of you, I think, have at least a draft copy of that document. You also have the final version of Volume 1. That is Phase I, Volume 1, the General Methodology Document. Volume 2, Part 1, on nuclear facilities has gone to the printer.

I think this chart here -- and we have covered a little bit on it with the Center -- this is the ASME management structure. Here, from this horizontal line, is the group that provides policy, management and oversight. This is the group, and some of you have participated. I know Dr. Shewmon on Section XI and others on various other areas. B31, some of you are familiar with that. Subcommittee 11, Subcommittee 3, these are all boiler code activities.

MR. MICHELSON: Where will the motor operated valves be on that chart?

MR. BOSNAK: It would be in another box. That comes out here, on the Committee Operation and Maint:nance.

MR. MICHELSON: That's just now shown ye:.

MR. BOSNAK: It's just not showing. There are several boards, actually, there are five boards. We only show two of them here. The Board on Nuclear C:des and Standards is now chaired by Bob Dick from Duke Power. The Board on Pressure Technology Codes and Standards, they deal with the non-nuclear area, is chaired by Walt Michel currently. There are three other Boards, Standardization, Safety Codes and Standards, and the Performance Test Codes.

The Board on Research is the one that we have been talking about here, and the Center for Research is the one that is physically located downtown. Codes and Standards, Research Planning Committee is this organization. I am the current Chairman of that group. We are responsible for getting the job done.

We currently have active projects -- there are six active projects -- totaling roughly about $1.1 million. Briefly, you are going to hear about one on Codes and Standards and Reliability, if you will, just the last slide in my presentation. That, again, is the Codes and Standards

Research Planning Committee. There is another Committee that doesn't show here. It's called the Technology Opportunities Planning Committee. It's the one that is supposed to look ahead with respect to needed research, not dealing with codes and standards. Before this group can start on any project it has to get the approval of the Board on Research which reports to this Council and Codes and Standards, the dotted line that you see coming out here.

We cannot start on anything. We can't go out and request funding from interested parties unless those two groups have given their approval.

MR. WARD: It's a complicated management structure; does it work?

MR. BOSNAK: Yes. I haven't had any problems. The only thing that might be complicated is over here, the boiler code reports to two masters. They are looking at how to perhaps simplify that. But there are dangers of separating nuclear from the rest of the world and vice versa. Those of us that have been involved in this for a period of years think it's a pretty good way to operate.

We have acquired the knowledge, particularly materials, welding, NDE and all of that, that has come from the basic industry.

MR. MICHELSON: Bob, before you leave that, something still bothers me a little bit. The O&M

Subcommittee is a good place to put testing all right, but is the design effort that is still needed on valves going to be there or is it going to be in Section 3.

MR. BOSNAK: That's another Committee. That's QME. O&M is a main committee, it's not a Subcommittee. O&M is a main Committee, and it deals with as you see, operation and maintenance.

MR. MICHELSON: Clearly, the --

MR. BOSNAK: The group that deals with the design is a relatively new group, Qualification of Mechanical Equipment, QME.

MR. MICHELSON: That's qualification. I am thinking of design now, not qualification.

MR. BOSNAK: That also includes basic design.

MR. MICHELSON: I am also thinking that's a Section III component, and you already have an organization for Section III components. Is valves being moved out of it?

MR. BOSNAK: Section III only deals with the pressure boundary right now.

MR. MICHELSON: There's a little more in the Code than just pure pressure boundary on valves, or at least there has been in the past. There are certain requirements on the gates and so forth. At one time they were ignored but finally got it in.

MR. BOSNAK: It's material properties. It really doesn't deal with the function. I agree with you, there needs to be coordination, certainly.

MR. MICHELSON: When it says nuclear components it really means pressure boundary of nuclear components.

MR. BOSNAK: Exactly.

MR. MICHELSON: And, the operability of the components is OEM?

MR. BOSNAK: Somewhere else.

MR. MICHELSON: Is that OEM, did you say?

MR. BOSNAK: QME.

MR. MICHELSON: Pardon me, QME.

MR. BOSNAK: Qualification of Mechanical Equipment.

MR. MICHELSON: Where is the design? It's doing design as well as qualification?

MR. BOSNAK: Yes. All of those bodies that don't appear here report to the Board on Nuclear Codes and Standards. So, there is some way of making sure that they talk to one another. That's always a problem.

MR. MICHELSON: In the case of valves it's not real clear how this is going to work, and valves are one of the big risk items.

MR. BOSNAK: Exactly. I couldn't agree more.

MR. MICHELSON: So, I think there is something strange about the program. I assume that they will get that figured out.

MR. BOSNAK: I hope by the time that we are through -- we have what we consider to be an integrated team here. We recognize the fact that valves are a large cause of risk. Again, what we are doing is developing a methodology which we think can be applied to other areas.

MR. MICHELSON: Methodology would work all right, but I wasn't quite sure -- I thought it was going to include valves.

MR. WARD: Bob, I thought I heard you say it is going to include valves, but you are including the methodology on --

MR. BOSNAK: Right now, and you will see the planning coming up later, valves is not one of the things that is included. It could be, but it's not, currently.

MR. WARD: I thought this is kind of a pilot program in a sense. Or, is it really intended to be a comprehensive, be all, end all program.

MR. BOSNAK: It's intended to be a comprehensive development of the methodology that you would use, but we are focusing on -- call it the pressure boundary, the passive components.

MR. MICHELSON: Is the valve disk considered a pressure boundary under the Code?

MR. BOSNAK: I think you will hear -- yes, it is.

MR. MICHELSON: I thought it was.

MR. BOSNAK: You will hear the things that may give you some more comfort on what we are doing.

[Slides.]

MR. BOSNAK: I have covered some of this already. Phase I is to provide the document which you have in your hands. That's Volume 1. Volume 2, Part 1, is for nuclear power facilities. Then, prioritize other areas, so many some of the things that Carlyle Michelson is talking about could fit in here later on. For Phase II, that has already -- at least for what we are going to be doing -- has been prioritized. Some of it, the priority depends on the sponsors as well.

Phase II is to prepare additional documents. You will see later on, exactly what we are talking about.

Again, it's applicable to any industry. I think this is very important. General risk-based methods that can be used to develop appropriate inspection programs. That is, I think, very important for you to keep in mind. What it does do, it brings into the picture economics. Whenever you deal with a complicated system you have to weigh economics and safety and engineering.

Volume 2, Part 1, again, is what we talked about with respect to component rankings, component probabilities of failure and the consequences. It has come up with an inspection strategy.

MR. MICHELSON: When you say this applies to passive components, does it apply to such things as flange to gaskets -- flange to connections and piping, and the possibility of failure of the gasket; is that the kind of --

MR. BOSNAK: Yes, and you will hear about that.

MR. MICHELSON: Okay. But it must be a passive component, not an active component.

MR. BOSNAK: That's correct. Here, Phase II -- and I want to spend a little time because this is what is coming. Phase II will apply the methodology that was developed in Phase I to other applications. The sponsorship for Phase II -- and I am going to flash up some of the organizations that are now involved. We have ten organizations, including the Federal government bodies, insurers.

I think the fact that we have this multi-industry, multi-discipline team is very important. It's also somewhat multi-national, and we hope to also increase the participation with others from abroad. Trade and industry organizations, as you see here, the Society is seeking additional sponsors.

The documents to be developed, Volume 3 is fossil fuel fired electric generating station applications. Volume 4, API is a very active participant in this area, petroleum refinery processing and storage applications. Volume 5 is for the Department of Energy, non-commercial nuclear facility applications. Of course, Volume 2, Part 2 -- and you will hear a lot more about that -- is going to be the detailed requirements that Section XI -- and there's a lot of interaction going in with Section XI. I think Dr. Shewmon knows about the interaction that takes place.

Once this has been developed, we just can't just drop it on Section XI and say here is what we think is needed. There is going to be a lot of interaction. Future phases under consideration, I suppose here we could put valves and active components. We haven't, but I think your input on that is most useful.

MR. WARD: Bob, I notice you have aircraft there. As I understand, the Air Transport Industry has had, for many years, a reliability centered maintenance program which seems to have some of the same goals and approaches that you are talking abo.: here. Is there any conscious connection between your program and that?

MR. BOSNAK: Yes. Ken Balkey and others will be getting into that. We do have on our team, people from the aircraft industry.

MR. WARD: Okay.

MR. BOSNAK: With respect to actually developing a document, that's down in future possible activity.

MR. MICHELSON: Is the aircraft industry more interested in passive failure than active failure?

MR. BOSNAK: Ken?

MR. BALKEY: I am Ken Balkey, and I am the Chairman of the Research Group. The Aircraft industry has had the reliability group that you mentioned for quite some time. It is a result of the Aloha Airlines accident as well as the 747, where part of the fuselage blew out over Hawaii. They formed an aging aircraft research group of the aircraft manufacturers and the airline companies about two years ago.

With Dr. Smith who has been on our group since the beginning from McDonnell Aircraft, he has been interfacing with the Federal Aviation Administration. In fact, we are due to have a meeting with the Federal Aviation Administration to determine how could the ASME research team help with their research work, trying to address the passive aspect of structures in aircraft.

MR. WARD: What about information coming in the other direction, the experience of --

MR. BALKEY: So far, Dr. Smith has provided us quite a bit of information from his applications at McDonnell Aircraft and also what has gone on in the airline industry. You can see some of it in the appendix of the

Volume 1 document. We have established -- he has brought his information and we have not transferred over to their group at this point yet.

MR. SHEWMON: Is that group also limited to passive components, or does it get into actuators too?

MR. BALKEY: The aging aircraft research group, from the best of my reading of the literature and talking to Dr. Smith, is has just passed.

MR. SHEWMON: Thank you.

[Slides.]

MR. BOSNAK: What I have up here now -- and you will see, and I will try to explain -- the difference between direct and indirect. These are the direct sponsors. Here, we are talking Phase II. NRC was a direct sponsor for Phase I. To give you an idea, Phase I was about $200,000.00. Phase II is budgeted for about $470,000.00. Currently, we have in hand, about $370,000.00. That is giving you some idea.

Phase II, of course as you saw, covers more than Phase I did, and that's why there are several areas. You see NRC, the National Board, the National Rural Electric Cooperative Association, the Insurance Industry. There are three here. API because, again, the petrochemical. DOE, Oil Insurance is another member of the insurance family, and EEI.

The direct sponsors put cash on the line into the project. The indirect sponsors bring forward their people, their resources, the research that they have done. They are contributing to the project. We have used the term indirect sponsors. The time of the people and the information that comes from these various companies, you see McDonnell Aircraft here. The University of Maryland. Again, Factory Mutual, Vic Chapman is here. Exxon, Niagara Mohawk is Lloyd Smith, who is here. Wisconsin is Chuck Tomes.

They are contributing, again, by their time. As you know, any of these projects take a lot of personal time. The information that they bring from their work experiences is invaluable.

I have a list of potential sponsors. Insurance, the Empire State is, again, in the fossil fuel area. FAA is interested. There have been presentations made to all of these groups by the Center and the team that we have. The representatives from Japan Power, Engineering and Inspection Corporation are here today. The Department of Interior and DOT.

Lastly, I have here -- some of you may have heard of this particular project and have gotten it confused with the risk-based inspection guidelines. Going back to about 1988 -- I think I am probably one of the culprits. I have asked the Boiler and Pressure Vessel Committee why don't we bring in concepts of reliability, cost benefit and those kinds of things into the Code process. There are a lot of code changes that are made in this period of time, perhaps a year or two years later we change again. No one has looked at the impact of how much have we achieved in safety gains and how much have we perhaps cost the industry that has had to comply. Have we looked at these kind of things.

So, they formed a group that was chaired by Sam Taggert of EPRI, and they recommended in fact that this is something that needs to be done. That was only done last February, 1991. So, it's only a year ago. This then, went to the Board of Governors which is the highest group in the ASME organizational structure. They said let's fund it, so it's funded about -- the figure is about $270,000.00. It's funded by the society to look at what is done with respect to the use of reliability methods in the Codes and Standards process, but also in the whole organization of the society.

It is a feasibility study. It started just last June. Dr. Bob Perdue is the project manager, our principal investigator. We expect by the end of this year to have a report that I hope will make some positive recommendations. What we say here is, for the Codes and Standards activity if found feasible and we think it will be, this would be then used to decide whether to initiate -- often times the society, and this is probably true of other societies --

receives a request to initiate a standards project if you will, on something that may be very useful or may be of limited use. How do you weigh all of these things in a so-called multi-attribute utility analysis, safety versus cost. Of course, the society is looking at what kind of revenue might come into it if a new standard is generated.

Again, for things that are now in existence that are being used and in some cases being used in a regulatory sense, how do we weigh these factors. How do we get the decision that is equitable to all, and still maintain safety.

Dr. Muscara was expected to be present. Why don't I start, because some of this is NRC research. Does anybody have his slides?

MR. SHEWMON: You have his viewgraphs?

MR. BOSNAK: Yes, I have them. I am not going to be able to answer all of the questions that Joe would be able to answer. He works in our Division. I joined Research in 1987. Some of this, you will see, started in 1977. I don't have all the answers. There are some people here from PNL that, if you do have questions, they would be able to answer them.

[Slides.]

MR. BOSNAK: This will effectively, we hope, try to explain what research programs we in NRC had. This goes back to 1977. What was started, there were several areas. I think what we are talking about here is the effectiveness and the reliability of nondestructive examination methods. Whether we are talking about ultrasonic, we weren't as interested at that time in radiography. Ultrasonic was the principal thing that we had in mind, because if the reliability of the method is poor -- if we didn't know what the reliability was, then how could you use it in any kind of a risk-based process.

That was what we are talking about here, how can we improve that process. Since we have referenced in the regulations the ASME code in 5055(a), how do you improve that. You see here the Round Robin tests that were conducted to quantify this probability of detection. That was the effort that was going on in the 1977 to 1987 timeframe.

Out of that has come changes within the ASME code. Principally, I am going to point to Appendices seven and eight. This is for people qualification. This is for performance demonstration, the process that you are using; can you effectively find the flaws that you believe are present and the kind of flaws, depending on whether you are talking about intergranular, IGSCC, or something else.

Having addressed at least somewhat the reliability program and out of that came things like SAFT-UT, what was next. You see here we are talking about what to inspect, the extent, the frequency, and the reliability of the inspection. In about 1986 or 1987, PNL began to work to explore what we call a risk-based methodology. That was going on at the same time -- about the same timeframe that ASME started its research program. You see that the selection is based on information. You go back to the PRA's that are around. The methodology that PNL was working on -- and you will hear a lot more about Surry this morning from the speakers that will follow. We think it provided a structured means for ranking the various systems in a nuclear power plant.

MR. MICHELSON: I am a little puzzled by that statement. My recollection of looking at the PRA's that are around is that they don't do a very good job in deciding what the probability of pipe rupture is. They kind of use what I would call generic numbers.

MR. BOSNAK: We have adapted these --

MR. MICHELSON: I don't think it has anything to do with this in that respect.

MR. BOSNAK: Again, you will hear more about how we did that or how we used that in the process. At the same time, we are talking about the Center which you heard earlier, has developed its program to come up with a method for risk-based inspection guidelines. As far as we in NRC are concerned, it looked like this was a perfect way to get exactly what we were looking for and to come out with a program that has been integrated industry-wide and, again, not only in the nuclear industry area.

What we did, we had a research grant that went to the Center for the Phase I work and for the Phase II work. The work that you will hear about from our friends from PNL here this morning right after me, will describe exactly how their prior work and the work that was going on by the Research Task Force from the Center were put together and integrated.

[Slides.]

MR. BOSNAK: The last thing that Dr. Muscara was going to say is that we are putting together, and you will hear about that methodology for developing risk-based inspection programs has been developed by both PNL and the ASME Task Force. The pilot studies, again, you will hear about those this morning.

In the future, in conclusion, we expect that the methodology that has been developed will be used -- and this is the bottom line. If it's not used, then all the efforts that we have gone through over these number of years will have been in vain. So, we will not let that happen. We expect that we can integrate these into the risk-based ISI programs. ISI, of course, again going back to Carlyle

Michelson, is the pressure boundary of the passive components.

With that, I am ready to have my friends from PNL.

MR. SHEWMON: Thank you very much. We are slipping a little bit on schedule, but not doing bad. Thank you.

MR. BOSNAK: Ken is our principal investigator, and he's the leader of our Task Force.

[Slides.]

MR. BALKEY: Thank you. Once again, I would like to add to Mr. Bosnak, that we sincerely appreciate the opportunity to meet with you today on this important project, not only for the nuclear industry but many industries. I would like to speak to the concern that Mr. Michelson raised dealing with valves versus the passive components.

Let me go back to how the project got started. I was a member of the Risk Analysis Task Force in its inception in 1985, and met with the Codes and Standards Research Planning Committee in June of 1986, Dr. Alan McGaysee who was Chairman of the Risk Analysis Task Force at that time. We identified several areas in the Code where I thought the probabilistic methods could be used.

Actually, that Committee was very concerned. They picked up on the area of inspection, because if you look across the United States, we are not building any new power plants, any new processing facilities, no new off-shore structures. Our infrastructure is getting old. The concern is, and there have been over the past ten years, several serious accidents that were structurally related; whether it was pipeline failures and so forth.

The concern was that the first defense, given that our economy is such that we are still not going to be really providing new facilities, the first defense is to provide some type of inspection program to the industry to lower the risk or mitigate the risk of these very serious accidents. We fully appreciate and understand your concern on the valves; that what has happened in the industry when the risk assessments are used, whether it's in the nuclear or in the non-nuclear areas, the risk assessments focus on the human error, equipment error and as you said, Mr. Michelson, the structural part is well modeled to some extent using historical data.

What happens with those assessments, is that the age degradation has a tendency not to be addressed. The focus of our project is that particular piece. We want to maintain that these structures will not be major contributors to risk. There are enough things already adding to risk in facilities across the country, and we want to make sure that the structural contribution remains at a low level. We feel that this is a good methodology to address that need.

In addition, when Mr. Ray Art who is now here from the ASME Center for Research, as we went to the sponsors, several sponsors were most interested in addressing not only the passive but also the active components. When we first started the project we were very concerned, should we do both. What we were concerned about is, if we took on both the passive and the active at the same time, the scope would be so large that we were concerned that we would not get to the specific recommendations we felt are needed in the structural area. We felt that at some additional time, whether this team or another team could be added through the research Center, to use these techniques to begin another research effort on addressing active components.

When you made your comments of -- I have written down -- the work with Mr. Art, that I think that could be a very important research need. There should probably be some active consideration of how our team could help form another team to address that particular need.

The other thing that I would like to address too is, actually, when we first met with the Codes and Standards Research Planning Committee the group at that time felt that Section XI was in place; the nuclear plants are inspected to the requirements in the ASME code. The other industries do not. Some of the other i dustries do have some recommended practice guides, but there is none a comprehensive section as Section XI. Actually, they wanted us to put a research task force together to represent the non-nuclear aspects.

You will see on the team members, that's why we have our representatives from the aircraft industry like Dr. Ayyub from the University of Maryland who is not even a mechanical engineer -- he's a civil engineer at the University of Maryland. When the project was starting to go through its approval process it was recommended that it might be wise to revisit the nuclear first, before launching into the other industries.

The way the project was structured was that instead of preparing a first document as nuclear, we still felt there was a much broader industry need. That's why we put the Volume 1 document together the way that it is. It's a general methodology that, while these other industries are waiting for their particular specific document to be written, at least there was something that they could start with. I can honestly say that I know that there are organizations who have taken the Volume 1 document outside the nuclear industry and are using those methods to address structural concerns. So, that initial need, we feel has been met.

Then, we have now come back focused on the nuclear, and now we are in our Phase II effort, expanding now into the other industries as Mr. Bosnak had stated.

What I would like to do first here is recognize the contribution of some very talented people. Rather than just reading through the names, I think it's more important to determine what skills and what technology are needed to set up a risk-based inspection program. There are three primary skills that are needed and are represented by this group.

The first one is the reliability of the inspection techniques themselves. We have Dr. Fred Simonen from Pacific Northwest Labs who has been working in that area on NRC research here for a least the past ten years. He is very well recognized in the industry for his skills. The next group is to address the concern of how can you predict a probability of failure in a structure, given the uncertainties in potential degradation that may be there, the reliability of the inspection techniques, the uncertainty in the loadings.

That requires a very special skill, and we call that structure reliability or structure reliability risk assessment skill. It's very different than the probablistic risk assessment techniques that have been used across the industry today. With that, there are several people on the Task Force with that skill.

Dr. Ayyub, from the University of Maryland, has developed models for bridges, marine structures and other civil engineering applications. Vic Chapman, from the United Kingdom, has developed models for the UK submarine program and for pressure vessels in piping. He has developed work in that area. Dr. David Harris, from Failure Analysis Associates, has done that work in both the nuclear and fossil, and he has even worked on the space shuttle engines in applying those type of techniques. As well, he had some processing equipment as well too.

Going down through this, Dr. Herb Smith, that's what he does for a living at the McDonnell Aircraft Company. He is a structural mechanics engineer for McDonnell Aircraft. You see, there are some contributors at Westinghouse. Bruce Bishop of Westinghouse is our expert, and he has been working with the team, making contributions to the project in that area. You can see that there are several people from several different applications, in trying to come up with methods to make failure predictions because you can't rely on historical data very well.

Or, if you want to determine the effect of new inspection programs or new techniques, you will almost have to model it rather than trying to make an estimate of what that number may be.

Finally, the last skills are the experts who have done what I would like to call is the probabilistic risk assessment of entire plants or systems or facilities. With that, there are a number of people. Dr. Brian Gore has been the expert for the Nuclear Regulatory Commission in that area for more than a decade. Dr. Dimitrios Karydas has developed that technology for the insurance companies. His company is an engineering arm for several insurance companies, and he has done everything from paper mills to fossil plants, to processing facilities and many other types of industrial insurance applications.

Jerry Phillips, who formerly worked for Carolina Power and Light, actually was the probabilistic risk assessment expert at Carolina Power and Light before moving to Idaho National Engineering Laboratory. He is now doing that work for the Department of Energy on their non-commercial nuclear facilities. Going down through the list, Truong Vo, who we have him here as an honorary member but is being brought up as to a full Member of the Task Force. He has been doing some very good work, which you will hear about, on the Surry application working with other members of the team.

I think I have covered just about everyone in that area. There are some other additional skills that are brought in. There is Dr. Lee Abramson from the NRC. He has been brought on the Task Force and actually has been working with us for the last 18 months to two years. His expertise has been involved in the expert elicitation to get initial failure probabilities to go into the risk assessment for structures. He has also been very instrumental in reviewing the probability and statistical calculations and methods that have been recommended in both the Volume 1 and the Volume 2 document.

You see some additional contributors down below on the bottom of the viewgraph here. Dr. Robert Perdue from Westinghouse is an economist. He is chairing the other project that Mr. Bosnak mentioned on the reliability, feasibility of using reliability methods in the code. His work over the last several years is taking -- we will speak about it later -- is integrating uncertainties and technical applications with the economic uncertainties. There is a strong interrelationship in trying to determine programs that meet safety requirements and economic requirements at the same time.

Guido Karcher and Radhakrishnam from EXXON have been very instrumental in providing a link to the American Petroleum Institute, and in helping get our Volume 4 document launched in that effort. In fact, the effort that they have done over the past year has been in addition to their own research they are doing at EXXON, and have contributed to the project. Mr. Karcher has worked with the

API executives within that organization to form a risk-based inspection group in the API made up of petroleum companies, that will interface with a subgroup of our research groups so that, as Mr. Bosnak said, we don't develop a research document and drop it on the group.

They are going to work with us, so that as the research is carried out they can decide what new recommended practices that they will need to put in place on their applications. That has been their contribution.

Mr. Stavrianidis has been working with Dr. Karydas on the fossil plant application for us, and has done some very excellent work. There is one name -- there are two names that I have missed. Lloyd Smith, from Niagara Mohawk, who you will hear about later, has developed using reliability methods on a fossil plant. He is going to talk about how these methods have helped to improve the availability of their fossil units at Niagara Mohawk.

The newest skill that we have just added to the group is, as we go now into take actual applications to make recommendations to the Code, we are adding Mr. Chuck Tomes from Wisconsin Public Service, who is the ISI engineer for Wisconsin Public Service. He was the ISI engineering at Kiwanee for the past nine or ten years. He is going to be providing very valuable information, hands on information that we need to have in order to finish out our Phase II efforts.

I think I have covered just about everyone on the group. You are going to hear from a spectrum of these people over the course of the day here.

MR. WARD: Ken, I am glad to see that you seem to be paying some attention to the statistical methods. This Committee has recently had some problems with application of some statistical methods in some of the NRC work. It has kind of developed some sensitivity in that area. Certainly, the PRA people are conversant with statistical methods, but it's not quite the same thing there.

Their concerns and emphasis tend to be one systems and so forth rather than making sure that the statistical approaches are pure and honorable and all that. I think that deserves some particular attention, I think.

MR. KERR: This is one of the great values of working with a team of people from the government sponsored laboratories, industry and academia. In fact, Dr. Ayyub at the University of Maryland, has made a tremendous contribution in the area of the statistics. In fact, a lot of the examples involving one he did with colleagues at the University of Maryland to contribute to the group.

He has a very strong background in that area, and so does Dr. Perdue at Westinghouse. There are several people in the group -- in fact, I would say just about everyone in that group is very conversant. We are aware of the concern that you folks have raised. That was one of the strong reasons why we brought Dr. Abramson actually onto the group to work with hand in hand, to make sure that that concern is addressed.

[Slides.]

MR. BALKEY: Now, for our Steering Committee. It is primarily made up of representatives from -- Mr. Bosnak is on the Steering Committee primarily from the aspect of the Codes and Standards Research Planning Committee and the Council on Codes and Standards. There was a question dealing with the complex management structure of ASME.

I can only say, this is a project I have been working with ASME since 1985 in getting the effort started. I have been in business for 20 years, and I would like to speak my own personal opinion. The management structure works quite well. The Codes and Management Standards Research Planning Committee that I meet with and several members meet with our group have been providing very valuable direction to the group. I have met with the Board, I have met with the Council on Codes and Standards, and the input that we get and direction is keeping us on track in making sure that we do get things delivered on time.

In addition, our sponsors -- a number of our sponsors come from the organizations providing direct financial contributions to the project. In fact, with us today is Mr. Bill Wendland from American Nuclear Insurers, and he is going to speak later about his perspective from the insurance industry in using this type of methodology.

I won't go through all the names but there is, once again, a cross section of people from government and the private industry. We have used on our -- we put our documents together. The ASME Center for Research requires and the Codes and Standards Research Planning Committee require the documents to go through a peer review. For instance, we had Dr. Vicki Bier from the University of Wisconsin who is very well recognized for her skills in PRA and in decision analytic techniques, and provides an outstanding contribution to our report.

John Boardman is the ISI engineer at Southern California Edison, and he reviewed the report from an inservice inspection engineer viewpoint. He is so interested in the project now, that he is now actually on the Steering Committee because he would like to stay on as we follow through our Volume 2 efforts. Ernest Throckmorton from Virginia Power has been working very closely with the PNL team in carrying out the Surry study, and he is providing direction -- of course, he has reviewed all of the documents too, to give us input on that report.

Finally, Mr. Bud Epps -- he was with Southern

Nuclear Operating Companies and now with TKS International. He was from a utility, and he also has reviewed the report and provided very valuable input.

You can see that there is a group that is overseeing to make sure that this project stays on track and does deliver.

MR. SHEWMON: We aren't making up any time on the schedule.

MR. BALKEY: I will skip the next one. What we say in our viewgraph here is that we -- on this viewgraph here, we have organized into subgroups. The group does meet three times a year collectively. The purpose of breaking the group into the working sessions first of all is to work closer. For instance the Long Range Planning Committee of Section XI on Monday, there is now discussion of possibly doing what the American Petroleum Institute has done, and that is to form within Section XI a group that will work very closely with this subgroup, so as the results come together they can be delivered into implemented into Section XI in a more feasible manner.

[Slides.]

MR. BALKEY: This is the process that has been developed. It's essentially a five step process dealing with how you want to apply risk-based techniques for inspection programs. The first box, of course, is defined the systems in assembling information that is needed to carry out a risk-based inspection program.

We have a qualitative risk assessment box in there, and my next viewgraph which I won't show at this point, what we are trying to indicate is that there have been some good qualitative work done in plant life extension efforts to rank degradation mechanisms within nuclear power plant applications. It does provide some insight in terms of where a high failure probability may exist.

The Code itself actually is built on a qualitative risk assessment approach, albeit it isn't implicit. The way the classifications are set up, the way indications are found and how they are resolved, it is a decision process built into the code that actually is following a risk-based approach. However, as I said, it's qualitative and on engineering judgment.

MR. MICHELSON: Excuse me. Clearly, many of those items are quite location-specific and plant specific and so forth. How do you do these general judgments, for instance, of consequence? It depends on the particular plant, is what the consequence of a pipe break might be. It depends on the location of the break within that plant as to what it might be.

MR. BALKEY: We are very aware of that, and you are going to see how that is handled in the next speaker.

MR. MICHELSON: Thank you.

MR. BALKEY: In fact, what I would like to do -- the last three components make up the presentation for the balance of the day. You will hear from Truong Vo -- will cover the risk-based ranking that has been done to address the concerns that you have just addressed, Mr. Michelson. Brian Gore from Pacific Northwest Labs will be doing the -- how you get target failure probabilities that have to be achieved with the inspection program.

Finally, Dr. Simonen and I will be back to discuss the actual development of inspection programs to meet those targets and address cost considerations at the same time. Not on the agenda -- we just learned last week that Mr. Chapman from England would be here. Mr. Chairman, I was going to ask that if there was a few minutes, if we could following my presentation, if he could talk about how they actually implemented a risk-based inspection program on the UK Submarine Program, taking actual inspection results and updating the risk assessment, making it a very living process. I think you would be quite interested in a few viewgraphs that he would have.

Finally, you will hear a prospective from -- Lloyd Smith is going to talk about how he has applied these techniques at fossil plants. You will get a perspective from Mr. Chuck Tomes from the utility on how he views the use of this technique and Mr. Wendlund on insurance.

MR. SHEWMON: Fine.

MR. BALKEY: I will close with that.

[Slides.]

MR. VO: My name is Truong Vo, and I am with Pacific Northwest Labs at Washington. In this presentation I will address one of the boxes -- ten -- addressed earlier in the failure mode of critical analysis. In this, I will briefly go through the methodology that includes the system prioritization and it follows by the component for prioritization. I will spend probably most of the time in the pilot applications, and specifically I will focus on the Surry applications. Finally, the concluding remarks of the methodology and the work to date will be presented.

For our methodology we utilized the two step approach. That is, at first we prioritize the systems using the PRA results and it is followed by the component prioritization for some selected systems. Again, the PRA information or the probabilistic risk assessment information in combination with the FMEA and FERC analysis, techniques will be used to identify and prioritize the most risk important system and component for further consideration.

At the system level we used the core damage frequency as the risk measure, and we developed the two criteria for accepting our prioritization activities; that is the Birnbaum Importance. It is defined as the probability of the core damage, given a system failure. In other words, studies the condition of probability of the core damage given the total system failure.

With that, we developed the inspection importance studies. We will describe this in the next viewgraph. That is, the product of the Birnbaum Importance in the system failure estimated. Again, the Birnbaum Importance is the core damage risk associated with the total system failure and the estimated rupture probability for that particular system of interest.

MR. KRESS: Pardon me. You say that the I is the change in the core damage risk.

MR. VO: Yes.

MR. KRESS: I fail to see how it is a change in risk. It looks like a contribution to risk, to me.

MR. VO: I should say that is the probability of the core damage, given that particular system. I should say that.

MR. KRESS: It's not really a change.

MR. VO: Basically, the derivative of the total core damage with respect to the particular system failure -- I should say that contribution to the total core damage.

MR. GORE: It's a change, in the sense of going from normal operation with the system in normal operating mode to the increase in risk when the system is assumed failed.

MR. SHEWMON: Sometimes that's called --

MR. GORE: The word changed is used here.

MR. VO: At the component level basically, for the most risk importance systems identified the further analysis will be identified for the component. Again, the core damage frequency is used as a risk measure and a failure mode and FERC analysis technique will be used to identify and prioritize the risk important component for further interest. The results will be calculate at importance index, or relative importance for each component within the system selected for the study.

You will see a little more as I present the results in the following viewgraphs.

MR. MICHELSON: You are doing all of this on passive failure conditions only, and once you experience a passive failure of course there are several active components; that, if they don't function you are in deep trouble. Yet, that part seems to be ignored in here.

MR. VO: No.

MR. SHEWMON: It's part of a PRA.

MR. MICHELSON: That's a problem with PRA. For instance, on reactor water clean up on a boiler PRA ignores it, because it says probability of the failure of the pipe is ten to the minus five range, probability of each of the valves will close is another ten to the minus three or four each. As a result, it's a non-problem. In reality it depends on whether those numbers are any good for the case of the pipe break as opposed to the case of normal operation of the valves.

Those kinds of things just aren't in PRA presently. That's why I thought we were going to get to it.

MR. VO: I think you probably it is much more clear for you later on in the following viewgraphs. You see application -- the Surry application. Hopefully, that will --

MR. MICHELSON: It will be clear later?

MR. VO: I hope so.

MR. MICHELSON: Thank you.

MR. VO: At a component level basically, again, this is the equation to describe the component prioritization activities. Basically, the core damage frequencies for that particular component of interest is the product of the failure probability of rupture. Probability is the interest parameter in this analysis, multiplied by another product -- summation of the condition of probability of the core damage given the system. In this particular case this is the Birnbaum importance.

For a time, the condition of probability of the system failure given the component failure basically we use the fault tree analysis, fault tree results from the PRA to identify this particular parameter. We also include a probability of a recovery operator.

Again, summation, basically we include the direct factor is the failure of the system. Given a component we also include in the direct effect; that is, for the particular component failure that could impact or damage the systems or components and could create some core damage -- the room and including the vital equipment.

This viewgraph basically tries to address since the PRA normally did not address most of the failure probability or rupture probability of some component of interest, therefore, I will elaborate this a little bit more later on during my presentation. Because of lack of that data and historical data, it is not sufficient for use in our analysis. Therefore, we used expert elicitation as one of the methods to come up with our rupture probability for our study. Again, we will discuss more this in the next few minutes.

MR. MICHELSON: Is your rupture probability going to be for unit length of pipe, for instance?

MR. VO: Yes, sir. IT will be in piping segment-
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MR. MICHELSON: If I have 100 feet of pipe with two locations where erosion/corrosion might be a possibility and I have 1,000 feet in another case with two cases, one case the rupture probability is going to be one-tenth of the other? It's only two rupture locations, whether it's 100 feet or 1,000 feet, it's the erosion/corrosion points that you have to look at from the probabilistic viewpoint, not the number of feet of pipe.

MR. VO. Probably we will address that in the next viewgraph as well. We haven't got there yet. We are still in the methodology now.

Let's talk about application of our studies. Basically, our developed method had been applied first as part of Oconee study, and again for this particular study we addressed the complete system prioritization activities for that particular plant using the PRA results. We performed limited prioritization. As I discuss in a little while, we selected auxillary feedwater system as one of the systems for further analysis. The method had been proved to be successful. Therefore, we are looking for a generic applicabilities. Therefore, we also selected some representative LWR for further studies.

Again, this study we could look at the system level. Finally, at Surry study, we performed a complete system prioritization and we also performed a detailed component prioritization. This study we will spend quite a bit of time on this and hopefully will have addressed a lot of questions that have been raised.

For Oconee Study -- just flip it over for results. This is the results for auxillary feedwater system at the Oconee 3 plant. This viewgraph plot by the consequence condition of probability of core damage versus the probability of rupture of the component. I think the message of this viewgraph is basically as you see, the component one, two, three and five it is relatively high -- it has relatively high rupture probability.

However, when they fail it makes a small contribution to the total core damage. Again, the component for that is the UST -- the supply line of the auxillary feedwater system. Again, when it fail it could disable the total systems. Again, component seven, that is the suction line of the auxillary feedwater system. Again, when it fails, it could cause the total system failure. Therefore, contribute significantly to the total core damage.

MR. KRESS: If the total core damage frequency was on the order of ten to the minus four due to all causes, would you look at whether or not these things are worth worrying about?

MR. VO: Basically, the message -- basically I provide you with the idea for your further performance of inservice inspection at component. For example, say what it depends is address for inservice inspection of the auxillary system for example say the UST supply line. Again, depending what it addressed and maybe the candidate up for further inservice inspection. Again, I think the message you could use these results to strategize your results to perform the ISI at your plant.

MR. MICHELSON: Clearly, in the case of auxillary feedwater if you should rupture the steam supply line in the auxillary feedwater compartment where the turbine is located, and if you then tried to close the isolation valves which will automatically close, you are going to have to use the right probability of closure. It's not the normal operation probability closure. Now, it's one with several times normal steam flows through the valve.

It's a new number. I don't know what the number is. Unless you have test data you don't know either. It's a considerably higher probability of failure to close than it would be under normal operation. That has to be in your PRA, if you are going to determine the real importance of the rupture of the main steamline that they had in the turbine for instance.

MR. VO: Again, basically, this is just the one system we selected. I think I will --

MR. MICHELSON: It took the one system you selected and the one example. That's very important in that system, namely now the ability to isolate the break. That affects core damage probability. The numbers presently used in PRA's are failure in the ten to the minus three range for those valves.

In reality, they must be much higher failure rates as we have found out from the test programs so far on motor operated valves.

MR. KRESS: You could incorporate that in your uncertainties along the horizontal access, it seems to me, if you knew that was a possible uncertainty.

MR. VO: That's right. Later on in the Surry application I think that probably should go. Later on, I think basically we plot the number for a system we selected at Surry study we get uncertainty bands here and there. We will get to it.

MR. MICHELSON: To get that uncertainty band you are going to have to have some idea of what the uncertainty is.

MR. KRESS: Yes.

MR. VO: For this basically we just tried to -- as I mentioned earlier, we tried establish a generic system ranking among the U.S. nuclear power plants. Again, it was not possible to perform the analysis for all nuclear power plants in U.S. Therefore, we selected a few representative plants for our further analysis.

The criteria that we selected for our analysis is based on the reactor vendors. For the plant types, the PWR's we included in the architecture/engineer consideration as where that is including the containment designs. Finally, availability of the PRA is one of the dominant important for our selection criteria.

Without going further in detail, these are the results of the -- these are the plants we have selected for our study. We selected Surry. That is, the Westinghouse, subatmospheric containment type. Zion, large dry, Westinghouse design. Sequoyah, Westinghouse condenser. Oconee, B&W large dry. Crystal River, B&W large dry. Calvert Cliffs, CE large dry and the two BWR's, Peach Bottom II and Grand Gulf 1.

Basically, most of the these plants selected was addressed in the NUREG 1150 PRA's.

MR. WARD: Can I ask a question? You seem to have gone to some trouble to select different type of containments, but your risk measure is core melt frequency.

MR. VO: That is correct.

MR. WARD: Is there really much significance then in this --

MR. VO: For some plants it is. Again, I might be wrong, it been quite some time for example -- for the Peach Bottom the RCIC -- I believe their reactor core isolation system -- I believe when a containment failure -- when a containment over pressure could provide some back pressure and disable RCIC I believe. Therefore, containments for some plants may be significant contribution for a core damage.

Again, it has been quite some time -- I believe one of the Westinghouse plants has something to do with the reactor cavities and could provide later on in the core damage phase, could provide some flooding the core and that type of measure. Again, that's why sometimes I forget exactly what plant it was.

To answer your question, yes, the containment design may be significant contribution to estimation of core damage frequencies.

[Slides.]

MR. VO: At the system prioritization, again, I indicated earlier we just addressed the system level only. Again, we ranked the inspection importance. In other words, the Birnbaum importance times the rupture probability of that particular system of concern. You see the ranking. Basically, first at the low pressure injection system. IN general that agree among the plants for the high pressure injection system. Reactor vessel pressure across all plants rank that type.

Inservice water system, I would like to say the worst for inservice water system as you see at the Zion basically, it seems to be the outlier basically sends the cause of the failure of service water system at the Zion could cause the loss of component cooling water system. Therefore, create a loss of high pressure injection system. In other words, you get the loss of high head and could contribute significantly to the core damage.

The auxillary feedwater system, steam generator, we separate ranking. We ranked steam generator separately for our further -- for other purpose of that study for reactor coolant system and power conversion systems. Basically, the message of you could get out of viewgraph is that you could use the results to balance your resource for performance of your ISI of your plants.

MR. WARD: The importance ranking is what you called the Birnbaum importance ranking; is that what that is?

MR. VO: Inspection importance. In other words, the Birnbaum importance times the rupture probabilities for that particular system.

MR. WARD: Okay, fine.

MR. VO: You have similar type but you don't have it in the package. You have a similar type of sketch like this for inspection importance. I mean, the Birnbaum importance in that case, I think probably you should see reactor pressure vessel should rank the highest. When you fail the reactor pressure vessel the core damage is assured.

MR. WARD: That's a pretty interesting plot.

MR. VO: There is another similar type of plot is for BWR's, and you do not have in the package. Basically in general, you see the reactor pressure vessel is ranked first and it's followed by the RCIC, the HPCI and I believe that service water system -- emergency service water systems. Lastly, the power conversion systems.

Let's discuss about Surry applications. For this particular application we performed our analysis in detail. Again, for the four systems selected we will elaborate in a few minutes. Basically, we selected the Surry 1 for our further study, basically due to the availability of the good PRA information. That had been selected for several ongoing NRC research programs for example, aging research program at the NRC, the risk program at the NRC.

With the results of the system prioritization activities -- and I presented earlier -- basically we selected four systems for further study. They are the reactor pressure vessel, reactor coolant system, low pressure injection system including accumulators, and the auxillary feedwater systems.

This viewgraph kind of repeats the earlier one I mentioned earlier, basically the core damage frequency. We use for our ranking purpose and FMEA methodology will be used to rank the components. Again, we did the rupture probability for that particular component of interest and we used expert judgment elicitation process for our analysis.

At Surry for --

MR. MICHELSON: Excuse me just a moment. I am puzzled by something here. You are using a PRA, of course, as the basis for doing this work. Why do you flip over to an FMEA for the risk important of components. Can't you get that from the PRA?

MR. VO: Okay. At first we used the PRA's. We tried to identify and prioritize the most risk important system. Again, I mentioned earlier that we used the two step approach. With the important systems had been identified we further used FMEA techniques to identify the component for the component systems.

MR. MICHELSON: The component level is in the PRA.

MR. GORE: The reason for the FMEA methodology is precisely because the rupture probabilities are not contained within the PRA. The PRA provides the information to identify the conditional probability of core melt given the loss of the component. The risk is the product of rupture probability times that conditional probability of core melt. Those two numbers go into the FMEA work sheet and are multiplied together to give you the risk then associated with the rupture of the individual components.

MR. MICHELSON: I am puzzled. Let's take auxillary feedwater, which is one of your examples.

MR. GORE: Fine.

MR. MICHELSON: You have say 500 feet of piping outside of containment on it. You determine what you think is the probability of failure per linear foot and multiply it by the number of feet; is that what you do?

MR. GORE: Not quite. We take the expert elicitation number estimated for the rupture probability of pipe segments specifically identified on the plant drawings.

MR. MICHELSON: From weld to weld.

MR. GORE: That's right.

MR. MICHELSON: Then you have "x" number of --

MR. GORE: You will hear quite a bit about the expert elicitation process. We are not ignoring the fact that it's not the --

MR. MICHELSON: I had asked earlier if you are doing it on a per foot basis. You are doing it on a --

MR. GORE: I didn't want to break in at that time. I wasn't quite sure --

MR. MICHELSON: It was quite a difference --

MR. GORE: -- what the protocols are.

MR. MICHELSON: You are doing it on a segment basis.

MR. GORE: Yes.

MR. MICHELSON: Why then do you need the FMEA? I know the probability of failure now, because I have the number of segments and the probability per segment.

MR. GORE: That gives me the probability of loss of one of two or three redundant supply trains supplying aux feedwater.

MR. MICHELSON: PRA has that built into the --

MR. GORE: So, what we have --

MR. MICHELSON: -- the core melt probability.

MR. GORE: We re-analyze the fault tree for that system is to determine the probability of loss of the entire system, given loss of the ruptured component train. This is the conditional probability of system loss given rupture, which he mentioned earlier.

MR. MICHELSON: You mean for instance, --

MR. GORE: Total loss of feedwater --

MR. MICHELSON: -- isolation valves failing to close; is that what you mean by a system loss?

MR. GORE: Total loss of aux feedwater, given loss of the redundant train.

MR. MICHELSON: That's in the PRA already.

MR. VO: Yes.

MR. SHEWMON: That's what he is saying, it's used in the PRA --

MR. MICHELSON: I am asking what is he using a FMEA for.

MR. VO: I think the key point of discussion basically I think because of the PRA did not address the rupture probabilities of the components of interest to us. Therefore using the result of the PRA and then we broke down for the -- we tried to incorporate or include the rupture probabilities in that particular components.

MR. BALKEY: The other thing, the reason you come back to the FMEA, PRA will calculate the direct consequence but these guys have gone with the utility and walked the plant down to see what indirect effect may occur, which you can't model in in the --

MR. MICHELSON: I am talking about the incompleteness of the PRA.

MR. BALKEY: That's right. So, they walked down the systems to get the consequences made up of a direct and indirect portion.

MR. MICHELSON: If you are going to refine that, then you really ought to include the probability of isolating that break as well. The real probability of it, not the used in the PRA, because the PRA did not recognize that you are under several times normal flow in those valves. Bob knows all about this problem. That's not in the PRA, and you have to recognize that.

If you want to modify that --

MR. SHEWMON: He has a comment.

MR. GORE: I will roger your suggestions and criticisms. We are in a pilot development of a methodology and its first application. We have a rather modest research budget. The few hundred thousand dollars that has gone into this effort has yielded, I think, some results which you will be very interested in.

Recognize that going back and reanalyzing and taking apart the PRA's is to change probabilities of failures of the active components is a non-trivial task, which we would be delighted to address given that the methodology proves out and we are given the go ahead for future work. Right now, we are in the tailored series mode.

MR. MICHELSON: If you had a truly complete PRA you wouldn't have the FMEA; is that your view?

MR. GORE: If you had a complete PRA that went down in the cutset retained for analysis, three to four orders of magnitude in probability which would put you into the many thousands of cutsets -- unfortunately, that information does not exist. So, we have developed this methodology as an approximation to incorporate the extensive investments in modeling these plants represented by the PRA's to combine rupture probabilities with conditional core melt probabilities, which we extract from the information in the PRA.

We are not re-analyzing the PRA's except to identify that conditional probability. But we roger that yes, we could go in there and further modify them once the methodology is proven relevant and useful.

MR. KRESS: The reason those things don't show up goes back to the question I asked before. They don't add significantly to the core melt probability; therefore, they get eliminated in the cutsets.

MR. GORE: That's correct. When I make my presentation on target risk, the whole objective of this exercise is to risk prioritize the small contributions to risk which --

MR. KRESS: That's why you have to go back and redo the FMEA.

MR. GORE: Yes. The objective is to keep those risks down in the grass and out of the PRA's.

MR. WARD: Now, I understand. The previous interesting plot you showed was, of course, only for each of those systems only dealing for rupture -- pressure boundary ruptures in those systems and not for failures of active components in the system. That's why we are working down in this --

MR. KRESS: Supposedly the active components come into that plot, because they show up in the conditional probability of core melt. They are in there.

MR. GORE: In some sense, yes.

MR. SHEWMON: Let's go on.

MR. VO: I would like to address one of my concerns. Basically, this is earlier viewgraph. The recovery probability operator -- it could include if an operator failed to isolate the isolation valves, something like that. Again, that would include in that equations. You have to point out in term ISI.

At the component level basically, we have to -- the Virginia Electric Power Company or VEPCO, they have to provide us a lot of technical information for our analysis. Basically, at the beginning of the analysis we obtain a system drawings from the site and we performed a number of system walkdowns and tried to identify the potential targets given the component failures.

For example failure of the piping segment of the auxillary feedwater system within the room at the Surry site and could damage the vital electrical bus nearby or could damage the valves, or could create the potential flooding for that particular rooms. We had performed a number of system walkdowns at the site.

We used standard review plant 3.6.2 for determining the indirect effects due to jet impingement of fracture in the system nearby.

[Slides.]

MR. VO: This viewgraph basically address the why do we need the rupture probabilities for our analysis. Basically, since the pipe rupture is generally excluded from the PRA and they make a small contribution as compared to the risk -- compared to failure of the active components. For example, in PRA analysis a lot of component rupture that had been included in the fault tree analysis -- however, at the final cutset analysis in PRA they had dropped out because at the PRA they had to kept up some certain level, for example, just anything less than one to the minus nine for example had dropped out from the PRA results.

The consequence for rupture of pipe segment had been estimated from the PRA by considering the failure of the adjacent active components. For example, lack of flow due to the pump or valve malfunctions failed to open or close, that type of nature. Normally, the only rupture of consideration for a piping within PRA -- consider for a case of LOCA only for example -- therefore, again, we used expert judgment elicitation.

This is the method we used for our estimates and rupture probability for the system of interest to us. Again, we basically should adapt the NUREG 1150 for expert judgment method developed for NRC. Basically there are eight steps. Again, first the selection parameter for our analysis, we are interested in the rupture probability of the piping segments or components depending on the systems -- I mean for example reactor pressure vessel we call the components weld or something like that. For other systems we are interested in the pipe segment. Again, pipe segment could include the pumps, the valve, the T-elbows, flanges and other components.

On the step two basically in the selection of experts, we had selected the -- we had chosen the expert members from the utilities, the vendor, the Federal governments, employees, and universities and so on and so forth. Before the expert elicitation really is conducted we send the material to the expert member for their familiarization of the issues being addressed.

During the expert workshop we also provide training. Again, the last workshop had been conducted last week. Dr. Shewmon was one of the members of our expert panel. We did not provide a training for our earlier workshop a couple of years ago but we did for the last workshop, and it took place last week.

Basically, for elicitation did a face to face -- that elicitation at the workshop -- with the results, we obtained we will combine and aggregate the results. Later, we will send the material back to our expert panel for potential review and revision. Finally, we document our results.

MR. KRESS: How do you combine the probabilities of failure that you get from a set of experts if you have five experts and have five different distributions that are markedly different from each other, orders of magnitude for example; how do you combine those?

MR. VO: Dr. Lee Abramson had that and maybe I will refer to Lee for maybe explain it better.

MR. SHEWMON: Will this come later in the program?

MR. KRESS: If it will come later, we can wait.

MR. ABRAMSON: As I understand it, this combination of the expert opinion is going to come after this project. It's what you do with it. However it's done, it's very important to make sure that you don't -- that you reflect the uncertainties in the expert opinion; that you don't necessarily try to get a consensus distribution.

I think it's very important to do that. How this is used, there are various ways of doing it. For example, it was done in 1150 -- try to reflect the uncertainty. I believe that is really beyond the scope of this project, is what you are going to do with the expert judgments. Right now, all we are trying to do is to get the expert judgments and to make sure that we are reflecting the full range of scientific uncertainties expressed by them.

MR. SHEWMON: Tom, was your question how you average these things or what you do with the average after you have it?

MR. KRESS: How you average them.

MR. SHEWMON: Averaging, I think, you have --

MR. VO: I think how you combine all the results.

MR. SHEWMON: How you combine ten experts, the numbers.

MR. ABRAMSON: What we are doing as far as this project is concerned is displaying the results in more or less standard box plots. For example, we take their median or so-called best estimates and present these in terms of a box plot with the extremes shown and 25th and 75th percentiles shown, as you see on the slide there.

This is a description of what the experts are coming up with. It doesn't -- it is not a combination in the sense that this tells us what we are going to do with them as far as calculating in a PRA. You certainly want to take account of the often very large uncertainties that are demonstrated here when you try to actually put numbers in. What that will do, of course, it will lead to large ranges of uncertainty in your results.

MR. SHEWMON: Okay.

MR. KRESS: I understand what they are doing now. I am not sure I agree that's the right way to do it, but I understand it.

MR. SHEWMON: Let's go on then.

MR. MICHELSON: Did you use expert opinion for other than probability of pipe rupture?

MR. ABRAMSON: We consider that there are a lot of different components that we asked some questions about.

MR. MICHELSON: Asked questions about, relative to their pipe pressure boundary rupture potential, or ask other questions?

MR. ABRAMSON: I think maybe I would rather not -- I am not that familiar with the specific questions that were asked of the experts.

MR. MICHELSON: The chart he just flashed, of course, was for pressure boundary --

MR. VO: For our analysis, again, the parameter of interest is the rupture probability of the component interest only. Again, we asked expert what is the probability of rupture of that pipe segment per year. We also asked for providing the rationale of the estimates. In other words, why the member provide us that particular results.

To make that eight bullets, eight items. Basically, at the expert meeting expert elicitation workshop -- basically we provide the historical failure data, what we could, and the data from other analysis including PRA results. Also, additional information from the site specific. We conducted an elicitation. Again, before actual elicitation there will be a lot of discussion to ensure all the expert member had the grasp of what we are looking for.

Again, this viewgraph represents an earlier expert workshop. That's not the last one.

[Slides.]

MR. VO: This is the example of the results I put up earlier. Basically, for the reactor pressure vessel as you see basically, we provided as the box. This is extreme value of the expert members provide us our results. The lower end of the 25 percentile and the high end is the 75 percentile of estimation of combined results. The circle in the middle, the median value of the estimates.

As Dr. Lee Abramson discussed, we tried to combine all expert member into single value for our use.

This is another example. Again, you don't have this in your handout. This is the results. We had a plot -- quickly -- last expert workshop last week. Basically, it is similar type of the results. In this case we looking for the RHR the residual removal system at the Surry site. Again, this is the plot and the median in the 95 percentile of the median case. You do not have this in your handouts.

MR. MICHELSON: These expert elicitation were for the several different systems of interest, including the service water system.

MR. VO: Yes, sir.

MR. MICHELSON: In the case of the service water system, did you elicit the probability of failure of large metal bellows in those systems, of which there often are?

MR. VO: Could you repeat? I didn't hear last part.

MR. MICHELSON: Did you include in the pressure boundary for service water systems a possibility that there may be a large metal bellows that was to fail, and what its probability might be?

MR. VO: Yes. We include from the -- again, Surry include from the suction side of the canal through the discharge side or other components --

MR. MICHELSON: Do you, by chance, recall the number that you got for probability of failure of a three foot metal bellows?

MR. VO: No, we had not done it yet. Basically we did it last week --

MR. MICHELSON: You are going to do it?

MR. VO: Yes.

MR. MICHELSON: You haven't done that one yet.

MR. VO: No. We elicit --

MR. MICHELSON: Metal bellows will be included as pressure boundaries, even though they are not necessarily covered by the code.

MR. GORE: We have the raw data. We have not reduced or analyzed the results of the elicitation process. It was finished last Friday. We haven't sat down to analyze the data.

MR. MICHELSON: You understand, you are looking beyond ASME components then?

MR. GORE: Absolutely. This is a risk-based analysis, and we are trying to follow the logical lines of inquiry.

MR. MICHELSON: Thank you.

[Slides.]

MR. VO: Again, this is with just plot for some components, that expert elicitation we conducted last week. This is another one, as compared to our base case. This is piping segment from the reactor coolant system through the first isolation valve to RHR, as compared to the first one. Again, you do not have this in your plots.

Basically in the summary, again for a system of interested as I indicated earlier, they are reactor pressure vessel, reactor coolant systems, low pressure injection system and auxillary feedwater system. Based on this four system the contribution of the component failures due to core damage ranging approximately one to the minus six to one to the minus 14 per plant years. Again, the median value.

The cumulative risk contribution was estimated about 2.1 to the minus six, and we will show you this in the next few plots. The total estimated risk is dominated by the failure of the reactor pressure vessel. Basically, it is 86 percent for the low pressure injection system components, ten percent auxillary feedwater system, and other components about four percent.

This is the cumulative plot for all the components within the four selected system. Again, as you see here, basically for some of them we defined that for some of them -- for the reactor pressure vessel we defined the other components for other system with the piping segment. An example is for example say the number six in your handout. Basically, you see low pressure injection system accumulator at the pipe segment between the accumulator discharge header through the RCS or reactor coolant system isolation valves. That is including the valves and T's and elbows and whatever included in that piping segments.

MR. KRESS: Those numbers correspond to dots going from left to right?

MR. VO: Yes.

MR. MICHELSON: Number one is the far left?

MR. SHEWMON: Number one is also the largest increment, I think. Number two is the next largest, in order that way.

MR. VO: Again, I'm not sure that the 37 is in here. Basically there are 37 components. Again, please keep in mind that there are more than 37 components. We tried to group together the component at the similar characteristics. Again, we could extracted out to the level of the pumps and the valves and the welds.

MR. MICHELSON: In soliciting the expert opinion, how did you handle such things as the possibility of erosion/corrosion on the particular system; was that included in their estimate of probability of failure, that they had to make some kind of judgment as to the likelihood that could appear in that system and so forth, and the number of points at which it could occur?

MR. VO: Yes.

MR. MICHELSON: That's all in their expert opinion.

MR. VO: Basically in our expert elicitation --

MR. SHEWMON: The answer is yes. Just let it go at that.

[Slides.]

MR. VO: This is another plot of our results. Basically, later on I think Ken and others -- we used this viewgraph to selected for component for further study to try to develop some strategies for ISI. This is another plots -- again, I am not sure if that is 37 in here or not.

MR. WARD: It looks closer.

MR. MICHELSON: Apparently, service water wasn't in any of these --

MR. VO: We have not -- these four system of interest, we have not included service water system in here yet. Basically this here again, not a block. Again, you see that the reactor region is ranked first, followed by the other RPV components, low pressure injection system, another RPV component. Lastly as you see, accumulator suction line, that ranked last. Not an entire block with the results that we have.

MR. SHEWMON: Go on.

MR. VO: We also performed a sensitivity and uncertainty analysis. Again, at this time, very limited sensitivity and uncertainty analysis has been performed. Basically two type of uncertainties we are addressed. They are the parameter uncertainties and the modeling uncertainties.

We addressed component rupture probability uncertainties. Remaining basically had been addressed in the PRA. Therefore, we have not done a lot of work in this yet. Again, will be done, probably the Monte Carlo type will be addressed in our future study.

On the modeling uncertainties, basically at this stage we are also performed the indirect effect uncertainty at this stage. Basically, you do not have in the handout basically the contribution to the core damage. The indirect effect is insignificant.

MR. MICHELSON: Are you going to look at human error as well as human recovery?

MR. VO: That is included in here, and will be addressed in the future udy.

MR. MICHELSON: Human error includes also the maintenance man who goes around and adjusts all the valves wrong and, therefore, none of them work?

MR. VO: I believe --

MR. MICHELSON: Is there a small but finite probability of that happening? I guess you didn't. I was trying to find out where human error was, and it was in that human recovery action.

MR. SHEWMON: This includes maintenance errors too.

MR. GORE: Human error is only included inasmuch as it was included in the PRA that did the initial analysis. It shows up in the conditional probability of core melt, given the rupture of the component.

MR. MICHELSON: If it wasn't in the original PRA model, then it won't be in your work.

MR. GORE: Absolutely. We don't have funds to go back and visit these --

MR. MICHELSON: I just wanted to find out --

MR. GORE: -- PRA's.

MR. MICHELSON: -- what was the scope of the study. Thank you.

[Slides.]

MR. VO: This is another plot, the same type of plot that you see earlier, again with uncertainties bar. Basically, uncertainty bars here, and addressed using different rupture probability estimator from expert judgment. In other words, the circle is the median value and this is the upper and lower values estimated from expert workshop. In other words, 25 and 75 quartiles.

Here is another type of plot. Basically, tried to -- later on we will be using this plot trying to address some of the target risk probabilities. Again, you see the message is all I can say is, this is basically the beltline regions is failure relatively high rupture probabilities. Again, when that rupture could make big contribution to the core damage.

MR. MICHELSON: The PRA's that you used, did they all include the internal flooding effects of these ruptures? It depends on whether they did the PRA with or without external events or with internal flooding. Some do and some don't.

MR. VO: In this one they have. Again, for our earlier analysis -- again, flooding is some point of internal events of internal plant. For our study we did not include external -- the flooding type.

MR. MICHELSON: You didn't include the consequence of the water release from the rupture.

MR. GORE: That's not quite true. As Truong mentioned, we walked down the systems and identified the potential effects of jet impingement on nearby active components, identified the location of motor control centers and other electrical components which would be expected to be impacted by the ruptures. So, we did not totally ignore it.

We did not try and go back and modify the PRA, except for including this in our analysis.

MR. MICHELSON: When you did this then, you must have taken some kind of credit for isolation of this. It wasn't an indefinite event. It had to be terminated. How did you decide at what point to terminate? Did you pick an arbitrary number like 30 minutes or something?

MR. GORE: We did not take credit for isolation, and we did not pursue this, probably to the extent to which you wish we had.

MR. MICHELSON: If you didn't take credit for isolation, you would be in very deep in water in some of these instances.

MR. GORE: Certainly, with the service water systems.

MR. MICHELSON: Yes.

[Slides.]

MR. VO: With that, I would like to basically conclude the presentations. The methodology had been developed and proposed. We have performed a number of pilot studies for Oconee and some representative plants in the Surry applications. Again, much work will be performed yet.

Again, the methodology had been included for ASME risk-based task force. Later on, Ken will discuss more about the ISI and the strategy of the ISI methods. That's all I have.

MR. SHEWMON: Thank you very much. We will take a break now, until ten minutes until the hour.

[Brief recess.]

MR. SHEWMON: Fire, when ready.

MR. GORE: I am Bryan Gore, from Pacific Northwest Laboratories. Before I begin my prepared remarks, I was moved by a question regarding the difference between the effects of active component failures and the passive components which we are addressing in this project. The question was put rather strongly to Mr. Bosnak when he was up here.

I would like to roger that PNL are currently involved also with a research project with the probabilistic risk applications branch in which we are looking at the inspection prioritization of active components. We have been involved in analyzing the PRA's for Oconee and Calvert Cliffs and ANO-1, to prepare risk-based inspection guides addressing system and component importance.

In addition, we have been involved in preparation of specific plant-specific generic based aux feedwater system inspection guides which have gone beyond the PRA results, and looked at specific root causes of failures within the aux feedwater system for a variety of plants looking at failures of turbine driven pumps and motor operated valve failures to test under design basis accident conditions, the effects of condensate slugs in cold steam lines causing over speed trip.

All of these types of things are being addressed but under a very different project. We are not unaware of them, it's simply not the focus of our discussion this morning.

MR. MICHELSON: You won't find the right answers on that point by looking at the present date PRA's. You are going back and taking those and given a new critical look at whether the right numbers were used in the PRA; is that my understanding?

MR. GORE: We are actually looking at, given the identification of the probabilities of failures from the PRA's, what are the root causes of these failures.

MR. MICHELSON: Maybe you missed --

MR. GORE: The pump fails to start to run --

MR. MICHELSON: -- my point completely then.

MR. GORE: -- is not a real good indicator to a resident inspector as to what he should be looking for.

MR. MICHELSON: Excuse me. I think you missed my point. The point is, if I look at the PRA -- those isolation valves are no, never mind, because they are so reliable. In reality, they may not be anywhere near as reliable as we thought, based on test results thus far. Therefore, you can't use the PRA to decide whether those are critical components from the viewpoint of risk or not.

The first thing you have to do is critically question whether the right numbers were even in the PRA.

MR. GORE: I think we are talking about a process here that we recognize, and we appreciate your comments, but as I think was stated earlier we are limited in the Delta's that we can use in the process. We recognize this is a limit. We can take care of these things in a later project. We understand there are limitations.

MR. SHEWMON: It's better to do something than nothing, maybe.

MR. MICHELSON: Or, better to do it wrong than nothing.

MR. SHEWMON: You may learn something to where you should look next. Let's go on.

MR. GORE: Thank you very much. I wanted to also express my appreciation that you folks were curious enough about what we are doing to invite us to present our thoughts and ideas to you. We welcome your comments.

[Slides.]

MR. GORE: The question of target risk, target rupture probabilities is really a question of what is the object of an inspection program. The Research Task Force's answer to that question is, to ensure that the plant risk is maintained at an acceptably low value that is specifically the plant risk due to ruptures of pressure boundary components, is maintained at an acceptably low value, namely a small fraction of the risk which would be caused by failures of the active components in the human operating errors.

In addressing this, we are focusing on the risk measure of core damage frequency due to internal events, as determined by analys's in existing PRA's. It is the same measure which we use for component risk prioritization, and it allows the most direct comparison with risks due to active failures. You can inspect the active and the passive components and effect the failures of them.

MR. WARD: Bryan, what is the basis of this vision for the program -- the first chart you want to maintain the risk due to ruptures as a small fraction of the total risk. If I was looking at some sort of a grand strategy for optimizing cost and benefits, I guess I would say the resources being spent on this activity could better be spent on activities to reduce the risk from the higher contributors -- perhaps they don't need to be spent at all.

MR. GORE: When you say cost and benefits, you are thinking cost and benefits of research program dollars I guess I would suggest that --

MR. WARD: Not ju~t research program dollars, but eventually this is going to be translated into some more elaborate and more expensive ISI requirements of plants, I guess.

MR. GORE: There is more than passing hope that that may not be the case. We don't know whether it is going to require more elaborate and more expensive ISI procedures or less. What we are attempting to do is to pursue the logic of a risk-based program development so that we can evaluate whether or not it may result in either increase or reduction of the ISI requirements. It will also provide an opportunity to evaluate economic risk right now, because we are working for the PNL for the Nuclear Regulatory Commission. Our work is focused on core damage frequency and the things that are nominally associated with the public health and safety.

The concept which we are developing is directly applicable to economic risk as well as safety risk. In fact, we have some suspicions that a good economic analysis may indicate that the ISI risk important from a regulatory basis may be less than the ISI needs that would be justified on the basis of improved economics of operation. In fact, there are some articles in the literature which in fact indicate that.

MR. WARD: I can see that. I guess my question is probably really more addressed to Bob, although your statement of the objective of the program was cleanly put. It sort of elicited the question. Bob, you know, you guys and your part of the Agency have done such a terrific job through the years that, when we look at the risk from plants we can't blame hardly any of it on your discipline.

[Laughter.]

MR. WARD: That's what it amounts to. You are asking that more of the Agency resources or some agency resources be devoted to making sure that you stay in first place or down here in the noise where you aren't contributing to risk. Meanwhile, the real risk at plants is from how they are operated and how active components function.

I guess if I can kind of be a devil's advocate here and try to look at a big picture, I wonder why we don't take the --

MR. BOSNAK: One answer to your question is that as things -- these are the passive components that we are talking about -- they age and plants get older; do we really have a good method for maintaining the record that we had in the past. I think Bryan answered one of your questions earlier with respect to these other areas.

The information comes from PRA's, and we recognize the information is imperfect, as you have heard. But this is a process that we have tried to settle on. The assumption that plant maintenance is always 100 percent, those are all the things that have gone into this thing. We want to be assured that we started out with NDE reliability back in the 1970's -- if we can take that into account with respect to the plant risk, perhaps we are trying to make our program -- I do admit that we are trying to improve what we have and afford also -- this is a research grant.

We are looking at not only in our own area but the national interest as well. I think a process such as this can be transferred to all of the other industries that you have heard about and will serve a tremendous benefit. So, it is not just purely a limited research program. This is a grant, but we think we are going to get a lot of out of it because we started on this process about almost 20 years ago.

Maybe it's not a perfect answer to your question, but I think it's the best that I can give.

MR. MICHELSON: But to make this thing work, we have to make sure that PRA's reflect aging effects as well --

MR. BOSNAK: And, they don't.

MR. MICHELSON: Or you will miss finding the right thing.

MR. BOSNAK: They don't.

MR. MICHELSON: What are we doing to try to improve the goodness of PRA in this regard? Unless we do improve it, this process is very limited.

MR. BOSNAK: This might be a -- this is a suggestion that the Committee makes. The shortcomings of PRA's, we have seen it in our process. Since we don't do the PRA's, we are not responsible for them but we have to use them. Nobody has really documented a list of the shortcomings. People have talked about them. This could also be one of the results of our research project here.

MR. CHAPMAN: May I say something, Mr. Chairman? From our point of view, we have now just put forward a program to our safety reliability director. With regard to the amount of inspection, it increased it by one percent, which is a very interesting job. With regard to the other question, what has been very interesting in doing this work is that where we have shown where the probability of failures may be concentrating in various areas within the plant, that has made our PRA people readdress much of the work they have done.

There has been quite a benefit, certainly from our point of view, from this work. I was making the comment to Ken a little while ago that for the first time ever, we feel that w are just one step in front of our PRA people now instead of four steps behind them.

MR. MICHELSON: You really should be behind them. They should be leading and you are following through with --

MR. CHAPMAN: I think I agree with that, but it's quite interesting that that has changed some of their thinking.

MR. MICHELSON: It's an iterative process, I guess.

MR. CHAPMAN: It is.

MR. MICHELSON: I think you are ahead.

MR. SHEWMON: Okay, onward.

MR. GORE: Moving right along. We suggest that an ISI program should be designed to hold the total risk of core damage due to component ruptures below a value which is a small fraction of the risk, determined by the PRA analysis of internal events. We have postulated five percent as an initial target risk value which seem reasonable and at least worth considering but, in fact, which we may find is not achievable as you will see when we talk about the Surry results, which we have already achieved.

MR. MICHELSON: A small clarification. Isn't a pipe rupture an internal event?

MR. GORE: Yes, it certainly is. But what we are looking at is the internal events analysis of the PRA, is what we use in quantifying the conditional consequences of that rupture.

[Slides.]

MR. GORE: That's the target risk concept. The object of inspections of individual components is to hold the likelihood of rupture of that component below some target value. So, to have a truly risk-based quantified program, we have to tie that value back somehow to some sort of a target risk. That's the little logical exercise which I am going through here.

In order to tie it back, we have to determine a target risk associated with each component. Once we have that and the conditional risk given rupture of the component, we can take the quotient and calculate a target rupture probability for that component. How do we get a target risk for each of these components that we have addressed?

Somehow, we have to take our total risk which we have suggested should be five percent of the total PRA value, and assign it among the components which have been evaluated. It seems eminently reasonable that this target risk should be apportioned among the components in proportion to the estimated risk which each one represents.

When we did this process for Surry, we found the somewhat interesting result that the total estimated rupture risk which was shown on the slides that Truong put up earlier, is just about five percent of the total PRA risk that was calculated for the Surry plant. That's an interesting fact because first of all, we only looked at four systems and we had four more to do including high pressure injection and inservice water. Five percent may not in fact be an appropriate value. We may have to revisit what seemed like a logical, although ad hoc, suggestion of five percent.

In any case, if we just take the Surry results, recognize that the total estimated rupture risk is about five percent of the PRA risk, then that's our target risk which we need to define inspection programs to maintain. If we apportion that in proportion to the estimated risk, then what that basically say is the inspection should hold the rupture probabilities of these risk important components to the values which were estimated in the expert elicitation panel which produced those results.

When we started out the logic of developing this we didn't anticipate that we would find that one to one overlap. We identified the methodology, and then were somewhat surprised when we polled the results in and found that result.

MR. MICHELSON: How do you handle the case wherein the total risk on a given plant is extremely small to begin with. You are still going to try to keep ruptures five percent of that extremely small number and, therefore, force a lot of things to keep it that small?

MR. GORE: In the present situation, I suggest that what we are proposing is reasonable. If we manage to stomp the estimated risk down by one and one-half orders of magnitude, then it's quite reasonable that we should revisit this. This is a policy decision that can be separated from the methodology, the concept of risk-based inspections and so forth, and can be wrestled with an appropriate number determined.

It's just one piece of a much larger overall puzzle. No, I am not presupposing that we should inordinately increase the inspection requirements if we are able to further push down the risk associated with active components.

MR. MICHELSON: You haven't suggested any ceiling though at this time?

MR. GORE: I don't think we are at a point at which that's appropriate. We are still struggling to get the first full application to the methodology and find out what the logic tells us. We believe we found some things that make eminent good sense. They support the engineering analysis, they support a lot of the good sense that's in ASME Section XI. We found some surprises, which suggest that maybe this isn't just a total waste of time also.

If this is the total risk associated with the rupture of components, about two times ten to the minus six, our five percent target risk is just about that value. Then, from a risk point of view, about two orders of magnitude in risk is where we ought to be concentrating our inspections. These are the risk dominant components. If we really focus on these risks, these components can move up several orders of magnitude. We probably want to do some sampling, to make sure that there is nothing untoward going on.

But it is these components from a basis of risk, that we ought to be focusing our inspections on. If we look at the Surry results, what does that tell us. The product of rupture frequency with conditional consequences of damage is risk, and that's going this way on the chart. Ten to the minus sixth in risk is this line here. Ten to the minus seventh, eighth, ninth.

The reactor vessel beltline welds are the most risk dominant components in the plant, by about a factor of 20. Below that, we have the beltline plate material, the lower and bottom shell welds, and the upper shell and nozzle welds. This is not a legend. These are actual points on the plot associated with the conditional core damage frequency of one. If you have a major rupture in any of these regions, you have no longer a guaranteed ability to prevent core damage.

Right on the same risk line to the beltline plate, we have the supply to the aux feedwater system, which also at this plant is a single failure. It has a much higher likelihood of rupture, but the probability of core melt is basically the probability of core melt given total loss of the aux feedwater system.

In addition, we have several discharge lines in the low pressure injection system and in the source and supply for it, and just for fun I included the core rod drive mechanisms. There is really two points here, also the instrument lines. You recall the plot that Truong put up, the box and whisker plot from previous expert elicitation which showed that the rupture probabilities of the beltline welds were the highest, there were a variety of points, and then there were some outliers. That was the rupture probabilities associated with the control rod drive mechanisms and the instrument lines.

They are up on the top of the vessel. So, we assessed that they would lead to a large break LOCA, and the conditional consequences of a large break LOCA are considerably less because of the ECCS requirements for low pressure injection and high pressure injection, the ability to keep water over the fuel.

These then, are the risk dominant components which we have identified so far in our study of the Surry plant, and to which we would suggest that a risk-based inspection program should focus primary inspection attention on.

We acknowledge that a recommendation of apportioning our target risk among all components in proportion to the estimated risk may not be best or most workable in all cases. There are other alternatives, and we are going to have to look at them. For instance, you could take the top ten risk dominant components and apportion the target risk equally among them. I don't think that makes sense, but it's an option.

Likewise, you may find that there is some component that is very risk important or modestly risk important, that you simply can't inspect adequately. You might allow that risk to rise and focus your attention on other components such that you can push down the risk associated with those components. We will have to see how things shake out in further analysis.

In any case, right now we are sticking with our recommendation of apportioning it on the basis of estimated risk.

[Slides.]

MR. GORE: Here is what the Surry results would look like if we took the basically two times ten to the minus six total risk, divided it by ten, and then assigned that equally to each of the various components identified. You would have to inspect somehow very aggressively, such as to push the probability of rupture of the beltline welds way down, but you could then allow inspections of other components to be relaxed if that turned out to be appropriate or necessary.

MR. BOSNAK: I just want to point out a typo on the abscissa on this one and the other one. The extreme right --

MR. GORE: Yes, that is meaningless. My apologies. This type of an approach you see, comes back to the whole concept, is there a target risk. What is the objective of inspection. If you can somehow say I am going to hold the total risk associated rupture for this plant to some value, then you have a rational method of approaching how you want your inspection program to be designed and what it should accomplish with regard to individual components.

In conclusion, I would suggest that this provides a logical quantitative method for addressing the question of how much inspection is enough, and whether it's more or less as Dr. Ward asked in his question, I can't answer that. We are trying real hard to find out.

Thank you very much for your attention.

MR. SHEWMON: Thank you. Fred, are you next?

MR. BOSNAK: I just want to introduce Ray Art, who arrived. If you have any questions about the Center, he is a fulltime employee of the Center, and will be able to answer those.

[Slides.]

MR. SIMONEN: My name is Fred Simonen, and I work at Pacific Northwest Laboratory. My presentation, I would like to change directions a little bit and start focusing on the aspect of inspection program development. So far, you have heard how we have tried to identify the high risk or important components in the system, how we looked at target failure probabilities, and the question of how much risk is enough.

This work is trying to relate those aspects to the whole question of how do we achieve these reductions in risk that we may want to d. for these high risk components. I think the important thing to always keep in mind, I think this program has always been looked at is that we are not looked at to do more inspection but in many cases actually doing less inspection or maybe no inspection at all on certain things that are not really at all of concern from the standpoint of risk but maybe they are inspected a lot by ASME Section XI type code requirements.

Other cases, there are things that aren't inspected that are very high, like the reactor pressure vessel. We have to maybe do more effective inspections, is what we are looking for. There are other things perhaps like service water systems, where maybe there is no code inspection at all is being done. Maybe some kind of a more minimum type of inspection is required.

I would like to say a little bit about the objective inspection program, how we tie in some of the NDE reliability data we have gotten out of our PNL program into this work; how we perform structural reliability assessment, probabilistic fracture mechanics in this area, and finally leading into this question of how we end up with improved inspection in programs which Ken will talk to you a little bit about on using the decision risk analysis methods.

What do we mean by inspection program. I have listed the things that really what you need to answer if you are going to develop an inspection -- what are you going to inspect, what vessels, what welds, what pipe segments. How many in the inspection, what kind of a sample size do you need to get the result you want. Even within the extent of inspection, are you just doing a surface examination, a volumetric inspection. What kind of area you need to inspect to find the degradation you expect to find.

Inspection frequency, how often are you talking about, once every ten years. Maybe some method that is done on an annual basis that -- method of inspection, maybe some cases just a purely visual inspection will be adequate where in other cases you need to go to more methods like UT/ET, perhaps even cocoustic emission in some cases.

Finally, what is the reliability of the inspection method. What kind of probability of detection is needed. Before going on, I would like to raise two points that Vic Chapman has emphasized to our ASME group very forcefully and I guess very often, the benefits of ISI really come in two areas.

In many cases where you have to look at ISI, you are not really reducing the failure probability of the system but what you are really doing is, you think the probability is low and you are doing an inspection to get confidence that it is low. This would be considered just something like a defense in depth. In other cases you may have situations where you don't feel your risk is where you think it should be, and you are doing sufficiently rigorous inspections to actually reduce risk.

However, I always look at this in terms of, if you are going to get either of these benefits you have to have an effective NDE reliability program. If you have a method of inspection, you are not going to find cracks. In any case, you are not buying anything for either of these aspects. You need a good NDE reliability and you need an overall program in terms of inspection frequency in sampling that will get you there.

A few years back in our program we had a session with some of the NRC staff on just where we should be going in inspection programs. Tney said maybe the first thing we ought to look at is some of the data that has come out of the inspections that have been done on plants over the years, I guess both to get information on where are the problems actually occurring in plants and where should we be doing an inspection, and also the question of have these inspections we have been doing to date have been discovering the problems that are occurring out in the field.

This viewgraph is a quick look at some data we pulled out of the NPRDS database. What we looked at was we pulled out some data from what I call front line systems, RCS/HPI type systems. We only looked at things like pipe thinning and cracking, things that Section XI type program would hope to detect. We have excluded things like vibrational fatigue that might occur in things like small diameter lines.

We are looking at how well has been the current inspection program has been doing in discovering defects in piping. What we found is amongst the reported incidents in this database, about 50 percent of them were coming out of what I would call UT type examinations, Section XI type examinations. There is a lot of them where cracks were detected as incidental observations, which was leakage observations.

If you look at the much larger set of data like Class 2 systems, we actually find that the inspection programs to date were maybe discovering something like 20 percent of the incidents, whereas things like incidental plant walkdowns, finding leakage were the primary things. I think the message that came out of this was that perhaps the inspections that are being done on plants now --

MR. MICHELSON: Excuse me, before you leave that slide. The NPRDS system, of course, is purely voluntary. There are various degrees of goodness in the quality and quantity of reports given to NPRDS. Do you have any feel for how representative this particular sample is in terms of what is going on out there? Is this an item that is routinely reported very well and in great detail, or is this an item that is only occasionally even reported?

MR. SIMONEN: We asked that question, and the answer we got was -- I guess some plants may be reporting 50 percent or more of their data and some maybe less than ten percent.

MR. MICHELSON: Just in this area though I am thinking of, not their total. Some plants do very well reporting some things and very poorly reporting others. I was thinking of just this area, which is --

MR. SIMONEN: I could only say somewhere between maybe ten to 50 percent, the information. There are other things we knew about already.

MR. MICHELSON: You mean, ten to 50 percent of these failures are being reported to NPRDS; is that what you are saying?

MR. SIMONEN: Yes. Our other question is, is this maybe a good random representative sample of what could be reported. My feeling is that it is probably a fairly reasonable sample. Some plants were fairly consistent --

MR. MICHELSON: That's not a very large sample, in terms of the tens of thousands of reports to NPRDS.

MR. SIMONEN: No, this is a very small -

MR. MICHELSON: Extremely small.

MR. SIMONEN: Right.

MR. MICHELSON: But, I don't have a feel for all of the things that could have been reported in this area of what this sample size means -- I don't know the answer. I thought you had some intuitive feeling.

MR. SIMONEN: The total number was something like there was 400 reports on piping cracks, leaks, structural type failures in these pressure boundary systems.

MR. BOSNAK: Beside the numbers, the other thing is the root cause often can't be depended on.

MR. MICHELSON: The key question that I had in mind was, are three percent of these events even being reported or are 90 percent; where are we? If only three percent were reported then this wouldn't mean much.

MR. SIMONEN: We did look at the -- there are things that we already knew about that, that had been fairly highly visible, and we did find a number of these things in there.

MR. MICHELSON: INEL has been monitoring that system for a number of years, of course, and knew the shortcomings of it. I just didn't appreciate the shortcomings in this area, and I still don't.

[Slides.]

MR. SIMONEN: NDE reliability. Recognizing maybe the reliability isn't where we think we would like it to be, what have been the recent trends. I think there is, through our PNL program and programs in Europe, there has been a lot more data available of just how reliable UT systems are, current systems. We have something now that we can start working into our structural reliability models.

The other trend is the codes and standards have been working to improve the reliability as practiced in the field. This is the Appendix 8 type introduction into Section XI. Given that this NDE reliability appears to be improving -- the important thing from our standpoint is that if we are going to have an impact on plant safety, these better NDE methods are going to have to be applied at proper locations and frequencies.

Finally, we are looking at risk-based methods that will use these NDE reliability data as input into structural reliability models. To just give you an example of what type of data we have to work with, this is some work out of our PNL Round Robin inspection program, an inspection of different types of piping. We see a big range of detection probabilities. We see like the clad ferritic materials where you get a crack about 40 percent of the way through the wall, we have essentially -- this is a case where every inspection team detected cracks of this size.

We are talking something maybe 90 to 100 percent POD in that range, where there is other cases, Cast Austenitic is a well known -- I think you are probably well aware that here is a material that you have a very, very low detection probability. What we want to do with this work is, given these kind of detection probability curves, what can we actually do with that kind of instrumentation to result in actually finding cracks in operating systems in plants.

MR. MICHELSON: Before you go on to that one, let me ask, these are usually looking at heat affected zones around welds and so forth, this previous slide.

MR. SIMONEN: That's right.

MR. MICHELSON: Some of our problems, of course, have been with such things as chemistry problems, wherein you get erosion/corrosion. These are not necessarily just at the heat affected zone of a weld. We don't even do any inspection in these other areas necessarily.

MR. SIMONEN: Exactly.

MR. MICHELSON: That's all missed in terms of this kind of an examination. It further increases the probability you are going to get a rupture by some amount, and I don't know by how much.

MR. SHEWMON: There has been, in the last couple of years, an active inspection program for erosion/corrosion, as you know. So, I don't quite understand why you say inspections are never done there.

MR. MICHELSON: Have not in the past but not traditional to do it, yes. First of all, you go do a calculation to decide whether to look in that area or not. This certainly is helpful. This has all been going on just in the last couple of years.

MR. SHEWMON: I suspect these numbers were just obtained in the last couple years too, though.

MR. SIMONEN: Right. The other curves for detection of erosion/corrosion, that would --

MR. SHEWMON: Let's go on.

MR. SIMONEN: Yes, let's go on.

[Slides.]

MR. SIMONEN: I don't propose to give you a lecture on probabilistic fracture mechanics. It would take maybe an hour to work through this flow chart. What I do want to emphasize is what goes into one of these piping reliability analysis. Things that are important is the initial quality of the weld, what kind of defects are present in a weld or pipe segment to begin with.

There are things of non-detection probability for the inspection methods, both pre-service and inservice inspections. Then we go on to factors that relate the fracture mechanics. You need things like stress history, cyclic stresses, various operating transients, pressurized thermal shock for example. The fracture mechanics brings in things -- this relates this to fracture mechanics parameters, material property data, crack growth rate information. The reliability is related to how well can we detect leaks in these systems.

Finally, the bottom line is trying to detect what the rupture probabilities and leak probabilities, and more importantly from our aspect, how does the inspection program have an impact on these. We have done a number of studies to get a feel for just how effective an inspection can be, and I will show you just very quickly some examples of what type of results and trends come from these works.

Here is a case where we are looking at components of very high leak probability over the course of an operating cycle. This was actually a thermal fatigue example. We looked at the situation of a given inspection that occurs at a ten year interval. One case, Case A, where the failures are due to some initial problem with the initial quality of the weld itself. We find here that an inspection program is not very effective in detecting and preventing these failures. What would have been needed is a much better inspection would have done the job.

Here's a Case B, where we have looked at where the failure rate is actually going up with time due to an aging type effect, where the cracks maybe weren't even there to begin with. We find the improvement in risk here. Here is where we would expect to have a big payoff, whereas we are getting some age-related degradation.

We have looked, for example, the high risk component in our risk prioritization appears to be like the reactor vessel beltline. We can look at what kind of impact different types of inspection might have on reducing the failure rate of a reactor vessel due to a pressurized thermal shock transient. Here, we see a case where we call a baseline case called no inspection. Here is a case, ASME code minimum requirements going back maybe ten years ago would have done to the failure probabilities, and see there's a very little difference in the probability of failure for these two cases.

Essentially, an inspection was doing -- having no benefit at all, as far as structure reliability. Here, we go to a case where we are looking at what kind of inspection probabilities we can get from a good quality near surface examination using ultrasonic inspection under ideal conditions with a smooth cladding on the vessel. What we see is, we are getting where we can expect to find maybe nine out of ten defects in this critical near surface examination. We are talking about potentially reducing failure probabilities here, maybe by an order of magnitude by aggressive high quality inspection program.

MR. WARD: The failure probability is reduced, because when you find it you shut the plant down.

MR. SIMONEN: You shut the plant down, perhaps you do a vessel anneal. You have to do something.

MR. WARD: Yes, okay.

MR. SIMONEN: Grind the crack out, maybe repair it. We have looked also at a scenario of stress corrosion cracking in stainless steel piping. What we have taken is what we call her, a probability of non-detection. Three curves that kind of represent where we think we are in this inspection area based on Round Robin results from our work done on our NRC program at PNL. The poor inspection is basically what we found was done maybe ten years ago when this stress corrosion cracking was really coming to light. What we find here is people, even the crack half way through the wall, they had less than a 50 percent chance of detecting that crack.

Good is what we feel is what the better teams are doing, and the performance demonstration we feel is something that will ensure that the field inspections are being done at this type of level, whereas you are talking about a crack of about 20 percent of the way through the wall you are detecting maybe only 20 percent chance of missing that crack. Advanced, I guess, is maybe a projection into the future, advanced technology where maybe something like SAFT -- if that's something that in the future is put in as part of the improved inspection programs. There, you get a ten percent a way through the crack and you only have one chance in ten of missing that defect.

Now, how does this relate then to an impact on actually the inspection. In stress corrosion cracking the difficulty is that if you don't inspect and often enough, you have a small crack and one inspection it is too small to detect before you do the next inspection. The crack growth rate has accelerated, so the failure occurs between the ten year inspection interval.

We used those POD curves there on the previous slide and did a probabilistic type fracture mechanics analysis to see what this does to component reliability. We looked at the poor inspection -- inspections which -- type of inspections that are going to be ruled out from the current code requirements. We see that this extreme case of doing 40 inspections over once a year, you are getting less than a factor of one. So, this is really cost benefit-wise, this -- you might as well not be doing any inspection at all. It's not doing any good at all.

If you are talking like the current type of inspection like four inspections per year, you are maybe improving the reliability by a factor of two or more. If you get an annual inspection interval, you are maybe proving reliability by a factor of perhaps ten or up in that range. If you look at the projected advanced techniques, then maybe like four inspections over the life of the plant, the current standardized ISI interval, then maybe you are getting a factor of ten improvement in reliability.

MR. MICHELSON: Do those numbers assume that you have a certain threshold of detection and everything detected at that threshold is repaired?

MR. SIMONEN: Right. That's exactly it.

MR. MICHELSON: Then you move on to a few more --

MR. SIMONEN: Right.

MR. MICHELSON: -- cycle again.

MR. SIMONEN: In this case you are inspecting all those welds that are susceptible to stress corrosion cracking.

MR. MICHELSON: You have repaired everything that exceeds your threshold of detection, tnere are some arbitrarily small threshold.

MR. SIMONEN: That's right. That gives kind of an example of what the structural reliability and risk assessment models will do. This is a point in this work where we are just kind of beginning. Now that we know what some of the high risk contributing components are, we feel now we know kind of what we need to address with these models. They are not easy, inexpensive models to exercise.

We have limited resources, so we -- what we want to do is address some of the high priority components and failure mechanisms as identified by the expert elicitation. We are going to develop and apply these models to evaluate what the impacts of alternative inspection scenarios are and perform some parametric studies using codes such as the PRAISE code which was developed by NRC research.

I will try to generalize the results, do some case studies and try to generalize the results. The whole outcome of this is to try to quantify the benefits of inservice inspection. Unless we get some factor of improvement from inspection, there is really no reason to perform an inspection. The numbers from this quantified benefits then will go into a decision risk analysis which Ken Balkey will discuss, which is basically a kind of cost benefit trade off type analysis.

MR. SHEWMON: Thank you.

[Slides.]

MR. BALKEY: Just to refresh everyone's memory where we are in this whole process, you have heard from Truong Vo on the risk-based ranking, you have heard from Bryan on the target failure selection, and Fred just began to talk about the quantifying the effects of inspection on meeting target failure probabilities in inspection programs.

Notice that our process is iterative. We realize that the first time through there may be things that aren't right, and the concerns that have been raised are brought back in. The whole process is that this should be a continuing living process as times goes on. That's actually the process that Vic Chapman is implementing in his UK Submarine program. What I would like to do is -- I am now down in that bottom box. What I have here is another flow chart that kind of expands on that bottom chart.

When you think about inspection program, what you are dealing with are some very serious decisions that have to be made. These decisions affect the safety of that component and also impacts the economic viability of operation of that plant. An example that I am going to discuss now in using decision analysis to integrate the models that Fred Simonen just discussed as well as PRA models again that Truong Vo and Bryan Gore discussed, and fold that into an entire cost benefit assessment that provides failure probabilities to meet the safety goals and to do an economic evaluation to determine the value of doing those inspections.

The example that I am going to discuss gets into evaluating how to evaluate an inspection strategy, and I am hoping I can save some time because I would like to have -- if it's okay with the Chairman -- Vic Chapman speak about, once you do an inspection how do you factor that back into decisions.

When we put our Volume 1 document out for review back in 1990, we spoke very little about the economic impact. We received some very strong criticism from steering committee as well as independent reviewers, that said that they felt if we just focused on the aspect of meeting the safety criterion -- they thought we were remiss in not talking the economics. The economics of inspection are expensive, and the impact of not finding degradation resulting in unplanned outages is also very expensive.

So, that's what we got Dr. Perdue from Westinghouse involved, and asked him if he would help us in integrating using these decision analysis models, integrating the technical risks for safety risks with the economic risks. The aspect of decision analysis actually has been around for about 20 years in the financial community and business community, but the aspect of integrating this with the tools that you have been seeing today that's new. That is where our research effort is headed. In fact, that's exactly the research Dr. Perdue's research group is doing for ASME.

There is a collaborative effort between the two research programs. In fact, a couple of the members, Dr. Abramson and Truong Vo are members of Dr. Perdue's group. There's a little tutorial example that is in the Volume 1 general document, just to say how you choose an inspection strategy. Essentially, wherever you see a square that means that there is a decision that has to be made, and that you have a control over that decision.

Where you see an oval or circle is a chance node. That means you do not have control over that; it's up to nature what will happen in that case. The decisions you make clearly influence those chance nodes, and that's how the decision analysis relates it together. In this simple example we have just picked a representative pipeline. In fact, it didn't matter whether it was a nuclear plant or a fossil plant or whatever.

There may be a current way that you are doing your inspection. However, somebody may have come up with a new technique to do inspection which maybe is more reliable; however, it is more costly at the same time. Finally, maybe because of inspections carried out there's a lot of push to say that we are not seeing anything so let's stop the inspection all together. By not doing inspection there is a cost associated with that also.

The way that gets folded in is, when you go to each case of -- you choose your inspection technique, you get into the questions Dr. Simonen raised. With that technique, how reliable is my technique in finding that degradation. With the current technique it may be 50/50. With this new technique that is being promoted, we find the degradation with an 85 percent chance rather than a 50/50.

Obviously, if you don't inspect at all, you have no chance of finding any damage.

What carries out is, if you do find some damage, some repair replacement will be done to try restoring that component to an adequate level of safety. In the case where the inspection does not find the damage of concern, then you reach the other chance node of what is the chance that component will rupture or leak or whatever, with remaining life over time. That is exactly where the structure reliability models that Dr. Simonen discussed come into play. In other words, these numbers are not achieved from expert opinion, they are achieved by running through these calculations. So, one can get a feel of the impact of inspection on the probability of failure of that component.

Finally, if the component does fail then one gets into a range of consequences. Here, we fold back into the PRA to determine -- with that consequence something that is a minor consequence or something quite major. Given that there is a tremendous uncertainty in that, we have reflected it here in terms of cost, in series of range of cost of $3 million to $20 million, and we have assigned uncertainties on the branches of that chance node. That helps to address the question -- when I am on this particular component what happens if my PRA is wrong. Dr. Perdue recommends that actually you should try to in this evaluation -- we come back into it -- as you try to span the range of uncertainty in that PRA model to determine that maybe I am not calculating it exactly right, it may be higher or may be even less than what I have in the evaluation.

At any rate, at the end of these branch nodes -- at the end of each of these scenario paths there is cost associated with it. You have the cost of inspection, you have the cost of repair, and you have the cost of having some accident occur within a given facility. Those of you who are familiar with probabilistic risk assessment, this is essentially an event tree. You take the probability along each scenario path and then multiply it by the total cost with that path, and you get an expected value for that particular path.

What is of interest here with the decision analysis, you also get the safety information out when one combines the probabilities through the path where failure does occur and you have a range of consequence, you can look at the scenario failure probability and determine how well does that probability match the targets that Dr. Gore talked about.

You can see with this hypothetical example that the current technique -- we have a failure probability of five and 100 with, when we add up all the costs associated with it, $532,000.00 per year. When you go to the new technique we get a lower failure probability, and because it helps to lower also things that may affect -- leaks that might keep a plant down but are not result in any threat to the public -- that actually you have a cost savings in the long run by going to that more advanced technique. You will find the damage and keep yourself in a more reliable node.

Finally, the aspect of not doing any inspection results in the highest failure probability but also the highest cost. This is just a simple example. What I would like to do now is go in through an actual example where we chose low pressure safety injection line which is one of the high risk segments identified in the Surry work and try to work through this process, keeping in mind that we have Section XI and all the costs folded into a nuclear example.

The first thing that is done, before the decision tree is put together, a blueprint has to be made up to determine how all the uncertainties both technical and economic, influence one another. The tool that is used for that is called an influence diagram. It actually begins from the right and working back to the left.

The first thing is the bottom line in terms of the evaluation from cost benefit is, what is the present value of each particular inspection strategy that we want to evaluate. First of all, this chart here is not a flow chart, it's not a pert chart. It's an influence diagram.

So, wherever you see an oval, that is an uncertainty. When you see an arrow going from one oval to another oval, that means that the uncertainty about that particular variable influences this variable.

Essentially, it works back here. You see working back through the present value of strategy costs, you see the impact of inspection cost itself. There is replacement power costs, not only for carrying out the inspection but if you do get into finding indications or damage, you have the whole range of impact on outage for evaluations, repairs, replacements in that economic model.

Where the technical part comes in, is in the influence of -- if we do have an accident consequential caused, and the uncertainties that influence it are in our case core damage. The uncertainties that affect core damage, of course, get into situations in piping where you do get breaks before a leak. Now, you can work all the way back to how that is affected by the ability to detect a degradation that may be going on.

Finally, you work back that the inspection strategy which is a decision node influences the ability to detect, and it also influences the cost of inspection. It also influences how much outage will be impacted as a result of the strategies that are looked at.

From this blueprint, in fact, in doing this evaluation more than one-half the effort is just getting this blueprint to be correct. Because if the influences aren't correct, then you will have errors through the rest of the evaluation.

MR. MICHELSON: Excuse me. The consequential cost is the cost to the public?

MR. BALKEY: It's the --

MR. MICHELSON: Damage to the public.

MR. BALKEY: It ranges, yes. On that particular one, yes. It is damage to the public.

MR. MICHELSON: Where is the damage to the plant itself in your own economic investment?

MR. BALKEY: It should work back.

MR. MICHELSON: It says Price Andersen beside it, which is not --

MR. BALKEY: That's a public cost there.

MR. MICHELSON: -- identifying the owner, I don't believe, or his loss of capital equipment.

MR. BALKEY: Replacement of power cost --

MR. MICHELSON: That's not the only cost.

MR. BALKEY: That's right. It's folded in here. Your accident can impact -- there is a consequence to the public, but it also is in this uncertainty here of replacement power costs if you have an accident occur. The question that is being asked is, if I have core damage there probably should be an arrow drawing up to here.

MR. MICHELSON: Replacement of power goes on for a period of time, perhaps, until you build another plant. You have lost that capital value of the plant that was involved. Somewhe e, it has to be in the accounting.

MR. WARD: I would have thought that was your one down there meant --

MR. MICHELSON: It says Price Andersen.

MR. WARD: -- it says given Price Andersen.

MR. MICHELSON: That inferred to me that maybe that was only the -- they were only considering the Price Andersen in aspects.

MR. WARD: I thought it meant they only had to pay for what Price Andersen doesn't pay for -- I mean absorb. That's not the --

MR. MICHELSON: Including their own loss of capital equipment.

MR. WARD: So, the public --

MR. MICHELSON: It could be. That's why I wondered where it was.

MR. WARD: The cost to the public is something separate from this.

MR. MICHELSON: That's why I wondered. It is in there though.

MR. BALKEY: Let me go through the example and we will see if it is. Now, you can see the decision tree for this example is much larger of course than the simple tutorial tree that was in the Volume 1 document. Of course, these chance nodes, they -- of course, this tree explodes out as you come across the tree.

You can see your choice of inspection impacts the chance -- what's the chance there is a crack to be present. What is the chance that crack may be larger than the current ASME acceptance standard. Then, you get into the chance that the inspection will actually detect it, what is the chance we are going to get into repairs. Of course, keep working across the path until we do get into the major radiation release. In each case there's an outcome economically across each of that whole expansive tree.

The input that goes into those chance nodes, we had for our example the technical uncertainties that one has to address. I should say we chose the low pressure safety injection but even in our Volume 2 document this is still for illustrative purposes. The group in our next phase is going to be going back and actually going back enhancing the numbers. We are just trying to go through to demonstrate how the technology links the tools together.

Essentially, you can work down each of the probabilities that have to go into the tree. But what I wanted to note was that to get these probabilities, the probability of a large leak or a large break before leak that, that comes from the structure reliability model. The other thing that comes from the structure reliability model is the aspect that the decision analysis needs a chance node. Yes, I will find it or no, I won't.

We know that there can be an entire range of flaw sizes that may exist. Or, if we are talking about wall thinning, there is a whole range of flaw sizes that may impact the integrity of the component. What is done is, we use the structure reliability model that, if I do the current ASME inspection with the current UT, the ten year interval with the performance qualifications that are done for the people who do that inspection, we take that probability of non-detection curve into what Fred Simonen discussed and calculate out a failure probability and end of life.

But then, we back calculate through the distribution of detection to get a single value that can go into the decision tree. So, it's a process where you use the tool to work it forward and back out, and average detection probability that goes into the decision analysis. You can see that with the current technique we are saying over the life of this example, the life of the plant, there is a 67 percent chance of detection.

You can see that if I double the frequency, if I would go in every five years instead of every ten, it greatly enhances the inspection -- the probability of detection. Finally, if I inspect every 20 years it drops down in reliability. Then, if we look to the future to improve the NDE techniques, you can start looking at some very high reliability numbers in detecting degradation.

MR. MICHELSON: Excuse me. I am a little puzzled. If I have a given set of NDE equipment, it will detect a certain leak size with high probability of success. But, if I double the frequency with which I do this, why does that change this conditional probability?

MR. BALKEY: Because --

MR. MICHELSON: I still have the same equipment and same threshold of success. I am just going to find whatever new one is generated between the last time I looked and the next time I look.

MR. BALKEY: I am going to borrow one of Dr. Simonen's viewgraphs here. Essentially what happens is, degradation is occurring over time. If you are going in at ten years the degradation will have had a chance to advance to a certain level. If one goes in at five years -- we are saying here, if I don't do any inspection the degradation is going to continue, and it will result in some failure probability.

I see what your point is --

MR. MICHELSON: You are going to double the frequency, that's all.

MR. BALKEY: You are doubling the frequency. You haven't changed the accuracy of it.

MR. MICHELSON: That's right.

MR. BALKEY: But, I need a single number to go into the decision analysis. As I said, what I am doing is, I fold in the entire probability distribution of cracks that may be present, and I go over the entire distribution of probability of finding those different flaw sizes. For no inspection, I have an end of life probability here. If I do an inspection every ten years my probability may be here. Five years, here. Ten years, here.

In other words, you will affect the failure probability with the frequency. Now, I back calculate out and affect a detection of finding that degradation over time. It's just a manipulation of the model in order to get --

MR. MICHELSON: I guess it all comes out.

MR. GORE: I think it's relatively straightforward. Basically, you are assuming that the initial crack distribution grows. When you look at time zero or time ten years, you will get maybe some of those cracks. You have a certain probability of detecting --

MR. MICHELSON: Finding them at --

MR. GORE: If you wait another ten years before you look again, those cracks may grow to critical size and you may get rupture. If you look after five years, the cracks may have grown to where you can detect them much more reliably, so that you can intercept the crack growth and make a repair.

MR. MICHELSON: The assumption is, you intercept those at five years that you can detect.

MR. GORE: Yes.

MR. MICHELSON: Waiting for ten years somehow changes the --

MR. SHEWMON: Ten years, some of them may have ruptured.

MR. MICHELSON: I guess that's okay. Thank you.

MR. BALKEY: Some of the cost factors that come in is the cost of the inspection, and you can read through the viewgraph. In terms of inspection costs -- what goes into direct cost here is, of course, the personnel, the training of personnel and buying the equipment. But the man-REM exposure cost also gets folded into that as well. . want to make that point clear, that that has to be involved.

Of course, if you find indications, you now can start impacting outage times and there is outage times for doing repairs. If you get into leaks or breaks, this is where the impact on the plant comes in; that, if you get into some type of large break, then there could be a very significant time that the plant may be out of service while the repair is being carried out.

MR. MICHELSON: The assumptio, always is that you had to shut down for some other reason anyway, and so there's no cost of shutdown in your inspection.

MR. BALKEY: It is in there. By the outage time, the cost of shutting down, the utility is out of service for a significant amount of time at a replacement --

MR. MICHELSON: You didn't assume it went out just for this purpose, out of service for this purpose.

MR. BALKEY: It is assumed that it is going out of --in other words, if I have a leak -- if there is a leak occurring in a plant and it is discovered, you are going to bring the plant down.

MR. MICHELSON: Then you are obviously out, but I am talking about routine five year, ten year interval. You do it, whether there's a leak or not.

MR. WARD: Inspection.

MR. MICHELSON: Yes.

MR. WARD: Inspection time.

MR. MICHELSON: Does the cost of inspection include the down time, or how do you factor in down time, since you probably are doing a lot of other things and that wasn't the reason you came down even.

MR. BALKEY: I will give an example, and I will look to my colleague Chuck Tomes who is an ISI engineer at Wisconsin Public Service. Essentially, you make your inspection plan, so you try not to impact.

MR. MICHELSON: That's right.

MR. BALKEY: Let's saying employing the ability of a new technique, a new technique that may require a longer time to perform the inspection -- in fact, we have it in the model for example that this is an incremental outage for an improved NDE technique. In other words, we are now going to impact critical path. We can't fit it in. The plan just does not permit us to put this technique in, and it is going to keep the plant out one more day. That's a cost that becomes very important.

MR. MICHELSON: A day of down time is attributed to the cost then.

MR. BALKEY: That's right.

MR. MICHELSON: Thank you.

MR. BALKEY: Then, of course, the economic analysis is done over the life of the plant and all the financial numbers have to be brought back to present value. We have assumed a discount factor of four percent. In fact, the numbers we have here are not fictitious. We have talked to utility engineers that give us some numbers to start with for sake of example.

Here, if you get into these large releases, the only examples we were going by were something like Three Mile Island. You are trying to say here's the impact on industry of that type of release. Of course, a major accident would be beyond that.

[Slides.]

MR. BALKEY: Now, that all gets folded together. There ends up being the numbers of importance, and that's what I am going to present here in this table. What I want to focus on right now are the first two columns.

For sake of example, we looked at the case of Section XI, what would that mean for our example if we have here; what would be the case of not doing any inspection; going to a frequency of inspecting every five years, inspecting every 20 years, or let's look to the future. If we just stay with the current ASME plan and we are now going to go much more advanced technique, we are looking out to the future, what may be the potential benefit of that.

What we have shown here are large leak probabilities. The break probability is a factor of ten to the minus three less than that. This large leak probability can be translated to two times ten to the minus seven as the break probability and so forth down. We have a footnote to that matter, to get the rupture reliability and multiply by .001.

The reason we have large leak probability, from examples we have done what drives the need for inspection or the importance of inspection, is more than just meeting the target risk numbers that Bryan Gore discussed. Many times preventing the first degradation before you reach that can be a big economic benefit.

Let me just go through, for sake of example. First of all, the current technique -- by the way, this no-ISI case that targeted -- that Dr. Gore showed in his graph was about two times ten to the minus seven. We are saying if you don't do any inspection you are right there at the target. Whether that target is exact, that would not be an acceptable strategy. The failure probability is too high for this particular application.

The code inspection though, does bring it down by a factor of three. If I go to a more frequent inspection I may be getting another factor of five, and you can see similar results consistent with what Fred Simonen had presented. If I go all the way to a real advanced technique, I may be able to drop that number by another factor of two.

When we fold through the decision tree you start to see that the expected costs results that the cheapest thing to do is not to inspect, and that actually improved NDE is not very cost effective if you are dealing with expected -- if you are just dealing with expected value. Actually, expected value is not a very good way to make decisions. You have to bring in another factor.

The reason this number is higher, the improved NDE is that the improvement in lowering leak probability and those costs associated with it, the benefit does not offset the increment as a result of this extra day of outage in order to perform the inspection. I will come back to the fact of expected values, as not being the right way to evaluate this problem. Expected values is saying I am going to take my chance over the long run averages. In some business decisions that's fine. But when you get to the case here where a pipe rupture can have a very significant effect on the business of the utility or the insurers who are -- on all the stakeholders involved in the problem, you have to bring in another very important variable and it's called risk attitude.

The decision tree focuses on uncertainties and probabilities, and the economic and technical factors. It does not incorporate the aspect of risk tolerance. Risk tolerance is a concept that economists use, and in fact we all experience in our daily life here. If we didn't have -- if we were not risk tolerant, none of us would carry insurance.

You want to protect the -- the utility wants to protect the business they have there of that plant. There is a factor that economists have developed, what they call a risk adjusted cost. A risk adjusted cost is saying I am -- I do have this facility with potential for a very serious accident. I am willing to pay above the expect cost in order to indemnify myself against that accident.

What the concept says is that knowing the seriousness of a serious radiation release, that you would be willing to pay more. That's the insurance factor. I would be willing to pay more to protect my plant in that particular case. The risk tolerance calculation is shown here by this equation. The value of risk tolerance is a function of the size of the organization. Utilities, for sake of an example, the average utility is capitalized between $1 to $1.5 billion. A rough rule of thumb of risk tolerance to an organization is about 15 percent of that number.

In other words, a real large corporation or business has the ability to self-insure itself. The R factor, this risk tolerance, is really the ability of an organization to self-insure against certain types of accidents. Anyhow, the risk tolerance factor is brought in, and now we have gone back through the decision analysis again with these factors. We are taking the outcome of the decision analysis, working them through the equations. You calculate a risk adjusted cost for each of those strategies.

With this example it works out -- it actually comes out pretty on the high side: that, if I choose a strategy of no inspection that the utility would be willing to pay up to $600 million above that in order to protect the fact of not having -- to perfectly indemnify themselves against having a serious accident of rupture of this line.

The thing we want to keep in mind is that this is a hypothetical construct, this equation. What is more important is not the number, what is more important is the ratio that comes out of it. When you bring this risk adjusted cost in and the aspect that a utility or business wants to protect their investment, now you get a different look at the choice of strategy. Now you find out that no inspection is absolutely not the thing you want to do. In fact, you work down to the two best choices -- end up being the improved NDE or inspecting more often. That's just the way this case came out for this hypothetical example.

MR. MICHELSON: How do I make sure that if I am concerned about economic risk that I make sure that all the systems that might lead to an economic risk are included in your set to look at? Your first set was developed more on the basis of plant safety and not on economics. Now, when you throw economic in perhaps there is a larger set to worry about than those purely safety related.

I will give you a good example. A boiling water reactor, reactor water clean up system. It is a system that has quite large piping, six to eight inches, contains reactor water at full pressure, full temperature at all times except when the system is shut down for some reason. A rupture of that system, even if the isolation valves were to work, would be a pretty significant economic impact depending on where the break is in that system, you might flush the ion exchange resins out into the building and things like this. It can get very sticky from a cost viewpoint.

That system wouldn't appear in your analysis here, because it got lost way on early in the cut sets. It shouldn't have, because the valves aren't as good as we think they are. Even if they were, it still is something you want to think about from an economic viewpoint.

MR. BALKEY: What we are doing with this whole process is, we are not just looking at high risk. We are also choosing systems that have a moderate risk, and we are going to pick some of those at the bottom and run through this same process again. It's not just we are picking out a couple of components and running through it. We are going to be looking at the entire range.

MR. GORE: I guess my comment with regard to the previous question has to do with the failure modes and effects analysis approach which we would use. The PRA focuses on core damage frequency. That is not relevant risk measure at this point.

MR. MICHELSON: It's not in the PRA.

MR. GORE: We vould go back and do a different type of risk analysis. We would look at the consequence of such a rupture. That's a fairly straightforward one. Here, we are not getting into situations where we have redundant systems and we have multiple failures that we have to deal with. We break that pipe, the consequence can be reasonably straightforwardly estimated in terms ions and radioactivity and clean up of the containment.

It's a completely different problem, I guess is the point that I am trying to make. The risk measure is fundamentally different.

MR. SHEWMON: We are starting to run over time, Ken.

MR. BALKEY: I am going to just quickly wrap up then.

MR. WARD: Could I just ask a quick question.

This risk tolerance factor is really kind of a subjective --

MR. BALKEY: That's exactly right.

MR. WARD: Does each owner -- are you going to have a methodology here where each owner can plug in his own number or something?

MR. BALKEY: You don't need to. What we did here, in the very next viewgraph adjusts it. In other words, what happens if our risk tolerance is off. What happens if the utility is smaller or the utility is larger, would it change our decision. We did a sensitivity study just on that particular factor.

You can see that if you are capitalized at one to one-and one half billion, you are somewhere in this range here for the average utility. You can see that the choice, the improved NDE, the ASME frequency still rack up in the same order. The order does not change until you would get way out until you have somebody of a very large business.

In other words, we plan to do sensitivity studies to make sure that the recommendation should be appropriate across the different sized organizations.

MR. WARD: What is the abscissa there?

MR. BALKEY: This is that risk tolerance. That is R. That's exactly the factor you raised the question on. It's R.

MR. WARD: Okay.

MR. BALKEY: I:'s a subjective number. We want to make sure that the strat3gies don't switch around. The other factor that I want to make mention is -- I am just presenting a straightforward result. Just like any type of assessment that is carried out whether it's PRA or structure reliability, the decision analysis, a major piece of this is to do sensitivity studies to make sure that the variables that you have in which could vary, how much it would affect the decision.

I have just shown one example here. You always go back and say if some of these probabilities I may not have the best information and what happens if it is different. Would it affect my recommendation for an inspection strategy.

In the interest of time, the only last point I was going to make was that the technique can be used to help define if I don't know something about a particular strategy in this particular case -- in fact, what we have done here is said that the NDE, the improved NDE is too hypothetical and is really not a good recommendation. Let's say that out of the work that Bryan Gore does, that the no ISI case does not achieve the target failure probability. You see that we are left with only two choices.

The two choices are present code, or maybe inspecting a little more often for this particular case. We can go back and determine it on some of the uncertainties. I may not have good information on for instance the one of the key uncertainties the chance of a crack actually being present in the pipe. The only thing that I am trying to save from this c 'e is that you can go back and determine the value of goin, out and getting good information, trying to achieve perfect information.

Essentially, this example goes through and says it's worth about $1.6 million to go back out and have a research program to take care of that particular chance node and try to get better information. With that, the effect of inspection when inspections are carried out, the things change. This now gets into the living process.

Mr. Chairman, is there a few minutes for Mr. Chapman to speak, and that would end the entire nuclear --

MR. SHEWMON: After lunch.

MR. BALKEY: After lunch, okay.

MR. SHEWMON: We will come back in one hour then, at 25 after one.

[Whereupon, at 12:25 p.m., the meeting recessed, to reconvene at 1:25 p.m., this same day.]

AFTERNOON SESSION

[1:25 p.m.]

MR. SHEWMON: Let's get started. Please proceed.

MR. CHAPMAN: Good afternoon, gentlemen. I am Vic Chapman, from Rolls-Royce and Associates. I am very proud to be here in your country to be able to talk to you. I shall move along as quickly as I can. I am going to pick up the point that Dr. Simonen made about the inspections relative both to a probability of failure and to confidence. Much of what I say will be obvious at the end of the day, but it's surprising how many people don't go through the logic to end up with the conclusion.

What I want to do is take an example to move through quickly, and I am going to sort of consider a simple weld. I am going to talk about inspecting that weld to start off with. If I inspect that weld, then I will effect of the probability of failure of that weld. As Dr. Simonen showed, if the inspection is at 95 percent or 90 percent chance of finding a defect that will lead to failure, then I can say that whatever the baseline probability of that failure is -- let us say ten to the minus four -- can be reduced by a decade to ten to the minus five.

That's very self-evident. But if that one weld is part of a sample of several welds, let us say 10 welds, then inspecting the one weld does not effect the probability of failure of any of the other welds, only that weld that is being inspected. If we believe that our object of the inspection is to reduce the probability of failure of this system, then we are going to be somewhat mistaken, because we are only inspecting ten percent of it. Even if we reduced that ten percent to zero the other 90 percent would still be there. The overall effect would be very low.

Therefore, we cannot be doing sample inspections in order to reduce the probability of failure. Therefore, you can ask, why are you doing the inspections. The only thing that can be left is to gain confidence. Then the question comes as to confidence in what. I spoke about ten to the minus four as failure, and there was an inference there somehow or another that that was the true probability of failure. But I think the one thing that is for absolute certain is, we do not know what the true probability of failure is of any one of our welds or components.

We may evaluate the probability to be ten to the minus four. Again, Dr. Simonen said that the kind of models that we use to model those probabilities, but we don't know that that is the true probability of failure. We only know that it is our calculated. If we talk about confidence, we might say that what we want is confidence that that value that we calculate is, in fact, true.

I would say that even that is probably not what we want. Again, Dr. Gore talked about a target. It might be that what we want to say is what we want to be as confident is that the probability of failure is less than the target probability of failure. We might evaluate the probability of failure for it to be five times ten to the minus five. Very wonderful analysis. Target we want is ten to the minus four, and we therefore say we are happy, we have met our target and everything is fine.

But then, you could look at the kind of input that you saw Dr. Simonen put up -- he didn't explain much quite right you said -- just appreciate that there is a lot of input with this. We could say, how do we know that that input is true. How do we know the defect density is right. How do we know that we have taken account of all of the types of transients that we are likely to see. How do we know that the stresses that we put in are right and the crack growth is right.

What we can do is to run those models with the ur tainty in them, and we can do what we might call a sensitivity analysis. It's not surprising that I can move that sensitivity such that the probability of failure becomes unacceptable. In other words, comes above my target. Just doing that doesn't tell me anything in its own right. All it tells me is that if I change the inputs I can change the probability of failure, and it tells me how sensitive it is to it. It doesn't tell me whether or not I am actually meeting the target. It is confidence in that which we want to gain.

The thing to remember here is that we are only inspecting a sample of this group, just perhaps ten percent or 20 percent. Now, when we were talking about the probability of failure and how inspection affected the probability of failure, the thing that we were interested in was that defect which would lead to failure which is, itself, quite a rare event, ten to the minus four. If we have a period let's say of time -- and this is this point that led to the inspection -- if we have -- there is a critical size AC which will lead to failure, if there's a crack growth Delta Ray over five years, then we need to be able to show that we can find a defect which is less than that critical size so that it won't fail. We might have quite good inspection efficiency of that.

But since what we are doing now is looking at a sample, we know that that rare event is extremely unlikely to occur in any of them. We hope that it won't occur in any of them. It is certainly extremely unlikely to occur in just one that we are looking at. So, it is not very important now for us to be able to say that we can find that.

What we really want to be looking at is what we would expect to find if the system were true. So now, I can go back to my original analysis which said the probability was five times ten to the minus five, and I can say if that were true and I did an inspection on this component which would affect this probability of failure -- but I could also say what would I expect to find from that inspection.

If I now look at my sensitivity analysis, some of those sensitivities may right go well up to a totally unacceptable probability of failure of say ten to the minus two, and I could still ask the question what would I expect to find if I inspected ten or 20 percent of this sample given that were true.

Once we have done that, we can then say if I carry out this sample procedure, when I get the results what can I do with those results. The answer is, we can now use a Bayesian logic to compare the results that we actually get with those that we would expect from all of the different scenarios that we put forward that could possibly be true. Effectively what we have done is say here is our best estimate which gives us a probability which is below the target, we do a sensitivity, we expand the uncertainties about defect distribution, crack growth or whatever -- you throw whatever you like at it basically -- and you expand that to cover a much wider range which includes a large number which are unacceptable.

Since you have a model, with that model and with the inspection that you are doing and with the inspection routine and with the efficiencies of those inspections, you say what would I expect to find. The key there, remember is, what you expect to find and not the rare event. You have to be careful about that in your future logic.

Then what you do is, you compare your actual results with those of this set in a Bayesian way to say which is most likely to be true of all of these possible contenders. Let me give you an actual example.

[Slides.]

MR. CHAPMAN: This is a pressure vessel which has a very large number of nozzles and a very large number of welds, therefore. What we were concerned about is the probability of failure of one of those welds. What I would like to have done is to have a flip-over to here, but I haven't got one. What I want you to concentrate on is this dotted distribution. I will now try to explain what that is.

What we have done here is structural reliability risk assessment. We have done our best estimate, but --

MR. SHEWMON: If you explain it against the screen you are more visible.

MR. CHAPMAN: I am going to try to talk about this dotted thing here and explain what it is. What we have done here is run structure reliability risk assessment, and we have run our best estimate. That gave us one probability of failure which, if my memory serves me right, was down about here.

Then what we have done is, expanded that to do 100 different type systems. It is many solutions. Of course, there are many ways you get to the same probability of failure. So, what you find is that with those 100 different ones you get different probability of failure. You can see we have done some improvements, but we have also done some bad ones. We have concentrated mainly on the bad ones, so you can see the distribution in this way.

What we have done is 100 different possibilities that could be true. What we are saying is, we do not know which is true because the one thing we don't know is the truth. All we know is what we can calculate and what could be true. This is the histogram then of those 100 cases.

What you then have to say to yourself is, what would I expect from my inspection sample, given each one of these were true. So, you now get 100 inspection sort of results, if you like, from your analysis. Then what you are going to do is, look at your real results and compare them to see which is more likely to be true. To show you some of those results these are them.

Here we see -- here you have date, here you have the sample size that was inspected and what was found. You can see here, we have cleared as non-crack like, cleared as non-crack like. Here we see our first crack-like defect. We have done an inspection here. That was then cut out and repaired, so the probability of failure of that one weld was of course affected because it was removed. But the probability of failure of all the rest were not. So, the rest of them in the sample were not. We have nil, nil -- now we see two not very good. Now we start to see three, two, one, none, none, none.

What we do then is to compare this set of results with what would expect to be true from each of our given samples. That's where the distribution changes to the shaded region. What we are saying now is that had this been true, had any one of these sets which give us this had only been true, we would have expected to have seen much more than we did see. Because we didn't say it, the Bayesian logic says I am now going to update my belief in that particular set. That is dropped down, and that is dropped down.

Note here that a couple here that haven't dropped down. Here, we can see it is sitting back normal. We can see these are starting to come up now. In fact, what we are saying is that we do believe that probability of failure seems to be quite large.

What you can do is study this really against your target. Let me cheat and look at the next slide because it tells you what the target is on the next slide.

[Slides.]

MR. CHAPMAN: What we are now talking about is this value here, roughly one times ten to the minus four. That was the target. The value we calculated for -- our best estimate is lower than that, but we are not really worried about that. We said how confident are we that we are meeting this target. What you see here is our starting position was just that initial distribution, which really doesn't mean a great deal. We start off with it giving us a very low confidence of being true.

As the results come in our confidence begins to climb, and what that is doing of course is, it is shunting that distribution over to lower values. You see here where we start to find the defect, it drops down a bit and climbs up, something found and it climbs up, something found and it climbs up. What you can see here is that this is beginning to level out at about 75 percent confidence. In other words, there are still cases that are coming up where the Bayesian logic is suggesting that the probability of failure could be lower than the target.

The question is, how far can you take this. Well, that's a difficult question to answer. When are you satisfied that you have enough confidence. Appreciate that by the time you try to get up to 95 or 99, you could be here a very long time and this could be a very flat distribution. However, if you drop down to 50 or 60 -- and we have had cases where that is true, where it has failed to get above here -- then you wouldn't feel very happy at all about the situation.

The key thing that I want to get over is that this is gaining confidence in a set rather than trying to affect the probability of failure of the individual one here. We are not trying to take account of how the inspection affects the probability of failure because it's only a sample, and we know it's not very significant. What we want to discover is where we have confidence that this component is coming up to scratch.

MR. SHEWMON: Your five to ten minute talk has gone a little over 15 now.

MR. CHAPMAN: Okay. Let me just conclude then, and say that the important thing that comes out of this is to really ask yourself what is your inspection for. I think these may raise some of the questions that you were asking a few minutes ago. If you believe it has affected the probability of failure then it is only affecting that which you are inspecting.

There, you are concerned about finding that which will lead to failure, and you might be able to get quite a good inspection efficiency of that. If you are looking at a sample, then you are unlikely to affect the overall probability of failure of the whole set, because you are only inspecting a small part of it. If you then orientate that inspection such that you are really thinking about it as affecting the probability of failure, you are only looking for the larger defects, you may find that the inspection is unable to tell you anything about what would be expected to go on.

Therefore, it actually doesn't give you any confidence. You may end up in a situation where you are doing an inspection on a sample which isn't a very good inspection efficiency, is very unlikely to find anything other than gross errors which you don't expect to have; therefore, you can conclude what am I ever going to get out of that inspection. You can also, from ones where you are affecting the probability of failure, get confidence as well. You can say here is the thing that I am inspecting, it has the probability of failure and my inspection is affecting it.

If the probability of failure is low enough then I don't need the inspection. So, I can now ask myself how confident am I from the inspections that the probability of failure is in fact lower or as low as I want it to be, and don't need to do the inspections. Now, you can end up in a situation where I have done a series of inspections on something, I have reached a point where I am very confident that a probability of failure of this is below my target, do I need to carry on inspecting.

You can address questions of, is my inspection worthwhile. I like to think you can address the question of, can I stop doing my inspections. The last point, if you think of the way now we have orientated to bring into what we inspect, those are the biggest contributors toward the risk. We now concentrate our inspections which can still be seen as a sample from everything, to the highest probability of failure elements and highest risk elements. We actually affect those, so we pull their probability of failure down by the inspection.

We can also gain confidence in them, that they are as low as we want them to; i.e., below Dr. Gore's target and that, therefore, other things are. This question of taking a few samples from outside is the same thing.

I think this is what is referred to as a living process. It is a process that we use to try to feed back the results to build up this confidence. I hope that will guide you in decisions about what is this inspection for and is it worthwhile.

MR. SHEWMON: Thank you very much.

MR. BALKEY: I want to introduce Lloyd Smith, because this is no longer nuclear application. We just thought there would be value to the Committee to see how people are applying these probabilistic methods in a non-regulatory environment, and showing the value to their application.

MR. SHEWMON: Thank you.

[Slides.]

MR. SMITH: These techniques you will see affect what the Committee does and has a little bit of insight. Please ask any questions as I go along. Otherwise, I will talk for one-half hour and won't answer your questions. I would much rather respond to questions.

I will focus basically on three or four points: Why we did analysis; methodology we used; results and the benefits; also on our approach to the analysis. Generally, we use supportive approach. We try to respond to what the needs of the various departments and the plants were, and helped them solve their solution. This way we ensured they buy-in. We circumvented when the major problems of the RCM or the reliability analysis, and that is implementation. We just give the appearance of giving them the tools and take and apply the tools and produce a good solution.

You will notice that I did not say that we address risk directly. However, we implicitly address risk. We reduce the number of plant transients and we diminish the time our plant is not under normal condition, which is when we are most at risk. We tend to focus on making maintenance the most effective and overall -- making maintenance effective.

Since the mid-1980's we have had dedicated reliability groups concerned with supporting the fossil portion of the company. We have looked at both active components and passive components. Various projects which we have been involved in are turbine generator protection schemes, limestone injection systems, control upgrade and so on. This covers a whole spectrum of various disciplines.

The turbine generator protection scheme was using fault trees and to do unavailability of various protection schemes to protect the turbine generator. I was determined in the mid-1980's that the turbine generator was not protected very adequately. It came to the attention of our engineers. Our engineers, being good engineers, came up with a multitude of protection schemes to protect them from everything. The problem was, they could not quantify how effective protection schemes were, where they were cost beneficial.

We went in and used fault trees to find the unavailability due to failures of the protection relays. We used event trees to model the event scenarios which could lead to damage generation and electrical bus work. We then used -- determined the contribution of the various relays to the protection. We found that yes, there were some protection schemes which protected the reactor and turbine generator better, other ones were marginal, and a large number -- especially a couple that were pets of the PUC which not only did not protect the turbine generator but actually produced negative results.

MR. MICHELSON: In looking at turbo generator protection, did you look at off-normal operations like testing similar to what happened at Salem?

MR. SMITH: We were looking at various electrical faults which could occur on all occasions, yes.

MR. MICHELSON: That event developed from being in a particular test mode and then having another failure or so along with it, not even realizing it. I just wondered, do you do that kind of an analysis.

MR. SMITH: That is what was done there, yes. We went through and basically just said for each protection scheme what could have failed, what could not have failed --

MR. MICHELSON: You did include the test modes.

MR. SMITH: Yes.

MR. MICHELSON: Okay, thank you.

MR. SMITH: They are all the same. We also looked at a system to put limestone injection into coal burning, to allow us to burn lower grade coal, a different grade of coal. The system was very complicated. We tended to focus on which of the portion of the system was less reliable, which one produced the highest impact on maintenance requirements. We used computer programs like Uniram which is a software program to quantify the fault trees. We used diagrams to represent all major subsystems. We did determine that a number of the portions of the system were unreliable and did require a lot of maintenance.

The third instance we looked at was control system for this -- the control system could be 30 years old, starting to fail. It could be replacement of parts. We looked at the failure data for it, and the failure data was rubber band breaking, paper clip falling off. They didn't have parts anymore, they were creating parts and creating an operating system as they could.

The control system upgrade claimed that they were going to improve availability. The problem was that we had done a similar control system two years earlier, and the availability of the plant went down and not up. So, we wanted to concentrate on where it could have improved availability.

Our objectives were to impact the control system upgrades on availability, discuss the impact of operational economy, to identify major contributors to unavailability of the plants, and then to transfer technology. We initially assessed the present utility's conditions and identified the major contributors on availability, and subsequently used root cause analysis to become proactive and correct the problem.

Through model trending we are able to predict components that were going to affect unavailability in the future and address them before that happened, producing a proactive program. We looked extensively at operator action, all the steps necessary to start the plant up to operate the plant and to shut it down, and then did some analysis as far as the optimum number and size of operators. Life extension program, of course, with fossil units, we looked at all the major components that were pressure boundaries that had big impact items.

The project of interest which relates mostly to system analysis is the Huntley reliability project. We did failure data analysis, plant modeling, human task analysis, recommendations, evaluation and implementation. The failure data development was review of system, equipment and problem experience, assess the data, determine what data was necessary. Fossil units were different from nuclear, in effect, that we have quite a dense database. We have lots of failures to look at.

On nuclear you are very sparse. You haven't had enough failures in the whole program to really produce a good database. We have lots of failures. Some are strange, but lots of failures anyway. We took the raw data, developed a database and put it on a computer, analyzed it, is it adequate to support the model. If it's adequate okay, but if it's not, we either get more data to a generic basis or we change the model to produce the detail necessary to the data to support it.

We looked at as much data as possible, again, reviewed documents; one lines, operating, interviewing plant personnel. A lot of times the plant personnel reviews are more important than anything else. That's how the plant is really operated, not how it is designed. We will find that the design and design engineers and the operations -- even management thinks there is a big disparity.

We have to take this failure data, and to make it useful we have to have a model of the plant. Once again, we review system and equipment, talk to the operators, find out how the plant is really designed, develop block diagrams which are just those systems necessary for the plant to produce its mission, 100 percent power, one or two feedwater pump trains, one condenser and so on. Develop fault trees to quantify the block diagrams, refine the fault trees, use failure data to quantify the fault trees.

Likewise, we did a human task analysis in great detail. We interviewed operators and asked them what they did. They came up with a list of 500 actions that they used to do to operate the plant. We wanted them, and they had about 1,400 actions. We did one thing -- two more things, and they didn't realize what they were doing, looking at instruments and making phone calls. There's a lot of things happening on a fossil plant.

Likewise, their procedures are two pages long to start the plant up. All it says is start feedwater train, shut down this, start that -- how they do it, they have little black books which they, from history, have learned from the previous operator. We took the raw data and determined what function they really do, and specifically what tasks and manpower analysis.

On a fossil unit we found that this is operated on a manpower basis. In other words, they have four or five levels of operators or men to do the same thing. The shift sup, the assistant shift sup, the boiler floor operator, the two control room operators. During the transient they are all walking around checking things. So that, if one person doesn't do one thing the next person does. On different shifts, different people do different tasks, depending upon how their personality works out. This is where a difference between that and the nuclear is.

If we just reduce it down to having a number of men to operate the plant as such, the availability and reliability of the plant just decreased based upon this depth theory. To summarize on a broad level, we look at the data, collect data, do model, human factors. Likewise, they all have the same steps and use the same people at the same time to do the analysis rather than ing them individually. That way, we have a cross-pollination of experience.

The data development was a major part of our problem and is a major part of a problem on nuclear also, getting a good data. We would like to get as much similarity between the data and our plant as possible. We look for the same industry, same type of failures, same environment, same company perhaps, location, age. As I noted earlier, actually, an environment affects the failure quite a bit. It may be off environment.

Maybe different trains fail. Train A fails differently than train B and different than train C. Failure data is different in each train for the same component and the same theoretical operating conditions. You look at maintenance records, you use operator logs, interviews, and walkdowns. We check for duplication.

The failure data looks like this -- where we have a system, failure date, record number to get back to it, component identifier -- this is a major problem at fossil units. The pump is the third pump in the second level, or the Northwest pump or the valve that is above some piece of equipment, or it has two or three identifier numbers, neither of which situation the computer likes very well. It's not a happy computer. You have to go through and reidentify all the components.

Then, the component itself is a pump, severity, catastrophic, degraded, incipient, failure mode, does it fail when running or does it fail to start and failure cause, is the shaft broken, is the motor burned out or whatever. We used the DBASE3 and Symphony to give us control of these. This is a typical sheet of failures. Once again, the system, the fuel, the boiler, the date record, type of equipment, copper pipe, severity, mode, cause. Was it a leak, did it fail, was it a shaft broken.

At this point, this is when most databases -- a lot of databases stop. They tell you the failures and you can tell how many there are, but you have no idea what the denominator is for a rate; how long were they operating, how many times did they start. This is NPRDS with their -- their problem in NPRDS is that they just don't know the denominator.

No matter how good you know the enumerator, unless you know a denominator you haven't got much. Your fuzzy feeling, once again, is not very useful in a computer and analysis. We spent a lot of time looking at exposure, and determining exposure time and start up. We went through all the operator logs for this case, looking ten years worth hour by hour, and determined how long each system ran. The Mils ran for how long, the fans, feedwater pumps. Notice that the feedwater pumps are not evenly distributed. They are two out of three necessary, 15 hours for this one and 7,000 for this. They were equally here. Here is seven hours.

This could represent the fact that there is a standby system ready to operate, ready to come on, ready. However, we found that there is equally good change that when the train failed they haven't repaired it. Another train failed down here -- we looked at which train had failed and easiest to repair, and used the other train for spare parts. Instead of having an installed spare train we had installed spare parts.

[Slides.]

MR. SMITH: It was difficult to put a repair rate on a component which had been broken for two years, just because it was an installed spare part. There is a problem there. We also looked at a number of starts, and this produced some interesting results which probably would be interesting on a nuclear plant also. Once again, feedwater train, notice starts were 20 a year, 20 a year, 20 a year, 200, 200. What is happening was management at the plant was getting very upset that the valves on the feedwater pumps were breaking and failing. They were sure the operation people were buying cheap equipment, they were not doing their job right, they were sloughing off.

What happened though was, these plants are low faulting plants. Every evening they drop the load and you just had a lot of the pumps go back on their curve, no problem. About 1985 the operators decided they wanted to save some power and shut off the spare pump. Every night they shut off the spare pump and every morning they turn it on again. They didn't tell anybody about that. Suddenly, the valves upstream and downstream, instead of operating 12 times a year were operating 200 times a year, wearing out, failing and management problems.

Just by looking at this management decided they weren't saving enough power to justify as many failures and as much maintenance loss of availability and went back to the old system of just coming back on the curve, and the problem went away.

[Slides.]

MR. SMITH: We take this data then, and we can identify component unavailability. This is a list of the main contributors for one of our fossil units. You notice here, coal burner number four is 12 percent, coal burner number two is one percent. It's a factor of ten. Same component, different parts in the system, different trains. Boiler tubes, down here to attemperators, high pressure feedwater banks and so on. This unavailability of these components.

We then put this through the plant model quantifying it, using a computer -- this is KAFTA. We have contributors to plant availability, 100 percent power. Once again, here is the tubes, attemperators, boiler burner number four, burner number two, combinations. Failure rate, mean time to repair, percentage of unavailability. Notice once again, they are very train dependent.

We did this for a number of years. Each year we updated our data, we made this a living program. We found that the plant took this data and said here's where our problems were. They went in and addressed the maintenance programs, and dropped down from 86 down to 90. Tubes, pumps, feedwater pump, turbine, mils. They had a number of projects that they wanted to get done but no justification for a number of changes in the design.

We did this analysis, identified the problems and they got seven approved within three months to get the work done with the resources. We also identified another plant. The precipitator, whenever they went in and did any maintenance in the boiler of the attemperators, they always sent a crew up and worked on the preciptators. The same thing happened sometimes on nuclear plants. You have these hidden agendas.

We knew that once you got the boilers taken care of, all the rest -- the precipitator were bound to produce a problem. We notified the plant of the problem a couple of years ago, when it appeared they were already starting to address them.

MR. WARD: Lloyd, us nuclear types are puzzling over what a attemperators are.

MR. SMITH: I am a nuclear type too, so I have a problem here. They are basically a temperature mixing unit, I believe. They are a preheater, aren't they?

MR. MICHELSON: I don't know.

MR. SMITH: I believe they are a preheater.

MR. MICHELSON: That would have been my guess.

MR. SMITH: I believe.

MR. SHEWMON: The comment back here says they are aired preheaters too, so that must be right.

MR. MICHELSON: At least we all agree, so it must be right.

MR. SMITH: We have now taken this data from 1985 and each year we update it and produce a new list of major contributors on availability. The operations -- the new list addresses those, and we are getting everything produced. The database covers about 30 years of plant data. We have 15,000 failures in it, and over 500 components, which makes the nuclear group people just drool for that type of database.

MR. MICHELSON: Is this an industry-wide database?

MR. SMITH: This is strictly unique to four plants.

MR. MICHELSON: Four different utilities, or four plants --

MR. SMITH: Four of our plants.

MR. MICHELSON: Okay.

MR. SMITH: It is commercialized though. We have commercialized it.

MR. MICHELSON: By that, you mean it's available to others for a price?

MR. SMITH: That's right. Basically, it's Huntley 65 and 66 for ten years, 67 through 69 for five years. Once again, it's over 11,000 legitimate failures. Those aren't the failures -- for example we had level one, two and three in the control room -- in the failures, and we have one failure the intake structure was level three. A week later many rats and intake structure level one. Those type we don't count.

MR. MICHELSON: There must have been some number of valve failures in the feedwater system and so forth over the years.

MR. SMITH: Oh, yes.

MR. MICHELSON: Were they not just not on this group for some reason?

MR. SMITH: They weren't major contributors to unavailability.

MR. MICHELSON: They were not major.

MR. SMITH: No.

MR. MICHELSON: I thought they were --

MR. SMITH: They were a major problem in maintenance though.

MR. MICHELSON: I thought those feedwater control valves were kind of a frequent --

MR. SMITH: They were, but they were always hidden someplace else. We worked on them while we were working on the boiler --

MR. MICHELSON: Hidden somewhere else, do you mean that they weren't the reason for shutting down?

MR. SMITH: Right. Also, we have three trains on these, so we have one down and fixing and two operating. They never show up as the loss of unavailability.

MR. MICHELSON: It's not really a reliability database, in the sense I would go to it and know how reliable the feedwater control valves were.

MR. SMITH: You could.

MR. MICHELSON: If I went back into it somehow.

MR. SMITH: Two steps, yes. Before you put it through the computer you would have this --

MR. MICHELSON: You would have the raw data.

MR. SMITH: That one, there. Just the component with unavailability.

MR. MICHELSON: They were tracked as being unavailable even though it didn't interfere with the plant availability necessarily.

MR. SMITH: That's right.

MR. SHEWMON: Or they didn't come above his one percent threshold requirements.

MR. SMITH: That's right. If you go back to here you find the feedwater heater bank for example.

MR. MICHELSON: Is that the valves?

MR. SMITH: I honestly don't know.

[Slides.]

MR. SMITH: In conclusion, I would like to say that we have incorporated a lot of the techniques that the ASME Committee is using. We applied it to diesel generators, control systems, limestone injection, process models, control models and so on. For the Huntley 65 and 68 we did the analysis in 1987. At that time the unavailability was 70.5 percent. That was before we used the database. In 1989, after we applied the database, we have unavailability now of 84.5 percent, which is a substantial increase in unavailability.

We used it for long term and short term decision analysis too. We have been asked, for example, to make one of the plants a co-generation plant. We are also applying and installing a coal gasification at one of the facilities. Both of those, we have looked back at the life extension, at the projected failures on the large turbine and large steam pipes, and have used that as part of the basis for deciding yes or no.

MR. MICHELSON: You do a similar thing for your nuclear unit?

MR. SMITH: We are doing a IPE PRA on it.

MR. MICHELSON: Yes, but this is not quite that.

MR. SMITH: No. We have not done this --

MR. MICHELSON: This sounds good. From your financial viewpoint it sounds good. But I just wondered why it wouldn't be applied to the nuclear unit on your utility.

MR. SMITH: Our nuclear unit the last five years have been on the watch list. They have a very different perspective of --

MR. MICHELSON: You still like to make money with it.

MR. SMITH: Yes, right.

MR. BOSNAK: I think in this case we were -- and the next one that follows -- we were trying to show the applicability to other and how the process really --

MR. MICHELSON: I was just curious though, as to why he didn't apply it to his nuclear unit as well, since it --

MR. SMITH: The fossil were very, very receptive. The only question was, why didn't he come in six months ago.

MR. SHEWMON: Thank you very much.

[Slides.]

MR. WENDLAND: I am Bill Wendland, from American Nuclear Insurers. We have a substantial sum of money at stake at virtually every nuclear power plant in this country and most of them in the world, and most of them in this country it's well over $1 billion per plant. Probably our biggest losses are Three Mile Island the reliability side, and Price Andersen kind of Act, we are still paying lawyers. Lawyer fees, class action suits. On the property side, we paid for the entire plant.

What I would like to talk about is why this technology is of interest to we, as nuclear insurers. What I prepared is just a summary, and I will touch on each one of these points briefly. I think most all of this was discussed in great detail today. I think the first question that comes to mind is, why is it important to us, as nuclear insurers.

As I said, we cover the entire facility, well over $1 billion in most plants in the United States and a minimum of $200 million on the liability side at every plant in the United States. Our interest extends beyond the public health and safety that you all are primarily concerned about. Our insurance covers the entire nuclear plant; all the buildings, all the structures, all the switchyards, often times buildings and structures outside the protected area. It depends upon the site itself.

The point is, we cover virtually everything on the site with a few exclusions. In our mind, the integrity of the components at nuclear facilities is essential in reducing insurance exposure -- economic driven -- and plant outages. It has been our experience, particularly in recent years and was recently highlighted with the IGSCC days, where the usefulness and reliability of many of the inservice inspection philosophies and technologies that we use today could be enhanced a bit. They have been in some cases with regulatory guides or with NUREG's and with some bulletins.

As plants get older, we believe -- and there is some experience to show -- that the effect of age-related degradations are going to start to take on much more significance. In that regard, inservice inspection will become even more important and more paramount, in terms of benchmarking where the plant is today and where it might be in the future.

It is a proven technology, as we have come to know. Vic Chapman, while we can't know the details of his work, we do know that it does work and it has been very successful in the United Kingdom in their submarine program. It is also being used by utilities, owners groups, and other national laboratories and other organizations within the United States and outside the United States in some form. Most recently, the insurers in the United States are starting to use the technology so that we can get a handle on where our exposure lies in areas where there is really no actuarial data from which we can work with.

In our opinion, the process complements existing technologies. It is really a refinement to ASME Section XI. We recognize that there is a substantial amount of inertia to change, and that's true in our society. We believe that this particular process is merely a refinement of the existing deterministic based fundamentals that are in Section XI.

MR. MICHELSON: Excuse me. Can your organization, as the insurer, require that certain of these processes be carried out as a provision of your policy?

MR. WENDLAND: Yes, we can, and that --

MR. MICHELSON: You have your own enforcement capabilities, irrespective of what NRC might do.

MR. WENDLAND: It's a matter of negotiation with us and the insurer -- it's a business relationship kind of thing.

MR. MICHELSON: If they don't want to do it, then you have to charge them a larger premium, I guess.

MR. WENDLAND: Right. The pilot work at Surry and some of the other work that the PNL people have done and also at Westinghouse and EPRI, demonstrates that the propensity of this particular technology could be used to enhance existing inspection purposes.

It facilitates in the incorporation of code, regulatory and economic factors -- a bunch of buzz words. What it really says is there's a lot of requirements that come to utilities. Chuck highlighted a few of those. NUREG's for IGSCC, erosion/corrosion kinds of things, bulletins that would address even some other things related to cracking and some kind of corrosion phenomena that we do. That all has to get factored into a utility, and they have to figure out how to address all of those needs with a finite level of resources.

In addition, this particular technology can be used for location kinds of welds; things like thermal fatigue cracking, some of the higher bending moment failures that we are seeing now in industry that we didn't anticipate before, and erosion/corrosion, something that we have talked about today, it would be used there. Those things all presently do not come under the auspices of ASME Section XI.

It also has the ability to factor in active components, which we have talked about briefly. Was it a conscious decision of the task force early on, after a lot of debate -- and we were actually pushing a lot of the inclusion of active components -- active components can very well be included in this entire approach. It's actually not very difficult, and it's being done on a minor scale in many areas today. It was not consciously done here at this point so that we could get the product and get the product on the street and available to the public as we have done thus far.

MR. MICHELSON: Do you include fire hazard as a part of your insurance?

MR. WENDLAND: Sure do.

MR. MICHELSON: So, you are quite interested in that aspect.

MR. WENDLAND: We are insuring the entire facility. Virtually, any kind of hazard and accident you could imagine, we are on the hook for. It also has this cost benefit. The cost benefit can be factored into this thing too. That's the economic part that I wanted to highlight. Dick touched on it briefly, but probably didn't go on in great detail.

If you have a lower probability of detection, for example, if you increase the number of inspections you actually now reduce the risk of some exposure. There is a cost there. On the other hand, if you have people that have a very high degree or high probability of detection, then maybe you can decrease the sample size. That all was part of the weighing game.

An example that I would like to point out in this particular bullet item is the thermal shield example. The reactor vessel internal is an example of which a thermal shield is a part. We have paid for a couple of thermal shields already, very expensive. Utilities have paid indirectly too, because of down time, outage time. If you go through a probabilistic risk analysis and assume failure of all the various components inside a reactor vessel internals, you will find that failure of all of those components, no matter what they are including the thermal shield, really don't change the core melt risk frequency very much.

However, if you look at those same components from an economic point of view, you find that there are two components; the thermal shield and some bolts -- and I have forgotten which ones those were. Those have a very high likelihood of failure. In addition, they can also result in some very large consequences. The thermal shield case, well over $100 million. That's a combination of insurance plus their outage insurance, plus out of their own pocket.

In that kind of case, those things aren't covered by ASME Codes, but it allows the utility executive opportunity to make a conscious risk decision based on his tolerance, of where he wants to devote some of his inspection dollars.

MR. MICHELSON: Since many of these processes that are being proposed are highly dependent upon the goodness of the PRA that is used as a starting point, to what extent do you look at PRA's independently of others to see if they are a good basis for their real risk that you people will be experiencing?

MR. WENDLAND: We look at them in great detail. Actually, we rely on much of the work of NRC. As I said, we cover the entire facility.

MR. MICHELSON: So, you are aware of the motor operated valve reliability questions then, because that could significantly effect the risk in rome cases.

MR. WENDLAND: Right. From our perspective, the way we would look at that, we have a finite resources pool as well. We would prefer that the utility take the initiative to address that whole thing. If they do that, then that's something that we don't have to look at. If it is something that they don't do, then we might want to stimulate them to take a look at some of those kinds of things. We do use the PRA's, where those are available. In some cases, those are the more reliable we would use.

MR. MICHELSON: Do you have in-house expertise to sit down and reformulate a PRA?

MR. WENDLAND: I would say no. In-house, no. What we would do is, we would hire a --

MR. MICHELSON: Consultant or something to do that. If you have questioned the outcome, then you might get somebody to check it.

MR. WENDLAND: Right. Then, probably hire another one to get --

MR. MICHELSON: To check him.

MR. WENDLAND: An independent review, to see whether he was right. That was an example back in the days of IGSCC, which was of great concern to us. We hired a fellow that you all might know, Roger Staley to work with us, and then we hired some other people to kind of look over his shoulder to guide us through that whole thing.

This particular process, in our mind, is a major refinement in risk-making ability by utilities. If you think back to the graphs that Ken showed earlier where he showed the influence diagram and the decision tree, those things are very complex and difficult to understand. I am a layman to this whole thing, and I look at them and understand probably a lot more than others. It is still a bit boggling to me.

One thing it does do that I have come to know is, as you participate in developing those particular things, you become much more knowledgeable about the uncertainties associated with what you are doing and the significance of the input to the people that are making the decisions. What you gain is, you gain a substantial amount of buy-in throughout the whole utility. At least that's our experience in the kind of work that we have been involved with.

MR. MICHELSON: What is your association with Factory Mutual?

MR. WENDLAND: They are a part of us.

MR. MICHELSON: They are actually are a part of your corporation?

MR. WENDLAND: They are a part of us. We are a pool -- American Nuclear Insurers is just basically two United States pools. There is about 200 companies worldwide that contribute assets to us, that we kind of manage the money and also manage the engineering resources and risk that they have. Allendale is a piece of us, Hartford Steam Boiler is a piece of us, most insurance companies that you know of in the United States and many of them in the world.

MR. MICHELSON: Factory Mutual was the people that you g[illegible] you have more detailed questions on certain hazards.

MR. WENDLAND: Actually not. Factory Mutual has some specialties in areas that we would tap in some areas.

MR. MICHELSON: I was thinking of fire protection, for instance.

MR. WENDLAND: Actually, we would use people from IRI. We have a fire protection staff. Most all of those people were trained at industrial risk insurers, their mainstay being fire protection in the country. It's kind of a rivalry between Factory Mutual. We utilize that expertise that is available to us, Factory Mutual being a piece of it. In fact, Factory Mutual, we are involved with this whole process for several reasons. One is the nuclear part, and that's the obvious one. The other one is not so obvious, is the fossil part.

We see most of our risk shifting as the nuclear industry is kind of shifting, shipping most of its focus to the operational aspects of the nuclear envelope. We see less of our exposure there because somebody is already looking at it. We see more of our exposure shifting over to what we broadly define as a balance of plant, things like turbine, transformers, erosion/corrosion, structures.

The work that Dimitri is kind of focusing in that area is -- we want to tap into that to gain a better perspective on where we can focus our resources to look at risk. This particular tool also is in my mind, is a major benefit in terms of communicating not only to the utility management about where it is you want to inspect -- somebody like Chuck, where he wants to spend his time, where he recommends his time. Also, when you talk to the PUC. Instead of having some things that they -- issues that they consider to be abstract because they are coming from technocrats -- you have now this decision making model which is really bona fide and accepted by the business community and has been for years. Say hey, look, this is the reason why we are doing what we are doing.

You have now an effective tool from which to debate. You have a quantitative and a pictorial process for that whole thing. It's a living process. That is something that we sometimes don't talk about very much when we get in our group. The living process is something that Vic Chapman is a champion of, where you factor in results of what you found. If you found some faults or you didn't find some results, you factor that back in the original analysis and fine tune it where you are going to look next time.

You might find -- if you think about it, there's a graph in your handout that kind of illustrates this -- where you have a constant risk line. The objective is to find out where your risk tolerance is, and those things are about your risk tolerance. You increase the inspections to reduce the probability or likelihood of occurrence. The more knowledge you have about that, the more confidence you have that you can reduce it. That's the living part of the whole process, as far as we are concerned.

Enhances strategic inspection focus. This was graphically exemplified in Truong Vo's slide, where he had a curve where he had the bullets that went from one to 37 I think they were, and you had the plateau up here. If you think about it, I think it was item 18. Those items and beyond, you don't get a lot of return on your investment in doing inspections. Those items below -- yet those items above are required by codes and by various regulatory requirements or jurisdictional requirements, meaning state boiler. You don't get a lot of bank for it, so why spend your time doing it. You don't really get much feedback.

If, on the other hand, you spend your time on the lower end you get much more return on your investment. That was shown in his slide. The bottom line is --

MR. WARD: Are any of those required by American Nuclear Insurers?

MR. WENDLAND: They are, indirectly. Every state has boiler jurisdictional inspections of Pressure retaining components. Some of those things are actually required by the local jurisdiction as well. That inspection is either done by one of our people at a plant or somebody that they hire by themselves. It would be an authorized inspector under the definition of the code.

There are also other things that are required to be inspected --

MR. WAPD: Is your company reacting to this new technology?

MR. WENDLAND: As a matter of fact, yes. We have taken a derivative of this process more in a qualitative sense right now. We have now implemented that within our own organization. We have our staff -- as I mentioned, the fire inspectors, and we also have a staff of pressure systems machinery inspectors. It's an extension of the boiler inspectors and authorized inspectors that you are familiar with.

Those people, we subcontract from Hartford Steam Boiler and from Factory Mutual to do our inspections of our insurers. This particular process is being utilized to focus those people and tell them where to go and look. Instead of walking into the plant and saying where do I go and look, I look at a turbine today or go and look at a transformer. If you go and look at reactor pressure vessel integrity -- only because today is Thursday and this is where I ought to look.

We now have a tool from which we can focus where we want to look. We have to have that, because we don't have -- as I said, we don't have any actuarial data. The business has actually been good to us. But when it's been bad, it's been real bad. That is actually with people in IRI and Factory Mutual -- you don't have data from which you can really be like an automobile insurer for example.

MR. MICHELSON: Let me be sure that I understood what you just said. Are you saying for instance in the case of fire protection inspections, that you are approaching it from a risk-based viewpoint?

MR. WENDLAND: That's correct.

MR. MICHELSON: Have you developed that concept in some kind of written documents that one might read?

MR. WENDLAND: Yes, I have. I am not sure that I am at liberty to give you one. I am presenting a paper at an upcoming ANS conference that talks of it. I can check with my people and if that's available, I will forward a copy.

MR. MICHELSON: If we could get a copy, that would be interesting to read about. I have a particular interest in risk-based inspection for fire hazard purposes.

MR. WENDLAND: Again, it is interesting to note -- I talked of change earlier. IRI has been around for 50 or 60 years, Hartford Steam Boiler 100 years. The insurance company has been around for a long time. I am not from the insurance industry, I am from an NSSS vendor prior. Change doesn't come easy in the insurance business. They are used to doing it the way they are used to doing it.

As times goes on, we are finding that you just can't afford to do it that way anymore, it costs too much money. More than that, it's how effective is it. Many inspections that you do you do because you have been doing them for a long time, but you don't really see anything. Much like the ISI people, they have been doing inspections for a long time because it's required. How come you do it, because the code says it.

Do I get anything from it? Sometimes I do, and sometimes I don't. We believe that --

MR. MICHELSON: It's looking in the right places.

MR. WENDLAND: That's right. This technology, in our mind, allows you to focus into those areas. When I talk about the insurance industry adopting this, they are adopting it but a bit slow, I guess is a fair way to say it. Even my colleagues, it takes a bit of time.

In our mind, this is also -- this is very readily adapted to non-ASME Section XI areas, something that Chuck touched on.

MR. MICHELSON: Excuse me. Could I follow up on my other question, just one more step. To your knowledge, is there any part of the fire business that is working actively on risk-based inspections for fire protection purposes.

MR. WENDLAND: I have to be careful. There was an organization that does fire protection inspections and specializes in that. An individual who is very well versed in this technology had developed some models and wanted to introduce those, that concept into his inspection from a research --

MR. MICHELSON: Which organization is that?

MR. WENDLAND: It's one of our member companies. I am not sure that I could really tell you.

MR. SHEWMON: He didn't say.

MR. MICHELSON: I know he didn't. We are having a meeting on fire tomorrow, and some people from Factory Mutual will be here.

MR. WENDLAND: It has to do with the issue of change. That organization has been around for years and years, and that's the way they do business, and they don't know how to do it any other way. As the economic times come about -- and they are all starting to see that as we are, we are laying off people as are they -- the economic pressures come about you have to be more thoughtful and more strategic on how you do business.

MR. MICHELSON: That's what --

MR. WENDLAND: That's what this is doing. This allows you to be that way.

MR. MICHEISON: Thank you.

MR. WENDLAND: This particular technology, in our mind, could be used very well for things like -- I didn't put them up there -- surveillance requirements, technical specifications, electrical components, balance of plant areas, erosion/corrosion, turbines, transformers, very readily used.

Again, you can factor in -- we, as engineers and scientists like to think of numbers, ten to the minus fifth, for example. We will spend all afternoon arguing bout ten to the minus fifth. Think about ten to the minus fifth with a couple of whiskers on it that Truong is famous for where it has a large amount of uncertainty, and let's deal with that. Let's see where that band is, and let's go after the inspection based on the uncertainty that we know and build up the confidence as we continue to inspect.

Finally, it can be used in management of age-related degradations. Fred Simonen's slide I think illustrated that most graphically, where he talked about the large benefit from inspections; where he had the two curves. He had one talking about the benefit of doing inspections where you had a crack that would grow early in life and it wasn't very much benefit where you did the inspection. But then, he had another curve where you had the effect of age-related degradation starting to manifest, where inspections played a very large component in reducing the risk.

I guess that is very important to us. As I said, we as insurers aren't quite sure where we are in the bathtub curve, or if there is a bathtub curve. But the challenge of the business community worldwide has been to us, are we going to start to see an increase in insurance loss as plants continue to age. We will be damned if we can answer that question. We can generate a few histograms, but we can't answer the question.

We do know this; we do know, based on the technology hand based on the things that I have seen these fellows do, that this is a very strong tool that will help us and help the industry in total, to be able to gage and to benchmark where they are in terms of age-related degradation mechanisms before they begin to manifest and before they become catastrophic.

With that, that's the business community or at least part of the insurance community.

MR. SHEWMON: Thank you very much.

[Slides.]

MR. BALKEY: I am just going to very quickly summarize where we are going from here on our research. I think you have heard that the work is already well underway to complete Surry, the structure reliability and the decision analysis calculations. Then, there's the intent to take a look at other PWR's and go into a BWR in the same level of detail that has been done at Surry for a good recommendation to be made for both the PWR and BWR designs.

We have an action plan that the team developed. I am not going to read through this. I think the most important development is number eight. As we continue to work with this, we feel that a recommendation was made to Section XI and was accepted quite well on Monday afternoon, that they consider forming a group within the actual code body that would work with the subgroup here; so that, as we do our research work they know it's coming, they can see how it would be very beneficial of use in actual revision or addition to codes itself.

I think the last slide I have summarized our efforts and has been said by many already. Some large benefits, of course, are the insights you gain in going through these processes that you don't get any other way. I think we do have a very unique team here, where we have people who are representative of private industry, government and academic institutions and across many industries This is just not a nuclear project. There have been many things of great value learned from folks like Dr. Ayyub from the University of Maryland on civil engineering applications and Herb Smith on Aircraft applications that we have considered and folded back in the work and is considered even in the nuclear case.

We feel that's a very strong case. The other thing, too, are the disciplines. We have everybody from the NDE engineers through the PRA, all communicating together which doesn't happen right now.

Volume 1 is out and you folks have a copy of it. Volume 2 will be out very shortly. We are already starting work on the additional volumes, and the interest in the technology is growing very fast. With that, I would like to speak on everybody's behalf, that we are very appreciative of the opportunity to be with you today. We hope you found value in our presentations and have a good feel for where we are going in the future. Thank you.

MR. SHEWMON: Thank you very much. Are there any other comments?

MR. MICHELSON: I, for one, would like to say that I thought this was a very interesting and beneficial, particularly from the viewpoint of where else it might ultimately, the same approach might ultimately be --

MR. BOSNAK: We hope the Committee would find it very valuable. Speaking from wearing my NRC hat, we are looking at this as a leverage group contributing time, resources. It is being multiplied, and we think we are getting good value for the resources spent. It's a status report to the Committee, and we would like to know what you would like to do with respect to the Full Committee. Are you going to make a report, or would you like us to participate?

MR. SHEWMON: I thought I would give a Subcommittee report, and just tell them of the work. I think we look forward to the second volume. When it gets down to where -- it will be interesting to talk to you again when the second volume is out and you have started to use it some, I think.

We are adjourned.

[Whereupon, at 2:55 p.m., the Subcommittee 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 Joint Materials Metallurgy/ Maintenance Practices & Procedures

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.

Mary C. Larkin

Official Reporter
Ann Riley & Associates, Ltd.

BRIEFING

ASME RISK-BASED INSPECTION GUIDELINES RESEARCH PROJECT

U. S. NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON METAL COMPONENTS

BETHESDA, MARYLAND
FEBRUARY 13, 1992

AGENDA

U. S. NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
SUBCOMMITTEE ON METAL COMPONENTS

Phillips Building
Bethesda, Maryland
February 13, 1992

BRIEFING: ASME RISK-BASED INSPECTION GUIDELINES RESEARCH PROJECT

TOPIC	TIME	SPEAKER
o CHAIRMAN'S OPENING REMARKS	8:30 - 8:40 AM	Dr. Paul Shewmon
o INTRODUCTION		
-ASME/Research Project	8:40 - 9:00 AM	Mr. Ray Art/ Mr. Robert Bosnak
-Overview of NRC Research Efforts	9:00 - 9:15 AM	Dr. Joseph Muscara
o OVERVIEW OF TASK FORCE AND OVERALL RISK-BASED INSPECTION PROCESS	9:15 - 9:30 AM	Mr. Ken Balkey
o APPLICATION OF PROCESS TO LWR NUCLEAR POWER PLANT COMPONENTS		
- Risk-Based Priorities for Inservice Inspection	9:30 -10:30 AM	Mr. Truong Vo
BREAK	10:30 -10:45 AM	
- Target Failure Probabilities	10:45 -11:10 AM	Dr. Bryan Gore
- Inspection Program Development		
+ NDE Reliability/Structural Reliability Assessment	11:10 -11:40 AM	Dr. Fred Simonen
+ Decision-Risk Analysis	11:40 -12:15 PM	Mr. Ken Balkey
LUNCH	12:15 - 1:15 PM	
o APPLICATION OF RELIABILITY METHODS TO FOSSIL FUEL-FIRED POWER PLANTS	1:15 - 1:45 PM	Mr. Lloyd Smith
o INDUSTRY PERSPECTIVES		
- Nuclear Utility	1:45 - 2:00 PM	Mr. Charles Tomes
- Nuclear Insurer	2:00 - 2:15 PM	Mr. Bill Wendland
o FUTURE WORK PLAN AND SUMMARY	2:15 - 2:30 PM	All

INTRODUCTION

BRIEFING: ASME RISK-BASED INSPECTION GUIDELINES RESEARCH PROJECT

U.S. NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON METAL COMPONENTS

ROBERT BOSNAK
RAY ART

BETHESDA, MARYLAND
FEBRUARY 13, 1992

INDUSTRY

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CENTER FOR RESEARCH AND TECHNOLOGY DEVELOPMENT

The American Society of Mechanical Engineers

ASME'S PURPOSES

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- Foster Engineering Education
- Advance the Standards of Engineering
- Promote the Exchange of Information Among Engineers and Others
- Broaden the Usefulness of the Engineering Profession in Cooperation with Other Engineering and Technical Societies

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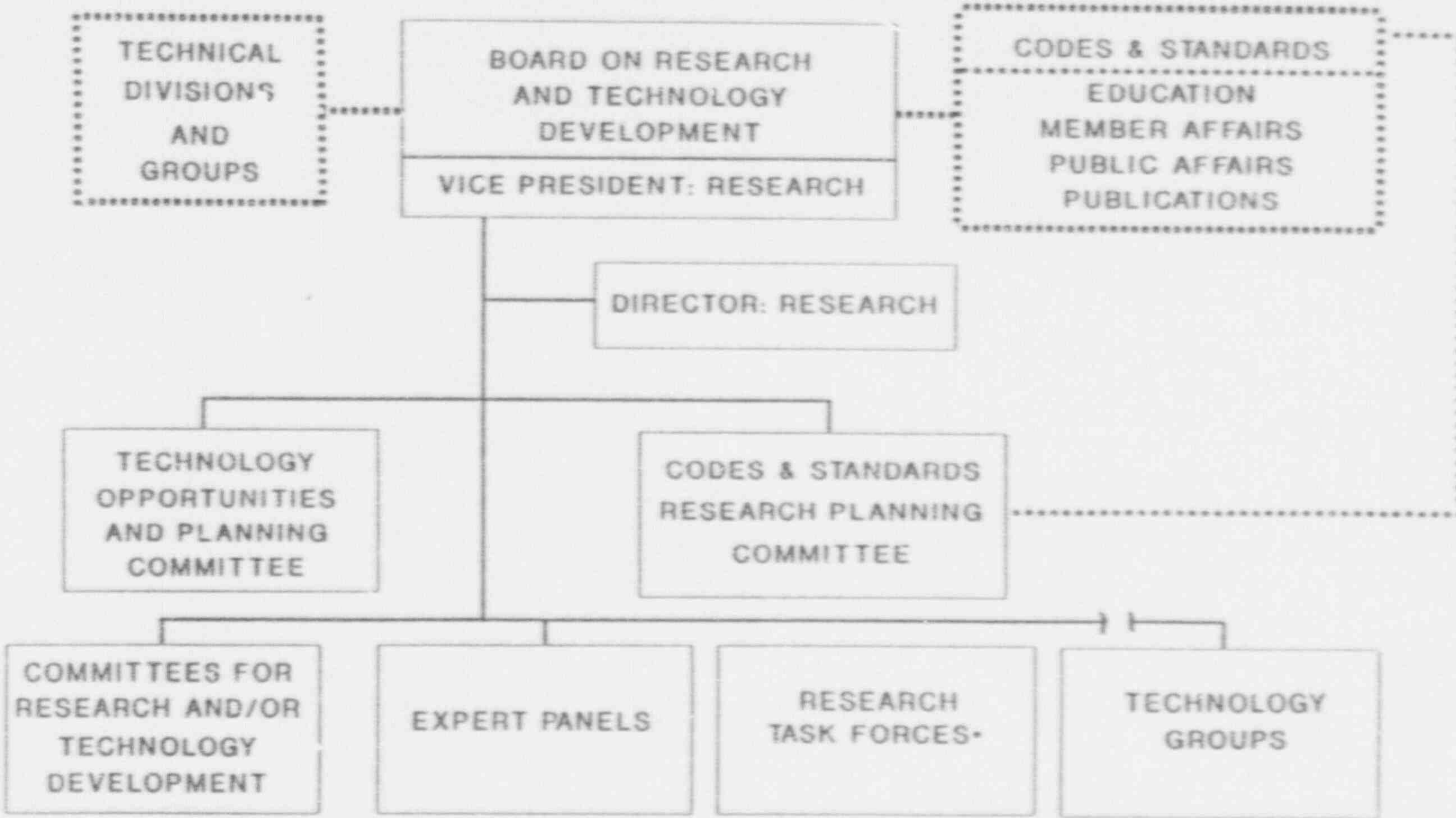

*Research task forces may be established by any permanent unit within the Center.

ASME RESEARCH PROJECT
RISK BASED INSPECTION GUIDELINES
NEED FOR PROJECT

- o COMPLEX STRUCTURES, SYSTEMS, AND COMPONENTS REQUIRE PERIODIC INSPECTION TO DETERMINE THEIR CONTINUING ABILITY TO FUNCTION AND TO ASSESS REMAINING LIFE.

- o CODES AND STANDARDS TO COVER PERIODIC INSPECTION PRACTICALLY NONEXISTENT EXCEPT FOR SECTION XI OF THE ASME CODE WHICH IMPLICITLY RECOGNIZED RISK THROUGH ENGINEERING JUDGMENT AND QUALITATIVE METHODS.

- o ASME CODES AND STANDARDS RESEARCH PLANNING COMMITTEE, THE BOARD ON RESEARCH AND TECHNOLOGY DEVELOPMENT, AND THE COUNCIL CODES AND STANDARDS ENDORSED A PROJECT TO DEVELOP A METHODOLOGY FOR INSPECTION WHICH EXPLICITLY AND QUANTITATIVELY CONSIDERS THE LIKELIHOOD OF COMPONENT FAILURE UNDER SPECIFIED CONDITIONS AND THE CONSEQUENCES OF SUCH FAILURE.

ASME RESEARCH PROJECT

RISK-BASED INSPECTION GUIDELINES

<u>INITIAL OBJECTIVES</u>

- o TO DETERMINE APPROPRIATE RISK-BASED METHODS FOR DEVELOPING INSPECTION GUIDELINES, AND
- o FOR CERTAIN APPLICATIONS, TO DEFINE RISK-BASED INSPECTION PROGRAMS FOR RECOMMENDATION TO ASME AND OTHER CODES AND STANDARDS BODIES

ASME RESEARCH PROJECT

RISK BASED INSPECTION GUIDELINES

PROJECT HISTORY

1985-86	RISK ANALYSIS TASK FORCE CODES AND STANDARDS RESEARCH PLANNING COMMITTEE RECOMMENDED A RESEARCH PROGRAM TO DETERMINE HOW PROBABILISTIC METHODS (PRA AND PSM) COULD BE USED TO ESTABLISH INSPECTION REQUIREMENTS OF INTEREST TO ENGINEERING COMMUNITY.
1986-87	CRTD FORMS RESEARCH TASK FORCE. MANAGES DEVELOPMENT OF RESEARCH PLAN.
LATE 1987	APPROVAL BY ASME BOARD ON RESEARCH AND COUNCIL CODES AND STANDARDS
1988	RESEARCH TASK FORCE MEMBERS DEVELOP DETAILED WORK PLAN
LATE 1988-89	FUNDING BY SPONSORS COMMENCES, WORK BEGINS
LATE 1990	VOLUME I GENERAL METHODOLOGY DOCUMENT COMPLETE
LATE 1991	VOLUME 2 PART 1 ON NUCLEAR POWER FACILITIES TO PRINTER

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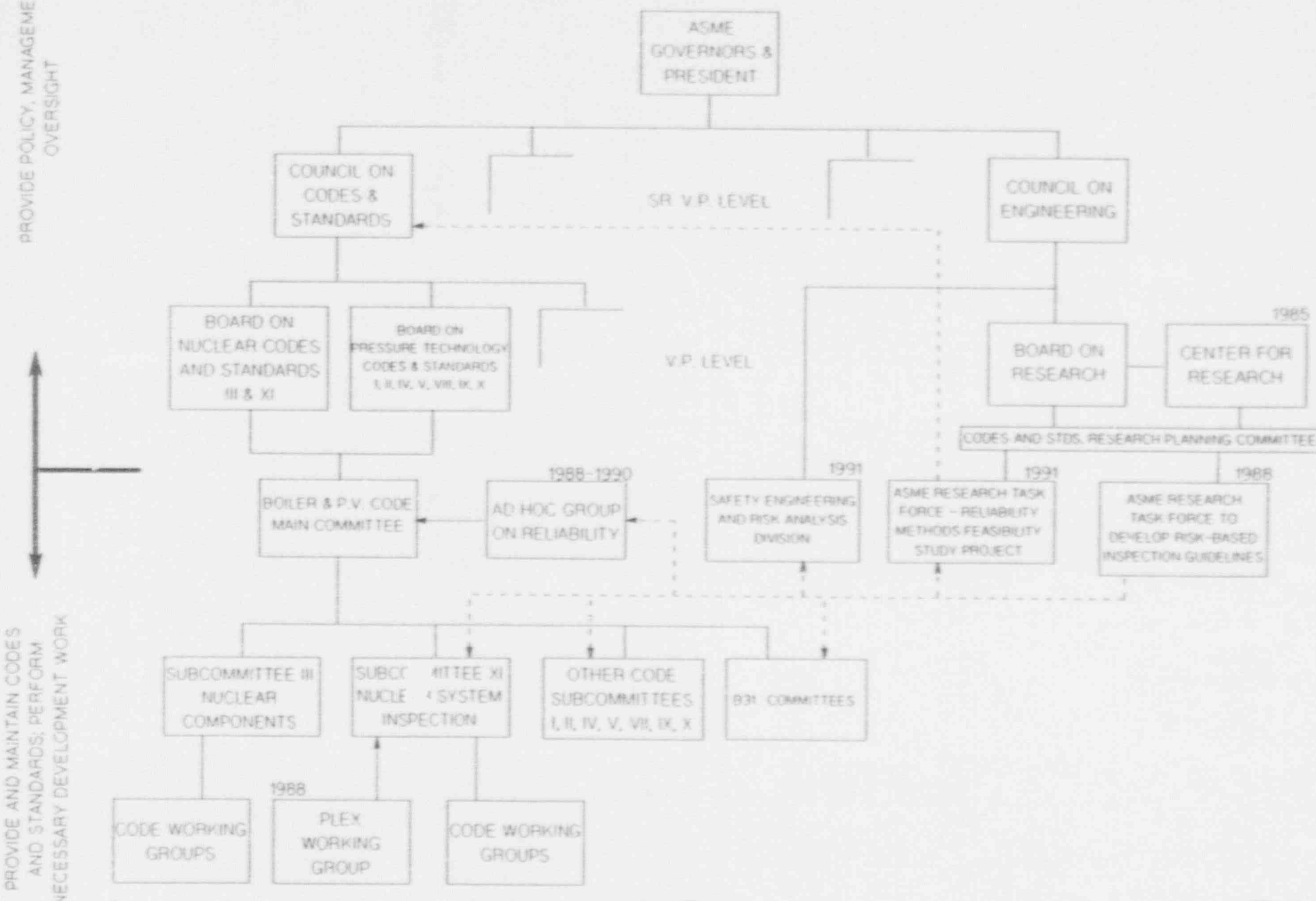
ASME MANAGEMENT STRUCTURE



ASME RESEARCH PROJECT
RISK BASED INSPECTION GUIDELINES
PROGRAM OBJECTIVES

PHASE 1

- TO PROVIDE A DOCUMENT THAT RECOMMENDS AND DESCRIBES APPROPRIATE METHODS FOR ESTABLISHING RISK-BASED INSPECTION GUIDELINES FOR FACILITIES OR STRUCTURAL SYSTEMS.

- TO PROVIDE A DOCUMENT THAT RECOMMENDS AND DESCRIBES SPECIFIC METHODS FOR DEVELOPING RISK-BASED INSPECTION PROGRAMS FOR NUCLEAR POWER FACILITIES THAT CAN BE INCORPORATED INTO SECTION XI OF THE ASME CODE.

- TO PRIORITIZE OTHER AREAS WITHIN (OR RELATED TO) ASME JURISDICTION WHERE STRUCTURAL FAILURES PRESENT SIGNIFICANT RISK FOR CONSIDERATION IN PHASE 2.

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PHASE 2

- TO PREPARE ADDITIONAL DOCUMENTS THAT RECOMMEND AND DESCRIBE SPECIFIC RISK-BASED METHODS FOR USE IN PREPARING NEW CODES AND STANDARDS FOR ESTABLISHING INSPECTION GUIDELINES FOR INDUSTRIAL FACILITIES OR OTHER STRUCTURAL SYSTEMS.

RISK BASED INSPECTION GUIDELINES
COMPLETION OF PHASE ONE

DOCUMENTS:

VOLUME 1 - GENERAL METHODOLOGY

VOLUME 2, PART 1 - LIGHT WATER REACTOR NUCLEAR POWER PLANT COMPONENTS

- o THE TASK FORCE DEVELOPED GENERAL METHODOLOGY DOCUMENT (VOL. 1) IS APPLICABLE TO ANY INDUSTRY. IT DESCRIBES GENERAL RISK-BASED METHODS THAT CAN BE USED TO DEVELOP APPROPRIATE INSPECTION PROGRAMS. VOLUME 1 IS AVAILABLE. DOCUMENT (VOL. 2, PART 1) FOR SPECIFIC APPLICATION TO NUCLEAR POWER PLANTS BEING PUBLISHED.

- o THE GENERAL METHODOLOGY USES APPROPRIATE EVALUATIONS FOR RANKING STRUCTURES, SYSTEMS AND COMPONENTS WITH RESPECT TO SAFETY AND ECONOMIC IMPACT, AND A STRUCTURED DECISION-TYPE PROCESS TO EVALUATE ALTERNATIVE INSPECTION PROGRAMS FOR METHOD, FREQUENCY, SAMPLING (HOW MUCH AND WHERE), AND CRITERIA FOR CORRECTIVE ACTION APPROPRIATE TO MAINTAIN AN ACCEPTABLE LEVEL OF RISK.

RISK BASED INSPECTION GUIDELINES
COMPLETION OF PHASE ONE (CONT.)

- VOLUME 2, PART 1 APPLIES THE GENERAL METHODOLOGY TO THE SPECIFIC APPLICATION OF LIGHT WATER NUCLEAR REACTOR POWER PLANT COMPONENTS TO CONSIDER COMPONENT RANKING, COMPONENT PROBABILITIES OF FAILURE, THE CONSEQUENCES ASSOCIATED WITH AN ASSUMED COMPONENT FAILURE, AND THE SELECTION OF A SUITABLE COMPONENT INSPECTION STRATEGY TO ACCEPTABLY MANAGE RISK, INCLUDING COST-BENEFIT CONSIDERATIONS.

RISK BASED INSPECTION GUIDELINES-COMMENCING PHASE TWO

- PHASE TWO WILL APPLY THE GENERAL METHODOLOGY TO OTHER APPLICATIONS, INCLUDING POWER AND PROCESS FACILITIES.
- SPONSORSHIP FOR PHASE TWO, CURRENTLY 10 ORGANIZATIONS INCLUDING FEDERAL GOVERNMENT BODIES, INSURERS, TRADE AND INDUSTRY ORGANIZATIONS. ADDITIONAL SPONSORS BEING SOUGHT.
- DOCUMENTS TO BE DEVELOPED:
  - VOLUME 3 - FOSSIL FUEL-FIRED ELECTRIC GENERATING STATION APPLICATIONS
  - VOLUME 4 - PETROLEUM REFINERY PROCESSING AND STORAGE APPLICATIONS
  - VOLUME 5 - NON-COMMERICAL NUCLEAR FACILITY APPLICATIONS
  - VOLUME 2 - PART 2 - RECOMMENDED INSPECTION PROGRAM FOR LWR NUCLEAR POWER PLANT COMPONENTS FOR ASME SECTION XI CONSIDERATION.
- FUTURE PHASES UNDER CONSIDERATION:

  CHEMICAL PROCESS FACILITIES, GAS PIPELINES, PETROLEUM INDUSTRY TANKERS AND OFFSHORE FACILITIES, AIRCRAFT, BRIDGES AND DAMS.

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RISK-BASED INSPECTION GUIDELINES PROJECT STATUS OF SPONSORSHIP

- DIRECT SPONSORS- U.S. NUCLEAR REGULATORY COMMISSION

  NATIONAL BOARD OF BOILER & PRESSURE VESSEL INSPECTORS

  NATIONAL RURAL ELECTRIC COOPERATIVE ASSOCIATION

  INDUSTRIAL RISK INSURERS

  AMERICAN NUCLEAR INSURERS

  HARTFORD STEAM BOILER INSPECTION & INSURANCE CO.

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  U.S. DEPARTMENT OF ENERGY

  OIL INSURANCE LTD.

  EDISON ELECTRIC INSTITUTE

o INDIRECT SPONSORS - WESTINGHOUSE ELECTRIC CORPORATION

FAILURE ANALYSIS ASSOCIATES

BATTELLE PACIFIC NORTHWEST LABORATORIES

UNIVERSITY OF MARYLAND

MCDONNELL AIRCRAFT COMPANY

FACTORY MUTUAL RESEARCH CORPORATION

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GAS RESEARCH INSTITUTE

GENERAL DYNAMICS, ELECTRIC BOAT DIVISION

JAPAN POWER ENGR. & INSPECTION CORP.

U.S. DEPARTMENT OF INTERIOR

U.S. DEPARTMENT OF TRANSPORTATION

INITIATION OF A NEW ASME RELIABILITY METHODS FEASIBILITY STUDY PROJECT

- THIS IS AN INTERNAL ASME FEASIBILITY STUDY UNDERTAKEN TO EXAMINE THE USEFULNESS OF DECISION-ANALYTIC RELIABILITY METHODS IN ASME CODES AND STANDARDS WORK AND IN THE SOCIETY ACTIVITIES. MANAGED BY CODES AND STANDARDS RESEARCH PLANNING COMMITTEE.

- THREE MEETINGS HAVE BEEN HELD SINCE JULY 1991 AND A FINAL REPORT IS SCHEDULED FOR COMPETION BY DECEMBER 31, 1992.

- DECISION ANAYSIS PROVIDES A STRUCTURED APPROACH FOR INTRODUCING RELIABILITY METHODS, INCLUDING COST-BENEFIT INTO AN ACTIVITY. DECISION ANALYSIS METHODS PERMIT COMPARING SPECIFIC OBJECTIVES WHICH MAY CONFLICT, SUCH AS SAFETY VERSUS COST.

- FOR THE CODES AND STANDARDS ACTIVITY, IF FOUND FEASIBLE, THIS METHODOLOGY MIGHT BE USED TO DETERMINE WHETHER TO INITIATE A NEW STANDARD, OR WHETHER A SPECIFIC REVISION SHOULD BE MADE.

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Overview of NRC Research Efforts

Briefing: ASME Risk-Based Inspection Guidelines Research Project
U.S. Nuclear Regulatory Commission
Advisory Committee on Reactor Safeguards
Subcommittee on Metal Components

Dr. Joseph Muscara

Bethesda, Maryland
February 13, 1992

NRC RESEARCH EFFORTS

PROGRAM TITLE: Evaluation and Improvements in Nondestructive Examination (NDE) Reliability for Inservice Inspection of Light Water Reactors

Program Initiated in Fiscal Year 1977

Program Objectives:

- Determine the effectiveness and reliability of ultrasonic inservice inspections (ISI) performed on commercial, light water reactor pressure vessels and piping
- Recommend Code changes to the inspection procedures to improve the reliability of ISI
- Based on the importance of components to safety, material properties, service conditions and NDE uncertainties, formulate improved inservice inspection criteria (including sampling plan, location, frequency and reliability of inspection) to achieve suitably low failure probabilities for the inspected components

BACKGROUND INFORMATION

EVALUATION OF NDE RELIABILITY

- Conducted extensive parametric studies on important inspection variables - 6000 measurements
  - Developed recommendations for improvements in procedures
    - RIL #113 in 1981
    - ASME Code Case N-335 in 1982
- Conducted two round robin tests to quantify POD as a function of crack size, false call rate, and sizing accuracy
  - Piping Inspection Round Robin in 1982
    - 6 ISI teams that conducted 1500 inspections
  - Mini Round Robin in 1985
    - 12 individuals and 3 automated inspection teams

BACKGROUND INFORMATION

IMPROVEMENTS IN NDE RELIABILITY

- Results of these studies showed that the ASME Code prescriptive UT procedures were unreliable
- Performance demonstration would provide the solution to achieving improvement in NDE reliability
- PNL and NRC staff began working in 1981 on developing the basis for NDE system qualification criteria. Several documents were developed including the drafting of a Regulatory Guide.
- Two industry meetings were held in 1983-84 to discuss concepts, discuss the documents developed, and obtain input on NDE qualification criteria
- Consensus from the 1984 meeting was that ASME Code should develop requirements using the PNL document as the basis
- ASME set up 3 special task groups with participation from industry, PNL, and the NRC to develop the requirements and resulted in Section XI Appendices VII and VIII (pub. in 1988 and 1989 Addenda, respectively).

IMPROVEMENTS IN INSPECTION PROGRAM

- Having addressed the reliability problem, now addressing improved criteria for the scope of the inspection program of what to inspect, the extent, frequency and how reliably to inspect
- The objective of such an inspection program is to maintain/achieve a suitably low component failure probability for systems and components
- In 1986-87 the PNL work began to explore a risk based methodology as the best means to develop improved inspection programs
    - Selection based on existence of information (good PRAs) and direct means for including safety (economic) goals as basis of the inspection program
- Methodology provides a structured means for generically ranking reactor systems, selecting components to be inspected, the frequency required and the inspection reliability required.

IMPROVEMENTS IN INSPECTION PROGRAM (contd)

- NRC reviewed a proposal in 1988 from the ASME Center for Research and Technology Development on risk-based inspection guidelines that closely matched the goals of PNL's risk-based task.
- Membership of the ASME task force represented a recognized broad based expertise for continuing peer review of the PNL risk-based work.
- Cooperation with the ASME Center for Research and Technology Development would facilitate the transfer of the methodology and results to ASME code groups for updating requirements for ISI programs.
- NRC decided to support the ASME Task Force through a research grant, and to promote close cooperation between the two efforts.
- The methodology has been jointly developed and research results and evaluations from PNL work are being used by the task force.

CONCLUDING REMARKS

- The NRC is supporting the research work at PNL and by the ASME Research Task Force on Risk-Based Inspection Guidelines. PNL's work has been used directly by the ASME Research Task Force.
- A methodology for developing risk-based inspection programs has been jointly developed by PNL and the ASME Task Force
- PNL has performed pilot studies to demonstrate the feasibility of various aspects of this methodology
- The methodology has been published in ASME and NUREG/CR reports
- In the future, the above methodology will be used to develop recommendations for risk-based ISI programs to improve code requirements. These recommendations will ensure that risks due to structural failures are maintained at acceptable levels.

Overview of Task Force and Overall Risk-Based Inspection Process

ASME Risk-Based Inspection Guidelines Research Project

U. S. Nuclear Regulatory Commission

Advisory Committee on Reactor Safeguards

Subcommittee on Metal Components

Ken Balkey

Bethesda, Maryland
February 13, 1992

Research Task Force on Risk-Based Inspection Guidelines

Kenneth R. Balkey - Westinghouse Electric Corporation, Chairman

Dr. Lee Abramson - U. S. Nuclear Regulatory Commission

Dr. Bilal Ayyub - University of Maryland at College Park

O. J. Vic Chapman - Rolls Royce & Associates Ltd., United Kingdom

Dr. Bryan F. Gore - Battelle Pacific Northwest Laboratories

Dr. David O. Harris - Failure Analysis Associates, Inc.

Dr. Dimitrios Karydas - Factory Mutual Research Corporation

Jerry H. Phillips - Idaho National Engineering Laboratory

Dr. Fredric A. Simonen - Battelle Pacific Northwest Laboratories

Dr. Herb Smith, Jr. - McDonnell Aircraft Company

Lloyd G. Smith - Niagara Mohawk Power Corporation

Charles A. Tomes - Wisconsin Public Service Corporation

Truong V. Vo - Battelle Pacific Northwest Laboratories (Honorary Member)

Bruce A. Bishop - Westinghouse Electric Corporation (Contributing Member)

Guido G. Karcher - Exxon Research and Engineering Co. (Contributing Member)

Dr. Robert K. Perdue - Westinghouse Electric Corp. (Contributing Member)

A. T. Radhakrishnan - ESSO Singapore Private Ltd. (Contributing Member)

P. A. Stavrianidis - Factory Mutual Research Corp. (Contributing Member)

Research Steering Committee on Risk-Based Inspection Guidelines

Raymond J. Art - ASME Center For Research & Technology Development

John D. Boardman - Southern California Edison

Robert J. Bosnak - ASME Council on Codes & Standards, ASME Codes & Stds Research Planning Committee, ASME Board on Research & Technology Dev.

Dr. Spencer J. Bush - Consultant, past Chairman - ASME Section XI

Robert N. Hill - Hoosier Energy Rural Electric Cooperative

David A. Osage - BP Oil (American Petroleum Institute representative)

Ray Davies - Det Norse Veritas Industrial Services, Inc.

Theodore A. Meyer - Westinghouse Electric Corporation

Evangelos Michalopoulos - Hartford Steam Boiler Inspection & Insurance Co.

Dr. Joseph Muscara - U.S. Nuclear Regulatory Commission

Michael E. G. Schmidt - Industrial Risk Insurers

Earnest W. Throckmorton - Virginia Power

William G. Wendland - American Nuclear Insurers

Independent Peer Review Committee

Volume 1 - General Document

Steven W. Pullins - Pullins Engineering Company

Dr. C. (Raj) Sundararajan - EDA Consultants

Paul J. Torpey - Empire State Energy Research Corporation

Volume 2 - Part 1 Nuclear Power Plant Document

Dr. Vicki Bier - University of Wisconsin

John D. Boardman - Southern California Edison

T. N. (Bud) Epps - Southern Nuclear Operating Company

ASME RISK-BASED INSPECTION GUIDELINES
INDIVIDUAL RESPONSIBILITIES FOR PHASE II (1991-1992)

PROJECT/TECHNICAL INTEGRATION - K. BALKEY

PROJECT	TASK FORCE	STEERING COMMITTEE
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	D. KARYDAS (R)	M. SCHMIDT (R)
	L. SMITH (R)	R. HILL
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	B. AYYUB (R)	E. MICHALOPOLOUS (R)
	D. HARRIS (R)	M. SCHMIDT (R)
	D. KARYDAS (R)	R. DAVIES (R) **
	G. KARCHER/ A. RADHAKRISHNAN (R) (CONTRIBUTORS)	S. BUSH
	OTHER API TASK FORCE MEMBERS	
NUCLEAR APPLICATIONS	F. SIMONEN * (VOL 2-PT 2)(R)	J. MUSCARA (R)
	J. PHILLIPS* (VOL 5)(R)	W. WENDLAND (R)
	B. GORE (R)	E. THROCKMORTON (R)
	V. CHAPMAN (R)	J. BOARDMAN
	K. BALKEY (R)	S. BUSH **
	L. ABRAMSON (R)	
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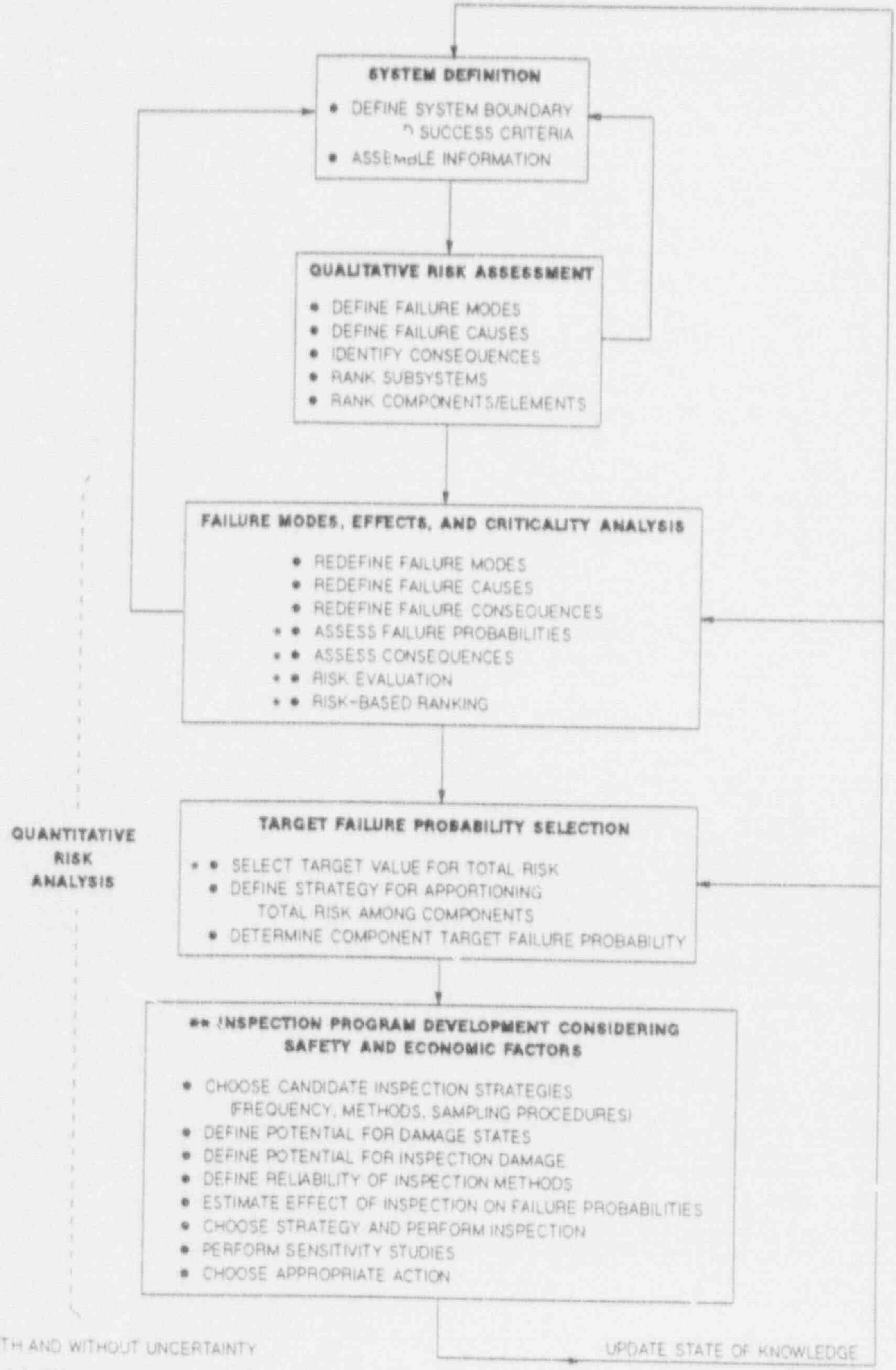
	R. PERDUE (CONTRIBUTOR) (R)	

* LEAD

** LIAISON WITH PVRC

(R) CURRENTLY CONDUCTING RELATED RESEARCH ON RISK-BASED INSPECTION

FIGURE 2-1 RISK - BASED INSPECTION PROCESS LWR NUCLEAR POWER PLANT COMPONENTS



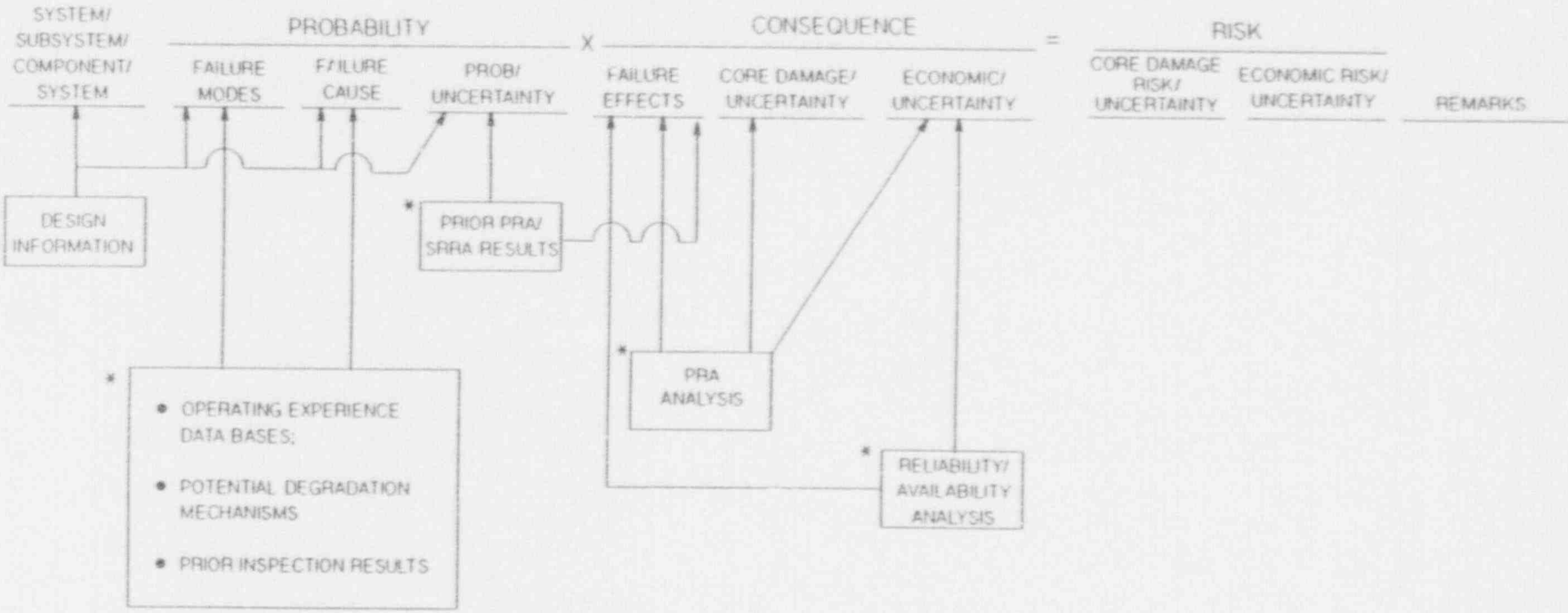
* WITH AND WITHOUT UNCERTAINTY

** USING DECISION-RISK ANALYSIS AND STRUCTURAL RELIABILITY/RISK ASSESSMENT METHODS

ASME SECTION XI ISI REQUIREMENTS IMPLICITLY INVOLVE RISK-RELATED CONCEPTS -

- o CLASS 1, 2, AND 3 CATEGORIES
- o EXEMPTION FROM EXAMINATION OF SMALL LINES
- o DECISION PROCESS WHEN FLAW INDICATIONS ARE FOUND
- o EXEMPTION FOR CLASS 3 COMPONENTS WITH PRESSURE < 275 PSIG AND TEMPERATURES < 200 F

FIGURE 2-4 INTEGRATION OF TECHNICAL INFORMATION INTO FMECA FOR RISK-BASED INSPECTION OF NUCLEAR POWER PLANT COMPONENTS



* EXPERT OPINION CAN ALSO BE USED HERE

Risk-Based Priorities for Inservice Inspection of Nuclear Power Plant Components

Briefing: ASME Risk-Based Inspection Guidelines Research Project
U.S. Nuclear Regulatory Commission
Advisory Committee on Reactor Safeguards
Subcommittee on Metal Components

T.V. Vo

Bethesda, Maryland
February 13, 1992

Highlights

- Overall Methodology
  - System Prioritization
  - Component Prioritization
- Pilot Applications
  - Oconee-3 Pilot Study
  - Representative LWR Study
  - Surry-1 Study
- Concluding Remarks

Overall Methodology

- Two-step approach:
    1. System Prioritization
    2. Component Prioritization
- PRA information in combination with FMEA techniques are used to identify and prioritize the most risk-important systems and components

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System Prioritization

- Core damage frequency is used as the risk measure
- Two criteria method for setting prioritization

  1. Birnbaum Importance - conditional probability for core damage given system failure

  2. Inspection Importance - defined by PNL to rank systems for inspection

Inspection Importance

- Inspection importance, I^{w} is defined as the risk measurement of the accident sequences involving system failures due to pipe break
- Calculation of inspection importance

$$I_i^{w} = I_i^{B} * P_i$$

where I_i^{B} = Birnbaum importance of system i; it is the change in core damage risk that is associated with a failure system i

P_i = estimated rupture probability of system i

Component Prioritization

- Core damage frequency is used as the risk measure
- Failure Modes and Effects Analysis (FMEA) technique is used to identify and prioritize the most risk-impcrtant components within the identified systems
- FMEA results are used to calculate the Importance Index or Relative Importance for each component within the systems
- FMEA results represent core damage frequency due to component failures

Component Prioritization (cont'd)

In mathematical terms, the core damage frequency due to component failure is

$$P_{cd} = P_f * \sum_i P_{cd|s_i} * P_{s_i|p_f} * R_i$$

where P_{cd} = frequency of core damage resulting from the component failure

P_f = failure (rupture) probability of the component of interest

$P_{cd|s_i}$ = conditional probability of core damage given the failure of system i

$P_{s_i|p_f}$ = conditional probability of system i failing given the component failure

R_i = probability that the operator fails to recover given a system failure

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Component Prioritization (cont'd)

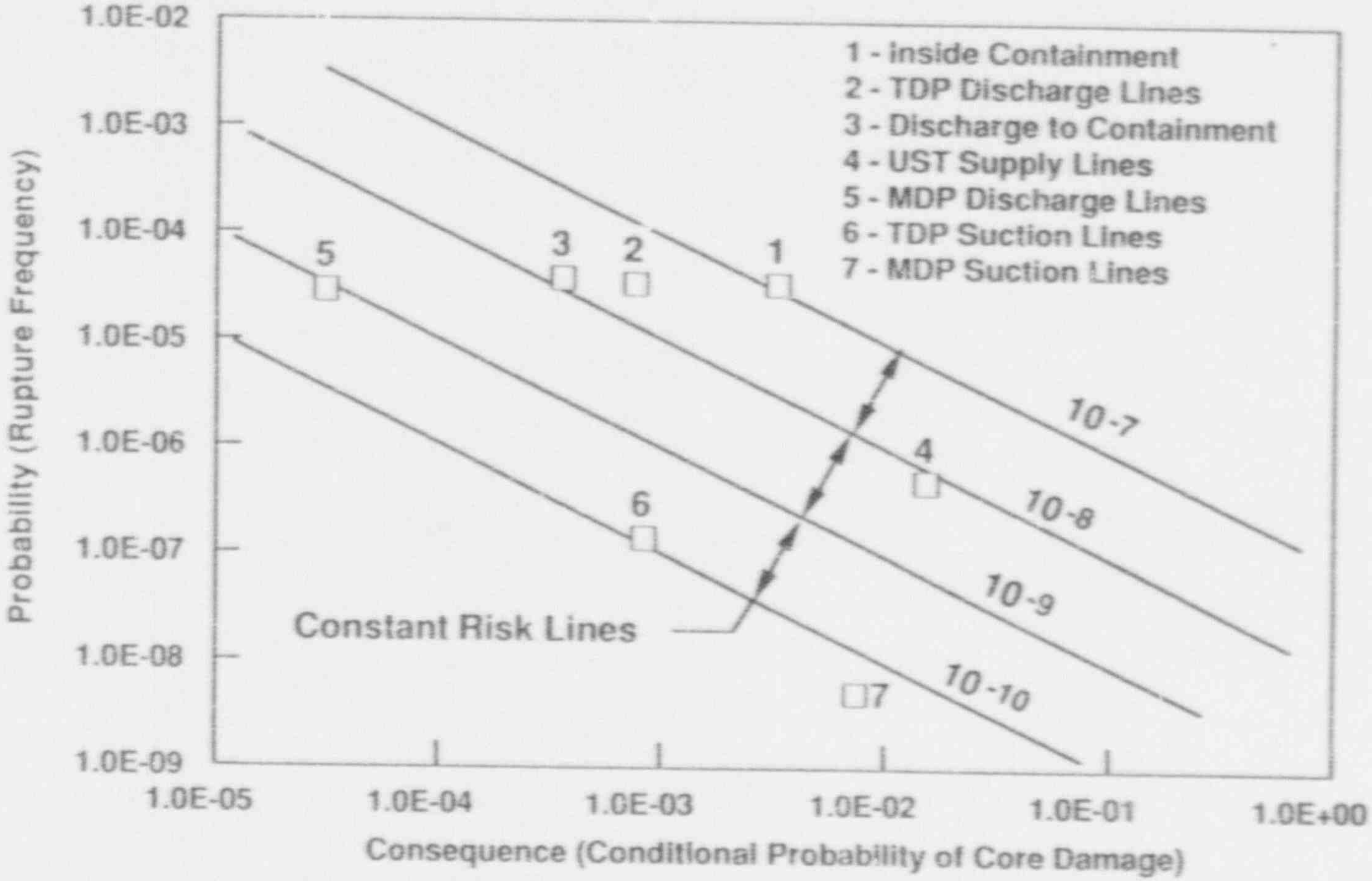
- Need probability of failure for each component
- Because of lack of an adequate data base on failure probabilities for components, Expert Judgment Elicitation Workshops were conducted

Pilot Applications

The overall methodology has been tested

- Oconee-3: System prioritization; limited component prioritization
- Representative LWRs: System prioritization
- Surry-1: System prioritization; detailed component prioritization

Oconee-3 Results



Representative LWR Study - Objective

- Established generic system rankings among the U.S. nuclear power plants

Plant Selection Criteria

The criteria used for selecting include the:

- Reactor vendor
- Plant type
- Architect - engineer
- Availability of PRA

Plants Selected for Study

Plant Name	Vendor/Type/A-E/Containment
Surry-1	W/HP/S&W/Subatmospheric
Zion-1	W/HP/S&L/Large, Dry
Sequoyah-1	W/HP/Utility/Ice Condenser
Oconee-3*	B&W/-/Bech-Utility/Large, Dry
Crystal River-3	B&W/-/Gilbert/Large, Dry
Calvert Cliffs-1	CE/-/Bechtel/Large, Dry
Peach Bottom-2	GE/BWR4/Bechtel/Mark I
Grand Gulf-1	GE/BWR6/Bechtel/Mark III

*Completed (NUREG/CR-5272)

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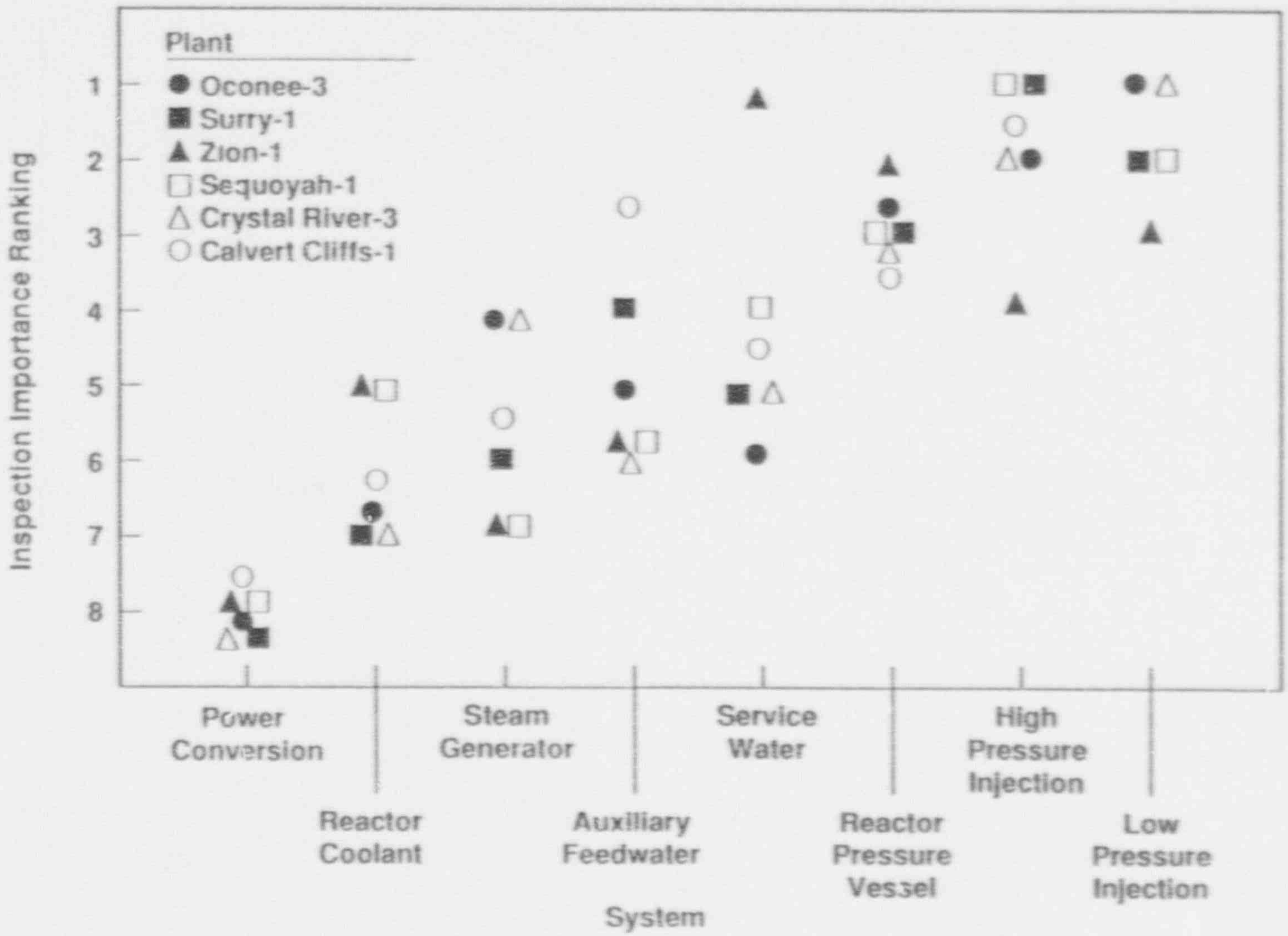
Inspection Importance Ranking for Various PWR Systems Based on Core Damage Frequency



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Surry-1 Study

- The Surry Power Station, Unit 1 (Surry-1) was selected for detailed study due to the high quality of the PRA information available, and because it has been selected for several ongoing NRC research programs

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System Importance Analysis

- Results of recent system prioritization (Representative LWR Study) for the Surry-1 were used to selected systems for further analysis:

  1. Reactor pressure vessel

  2. Reactor coolant system

  3. Low pressure injection system, including the accumulators

  4. Auxiliary feedwater system

Component Importance Analysis

- Core damage frequency was used as the risk measure
- FMEA methodology was used to identifv and prioritize the most risk-important components within the selected systems for inspection
- Need probability of failure for each component
- Because of lack of an adequate data base on failure probabilities for components, the Expert Judgement Elicitation process used for NUREG-1150 was employed

Component Importance Analysis (cont'd)

- Plant system drawings, plant-specific video information management system (VIMS), and system walkdowns were performed to identify the potential targets (vital electrical buses, etc.)
- Guidance in the Standard Review Plan (SRP) 3.6.2 will be used in determining the indirect effects, e.g., jet impingement effects on systems nearby

Component Importance Analysis - PRA Data to Rupture Considerations

- Pipe ruptures are generally excluded from PRAs, since they make small contributions to risk compared to failures of active components

- Consequences for ruptures of pipe segments have been estimated from PRAs by considering failures of adjacent active components (e.g., lack of flow due to pump or valve malfunctions)

- PRAs generally provide no information on probabilities of pipe rupture (except for LOCA events)

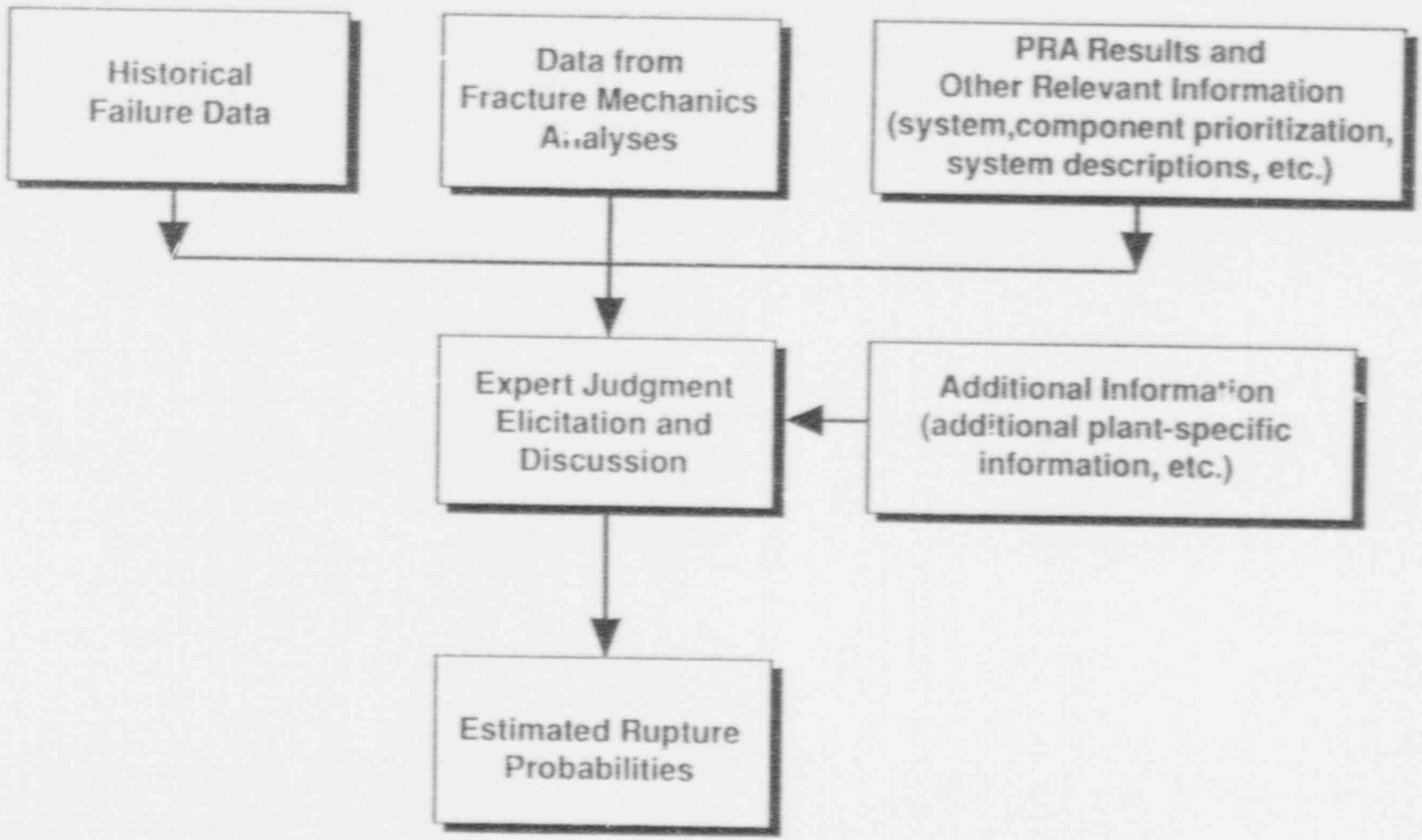
- Therefore, rupture probabilities have been derived from available literature and expert judgement elicitation, and then combined with consequences from PRAs to calculate risk contributions

Expert Judgment Elicitation Process

- Except for some minor modifications, the process is generally adapted from the recent method developed for use in the NUREG-1150 PRAs

  1. Selection of Parameters
  2. Selection of Experts
  3. Familiarization of Issues
  4. Training of Experts
  5. Elicitation of Experts
  6. Recomposition and Aggregation of Results
  7. Review and Revision by the Panel of Experts
  8. Documentation

Process for Estimating Failure Probability Using Expert Judgement



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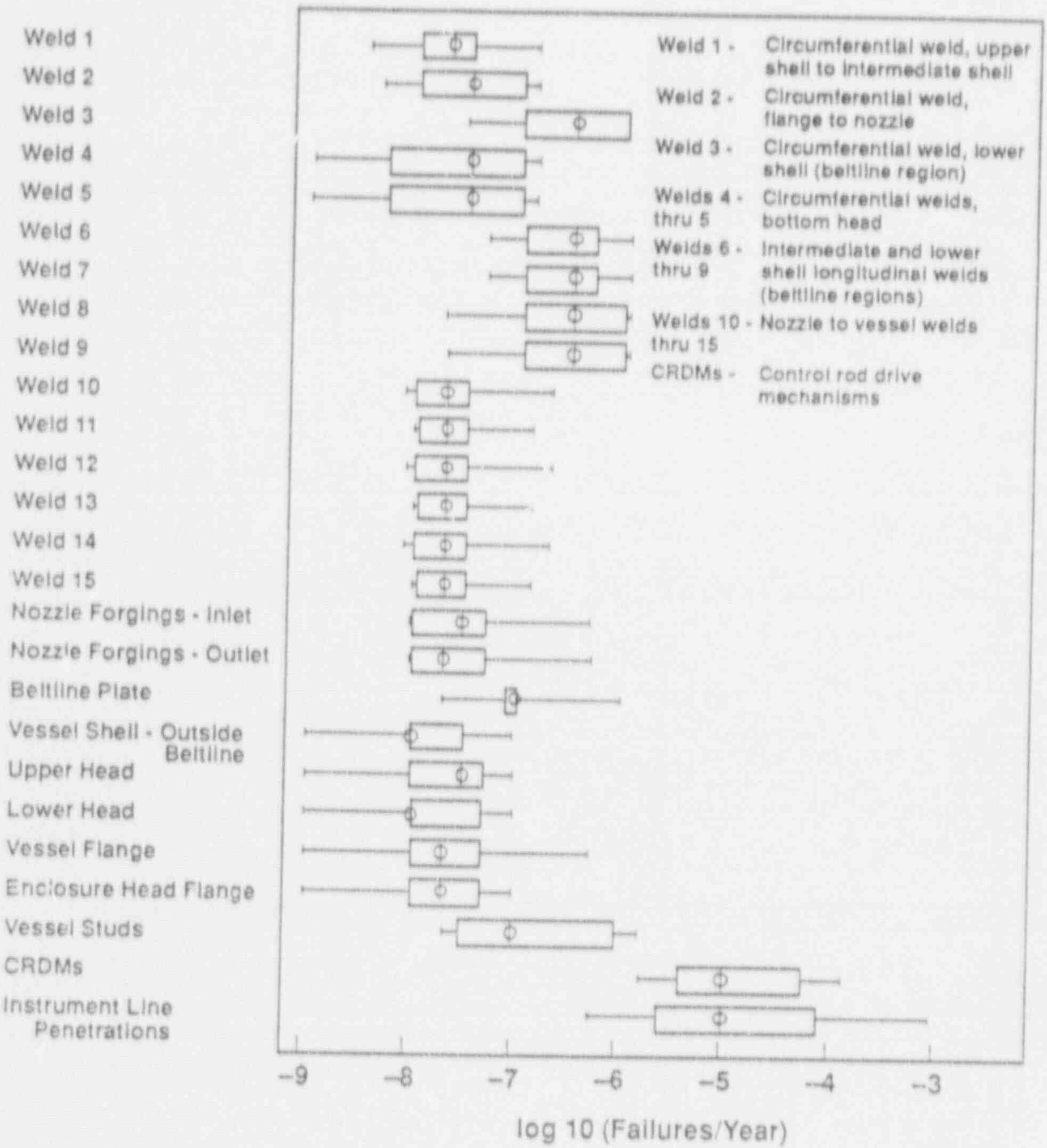
Estimates of Failure Probabilities for Surry-1 Reactor Pressure Vessel Components



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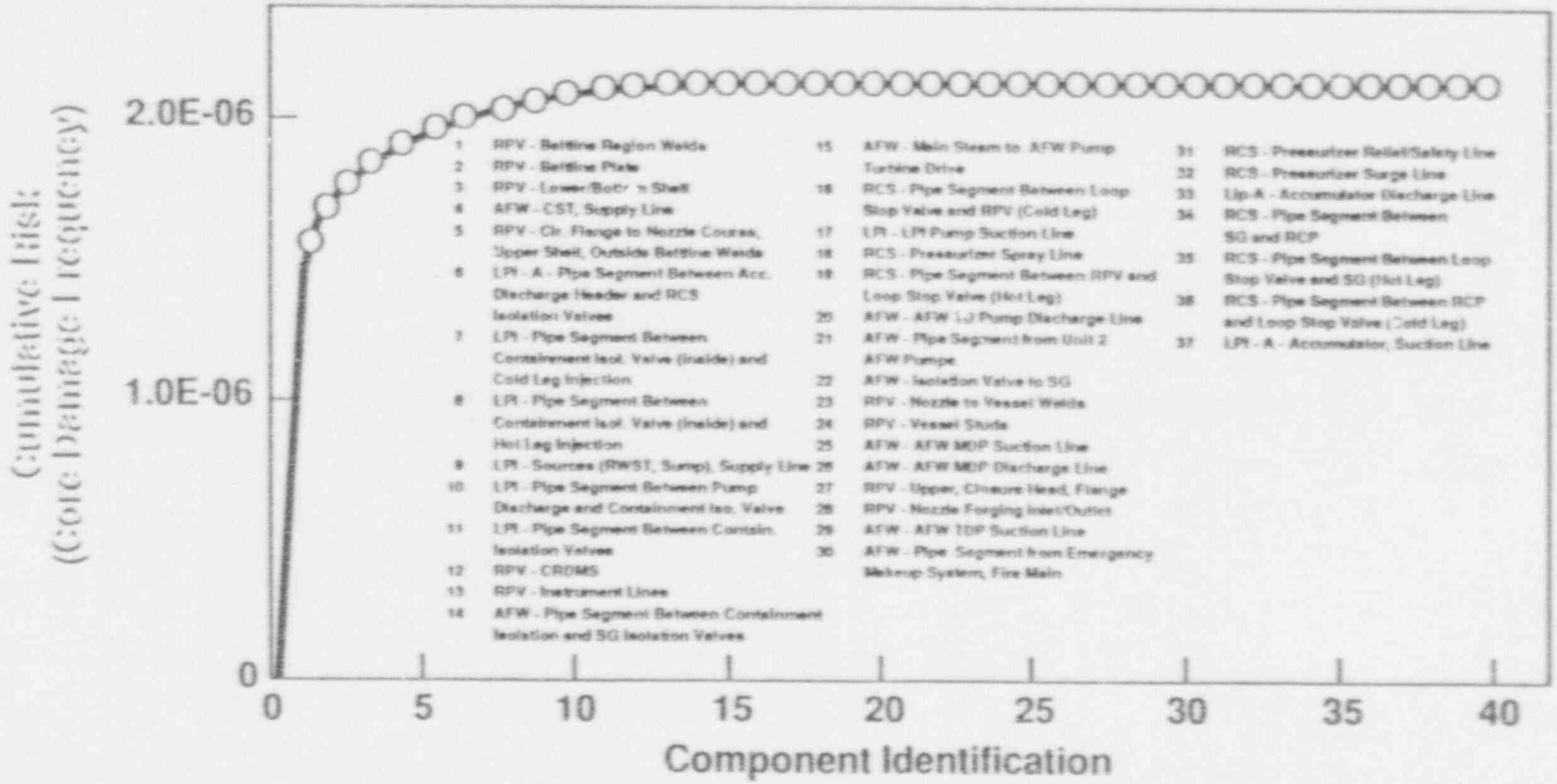
Summary of Results for Surry-1 Study

For the 4 selected systems

- Contributions of component failures to core damage frequency range from 1.60E-06 to 1.60E-14 per plant year (based on the median values excluding potential floodings within the plant)
- Cumulative risk contribution is estimated to be about 2.10E-06 per plant year
- The total estimated risk is dominated by failures of
  - Reactor pressure vessel components (86%)
  - Low-pressure injection system components (10%)
  - Auxiliary feedwater and reactor coolant system components (4%)

Cumulative Risk Contributions of Surry 1 Components (Showing Decreasing Contributions of Lower Ranked Components)



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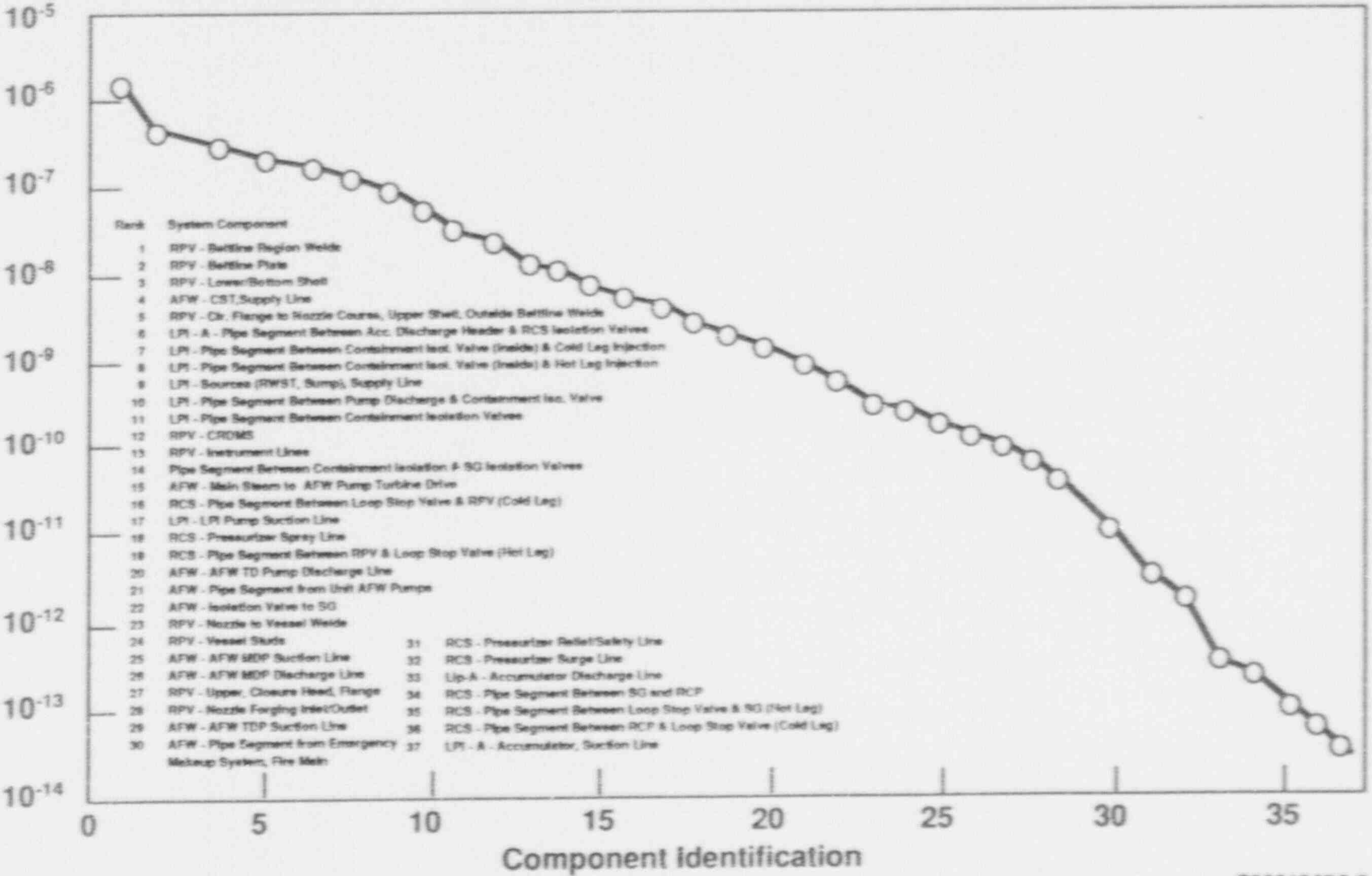
Comparison of Residual Risk with Component Rankings

Residual Risk (Core Damage Frequency) If Inspections Eliminate
All Risk from Components Ranked Higher than Component



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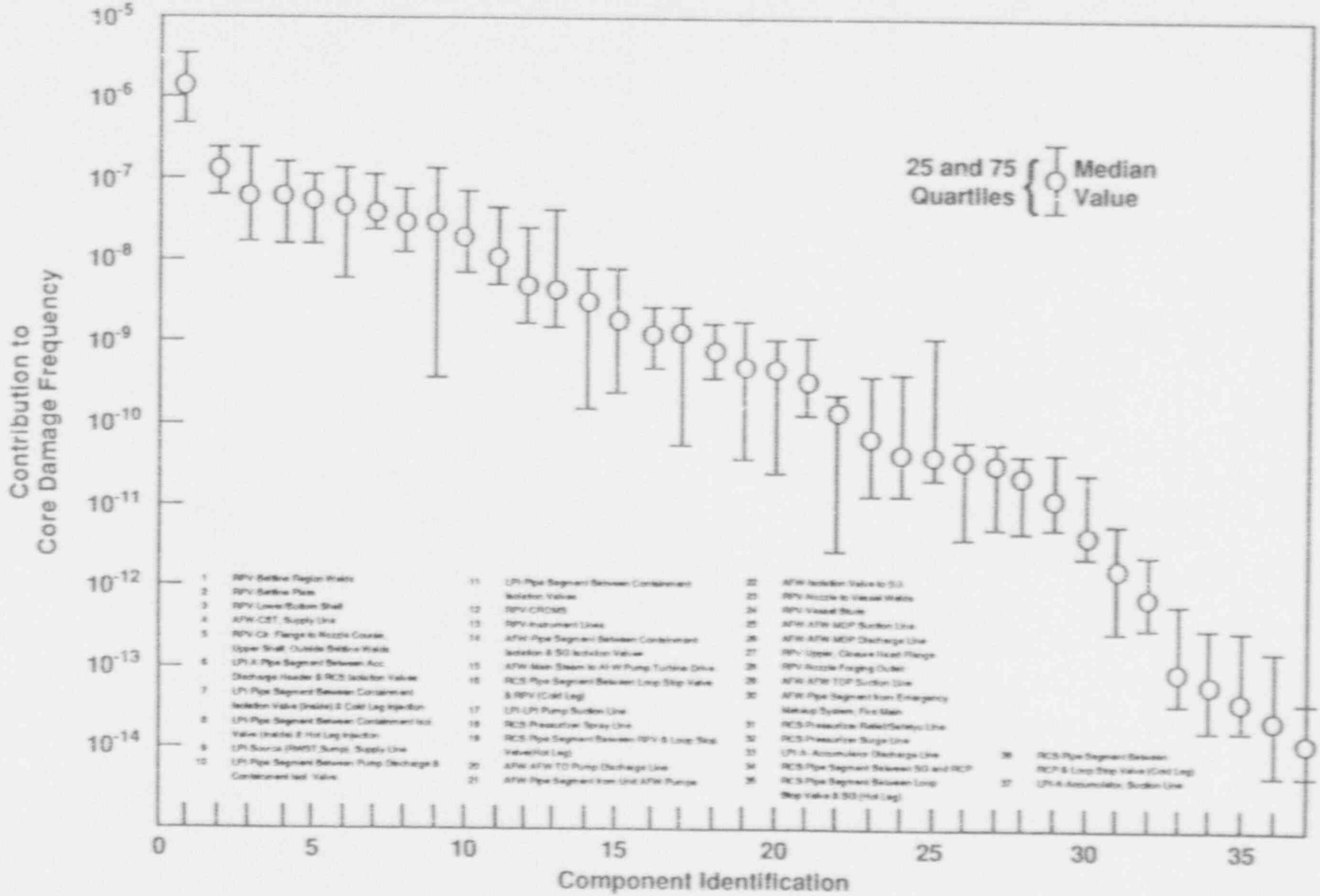
Sensitivity and Uncertainty Analyses

Two basic types of uncertainty were addressed:

- Parameter Value Uncertainty: component rupture probability, conditional probability ofcore damage, human recovery action and core damage frequency for component failure

- Modeling Uncertainty: treatment of the indirect effects (excluding potential floodings within the plant) of component failures in the model

Risk-Based Rankings of Surry 1 Components with Uncertainties in Estimated Rupture Probabilities



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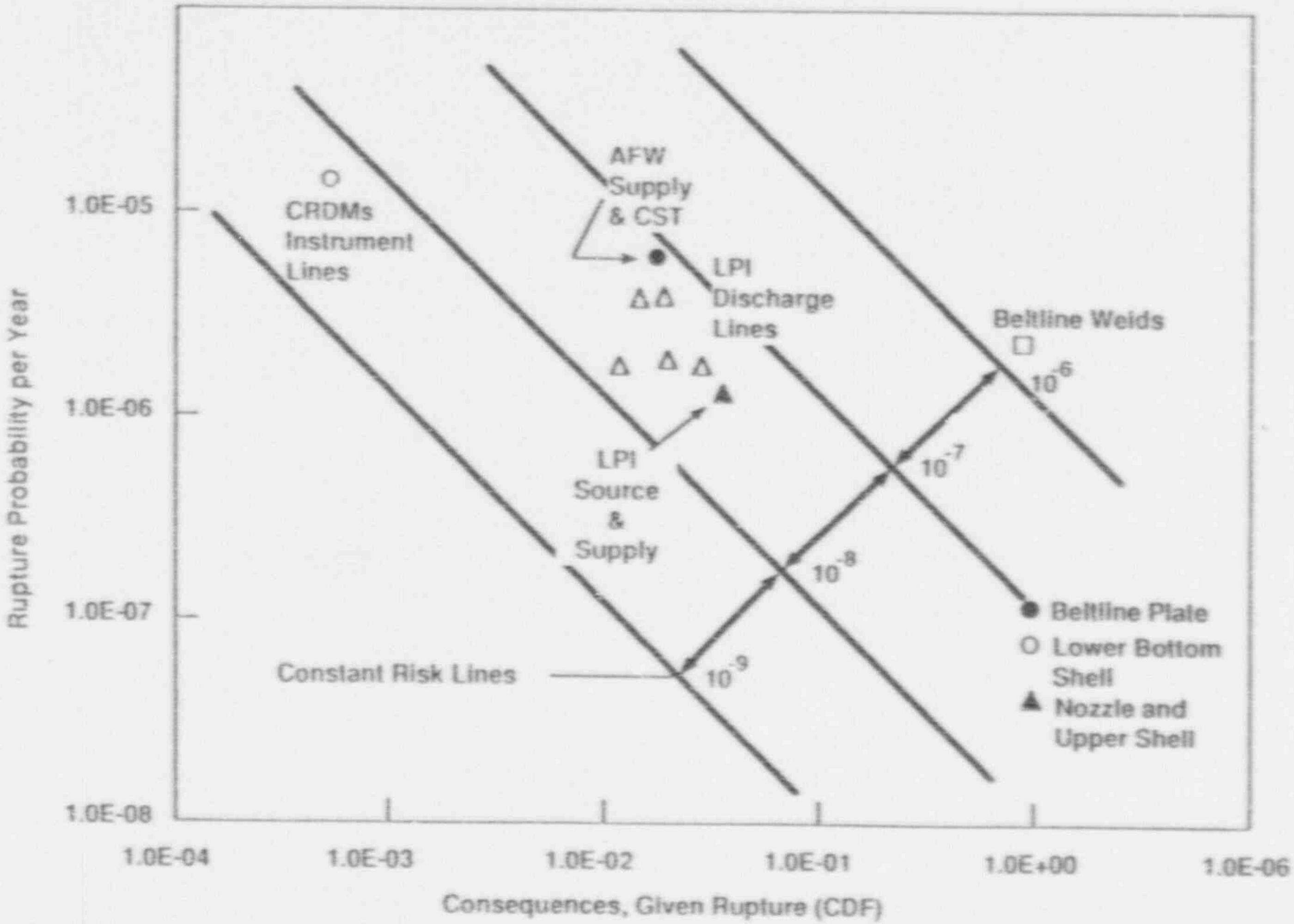
Surry-1 Risk Results



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Concluding Remarks

- A methodology for developing risk-based inspection plans has been proposed
- Pilot studies have been performed to demonstrate the feasibility of the methodology
- The methodology has become part of the recommendations of the ASME Research Task Force on Risk-Based Inspection Guidelines
- Detailed ISI requirements will be developed in the future. These requirements will ensure that risks due to structural failures are maintained at acceptable levels

TARGET FAILURE PROBABILITIES

Briefing: ASME Risk-Based Inspection Guidelines Research Project
U.S. Nuclear Regulatory Commission
Advisory Committee on Reactor Safeguards
Subcommittee on Metal Component

B.F. Gore

Bethesda, Maryland
February 13, 1992

Objective of Inspection Program

To maintain plant risk due to ruptures at an acceptably low value

- Namely, a small fraction of the risk due to failures of active components and human operating errors

Risk Measure Selected

Core damage frequency due to internal events, as determined by PRA analysis

- Same measure as used for component risk prioritization
- Allows the most direct comparison with risks due to active failures

Target Risk Concept

ISI program should be designed to hold the total risk of core damage due to component ruptures below a value which is a small fraction of the risk determined by PRA analysis of internal events.

- 5% is an initial recommended target risk value, but this may not be achievable

Objective of Component Inspections

To maintain component rupture frequency below a target value

- Determined from a component target risk and the conditional risk given rupture of the component

Component Target Risk

Determined by apportioning total target risk among the components

<u>Recommended</u>

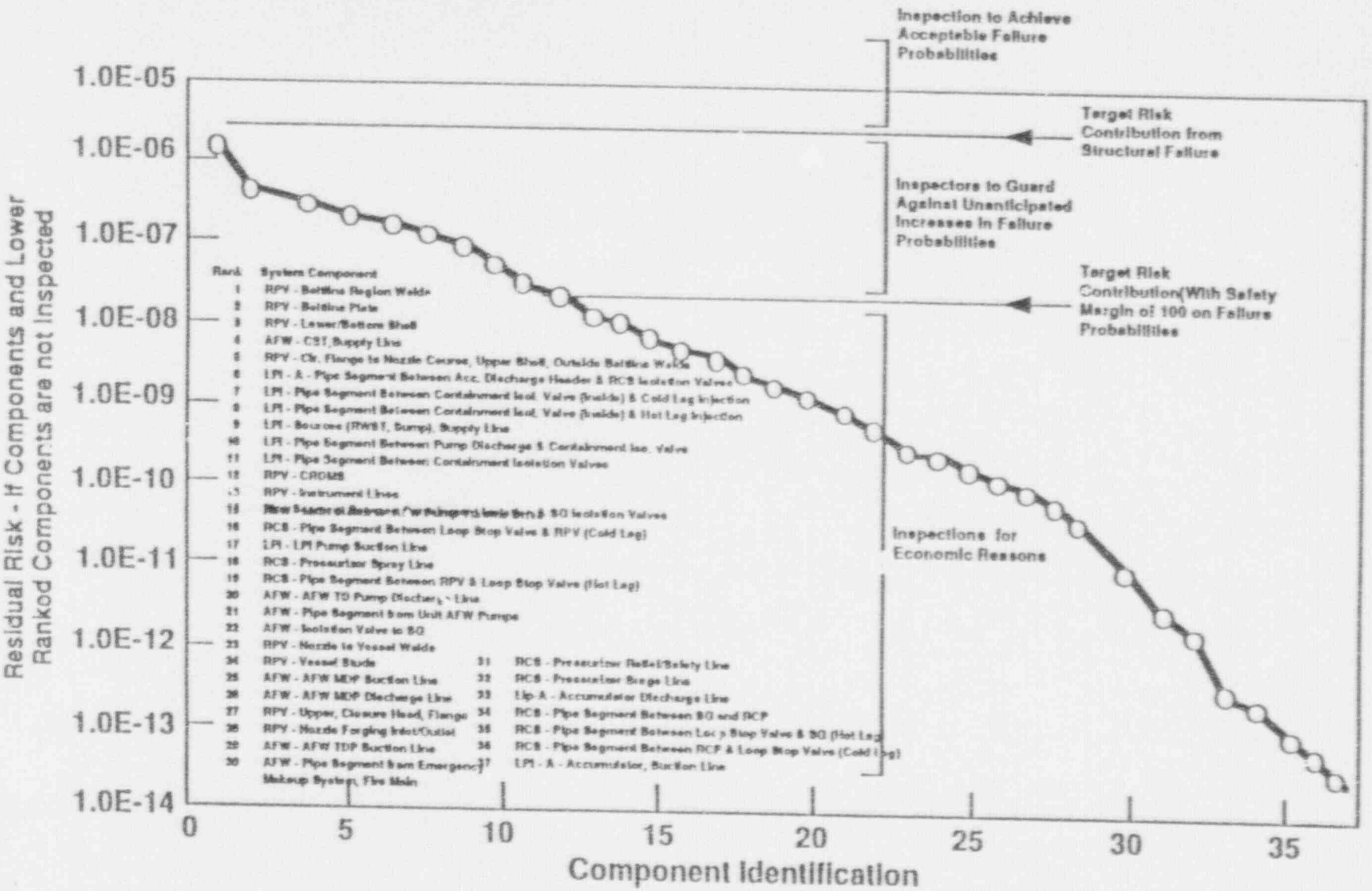
Apportion target risk in proportion to estimated risk

- May result in unachievable inspection requirements

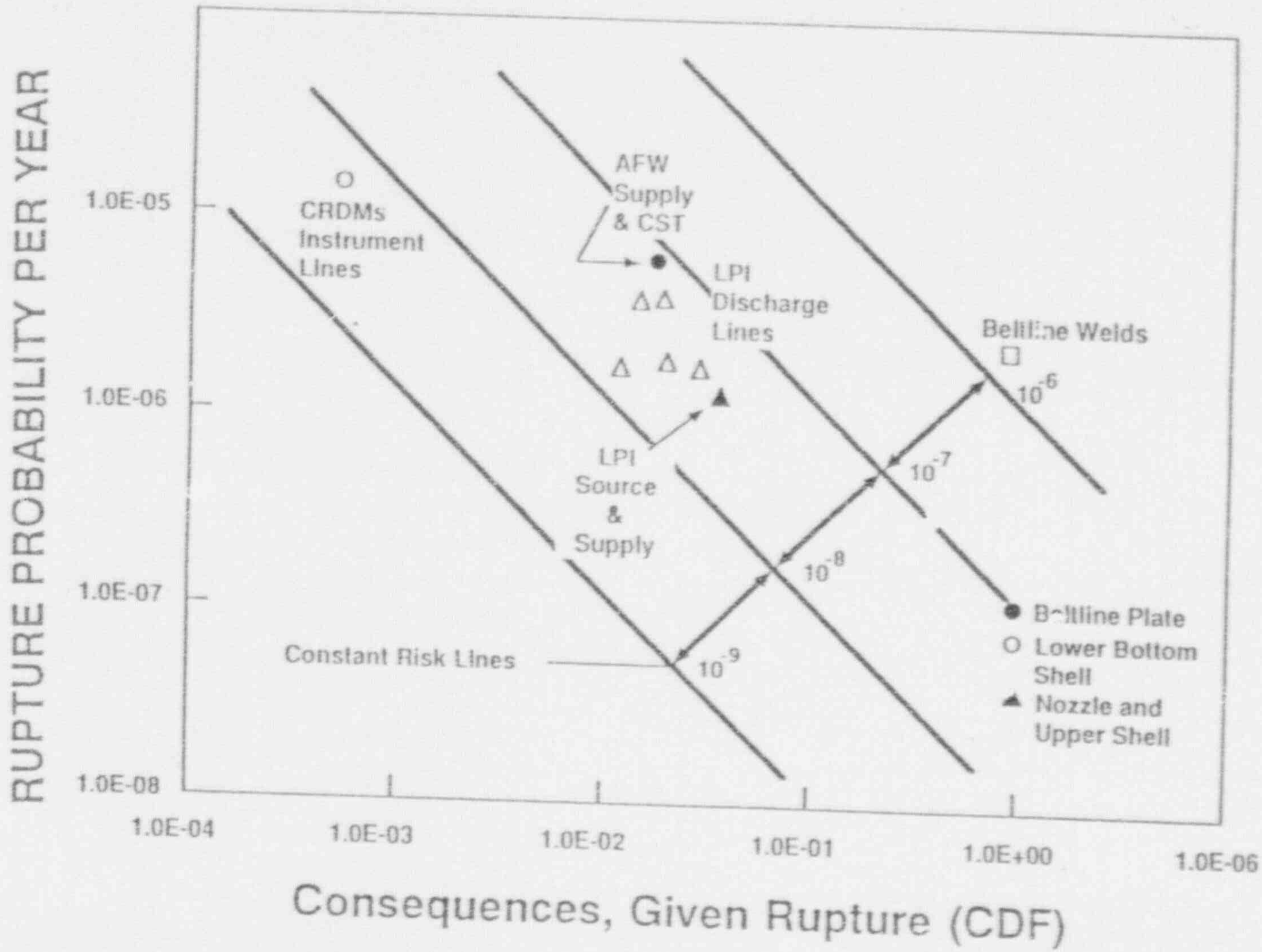
Surry Results

- Total estimated rupture risk is about 5% of PRA risk
- Then target risk, both total and component, equals estimated risk
- Then the target rupture frequency, to be maintained by inspections, is just the estimated rupture frequency used in the prioritization analysis

Comparison of Residual Risk with Target Risk from Structural Failures



SURRY-1 RISK RESULTS



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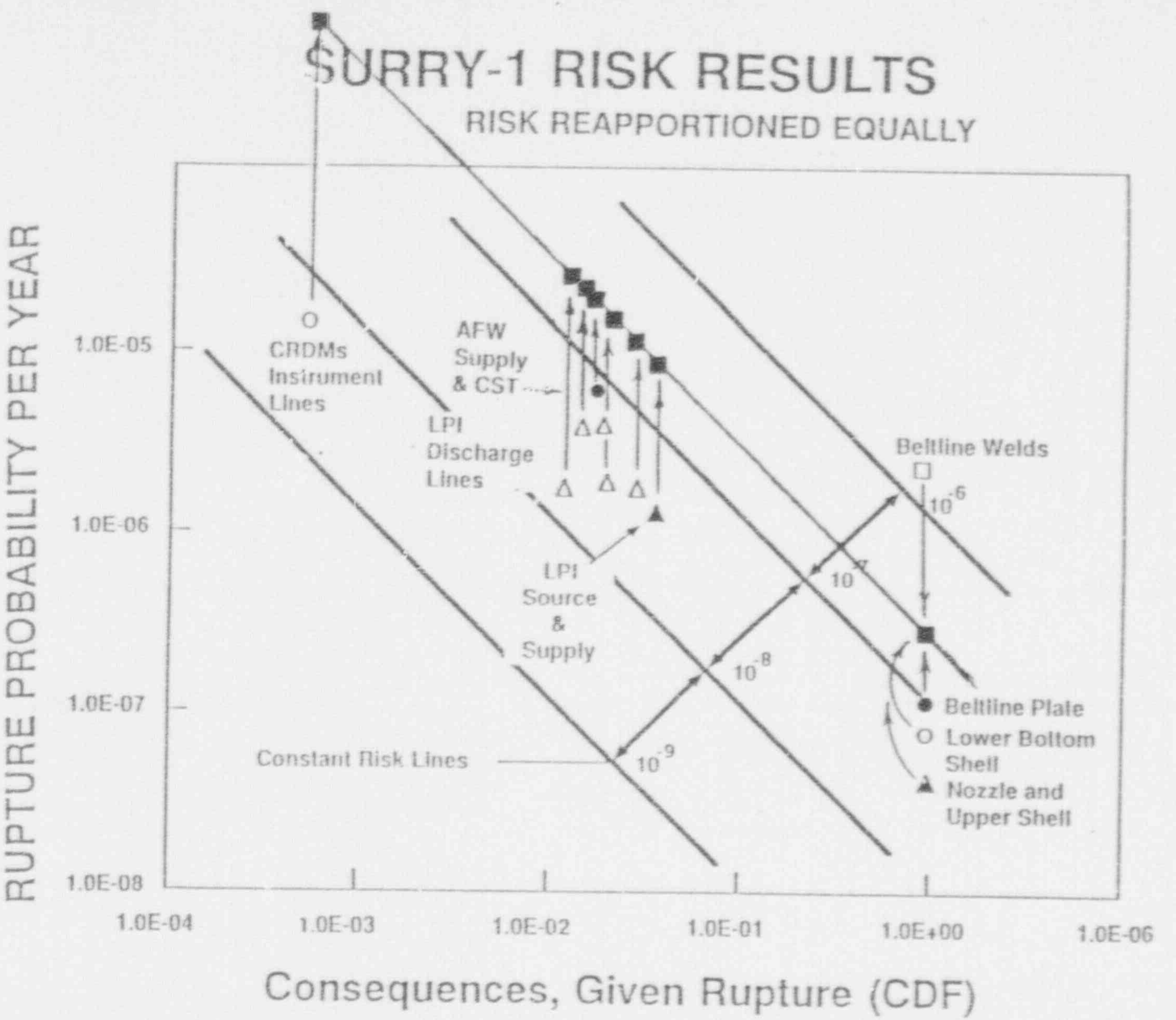
Alternative Strategies for Risk Apportionment

- Apportion target risk equally among risk dominant components
- Apportion target risk to alleviate hardest-to-meet inspection requirements
- More information is needed to evaluate need for or appropriateness of these alternatives

SURRY-1 RISK RESULTS

RISK REAPPORTIONED EQUALLY



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Surry-1 Components Risk Importance Parameters

System-Component	Cond. Core Dam. Freq.	Rupture Frequency	Core Damage Frequency	Rank
RPV - Beltline Welds	1.0	1.58E-06	1.58E-06	1
RPV - Beltline Plate	1.0	1.00E-07	1.00E-07	2
RPV - Lower/Bottom Shell	1.0	7.32E-08	7.32E-08	3
AFW - CST, Supply Line	1.70E-02	4.03E-06	6.86E-08	4
RPV - Clr. Flange to Nozzle Course, Upper Shell, Outside Beltline Welds	1.0	6.16E-08	6.16E-08	5
LPI-A - Pipe Segment Between Acc. Discharge Header and RCS Isolation Valves	1.80E-02	2.59E-06	4.67E-08	6
LPI - Pipe Segment Between Containment Isol. Valve (Inside) and Cold Leg Injection	1.60E-02	2.60E-06	4.16E-08	7
LPI - Pipe Segment Between Containment Isol. Valve (Inside) and Hot Leg Injection	3.04E-02	1.25E-06	3.80E-08	8
LPI - LPI Sources (RWST, SUMP), Supply Line	3.64E-02	1.00E-06	3.64E-08	9
LPI - Pipe Segment Between Pump discharge and Containment Iso. Valve	2.00E-02	1.38E-06	2.76E-08	10
LPI - Pipe Segment Between Containment Isolation Valves	1.20E-02	1.22E-06	1.46E-08	11

Surry-1 Components Risk Importance Parameters (cont'd)

System-Component	Cond. Core Dam. Freq.	Rupture Frequency	Core Damage Frequency	Rank
RPV - CRDMs	5.00E-04	1.00E-05	5.00E-09	12
RPV - Instrument Lines	5.00E-04	1.00E-05	5.00E-09	13
AFW - Pipe Segment Between Containment Isolation and SG Isolation Valves	4.00E-04	8.32E-06	3.33E-09	14
AFW - Main Steam to AFW Pump Turbine Drive	1.64E-04	1.28E-05	2.10E-09	15
RCS - Pipe Segment Between Loop Stop Valve and Rpv (Cold Leg)	1.13E-02	1.42E-07	1.60E-09	16
LPI - LPI Pump Suction Line	1.36E-03	1.10E-06	1.50E-09	17
RCS - Pressurizer Spray Line	1.00E-04	1.00E-05	1.00E-09	18
RCS - Pipe Segment Between RPV and Loop Stop Valve (Hot Leg)	2.86E-03	2.00E-07	5.72E-10	19
AFW - AFW TD Pump Discharge Line	2.29E-04	2.29E-06	5.26E-10	20
AFW - Pipe Segment from Unit 2 AFW Pumps	1.40E-04	2.98E-06	4.18E-10	21
AFW - AFW Isolation Valve to SG	2.60E-04	6.15E-07	1.60E-10	22

Conclusion

This provides a logical, quantitative methodology for addressing the question:

"How much inspection is enough?"

Inspection Program Development
NDE Reliability/Structural Reliability Assessment

Briefing: ASME Risk-Based Inspection Guidelines Research Project
U.S. Nuclear Regulatory Commission
Advisory Committee on Reactor Safeguards
Subcommittee on Metal Components

F.A. Simonen

Bethesda, Maryland
February 13, 1992

Topics

- Objectives of inspection programs
- NDE reliability
- Structural reliability assessments
- Development of improved inspection programs

Elements of Inspection Program

- o What to inspect
- o How many components to inspect (sample size)
- o Extent of inspection (surface, volume, etc.)
- o How often to inspect
- o Method of inspection (visual, UT, ET, etc.)
- o Reliability of inspection method

Benefits of Effective ISI

- Increased confidence in structural reliability (defense in depth)
- Decreased failure probabilities

Benefits can be achieved only if NDE reliability
<u>and</u> ISI programs are effective

Discovery Method for Degradation - from NPRDS Data Base

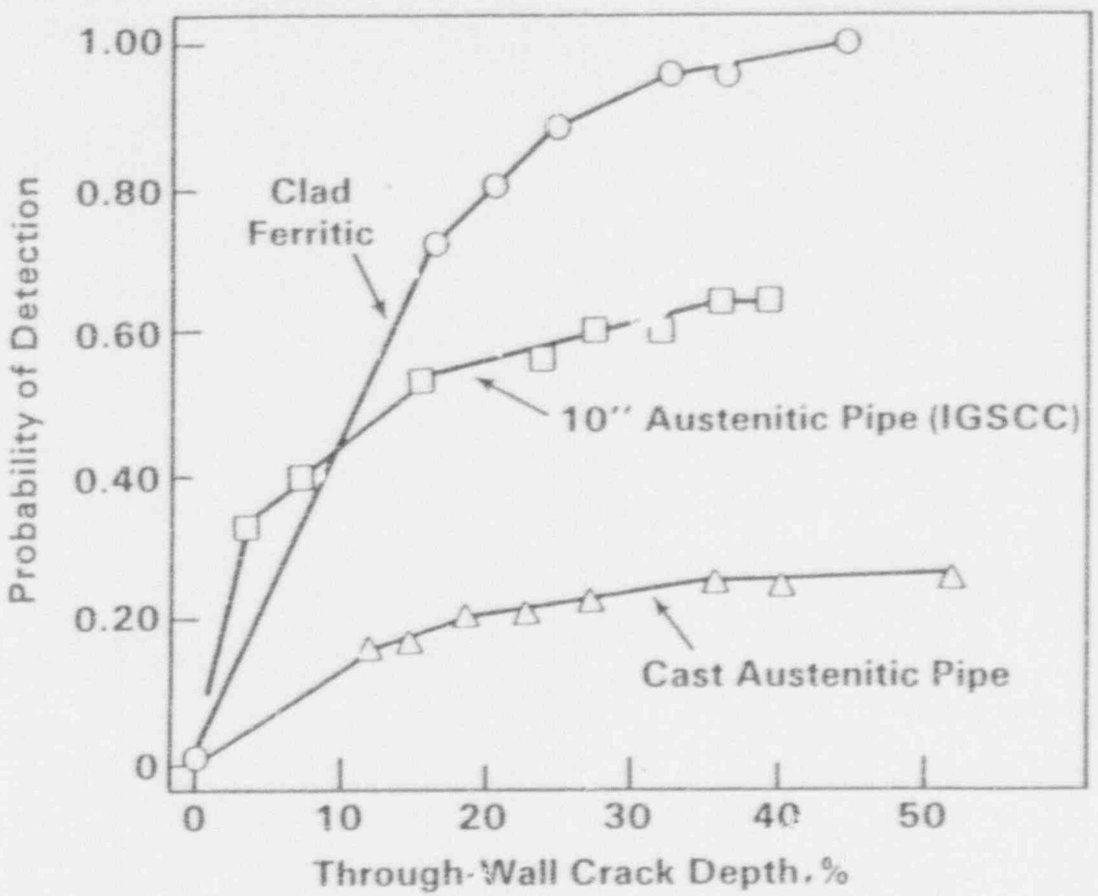
Discovery Method	Number of Reports
Ultrasonic (UT) as part of ISI program	50 (52%)
Surface penetrant (PT) as part of ISI program	11 (12%)
Visual as part of ISI program	3 (3%)
Leakage detected as part of ISI program	9 (9%)
Leakage Detected as part of other systematic program (e.g. hydrotest, alarms, etc.)	2 (2%)
Leakage detected as incidental observation (e.g. walkdown inspections)	21 (22%)
Cracks detected as incidental observations	0 (0%)

Five most important systems only
Wall thinning and cracking only
Excluding vibrational fatigue
Pipe diameters 3.0 inch or greater

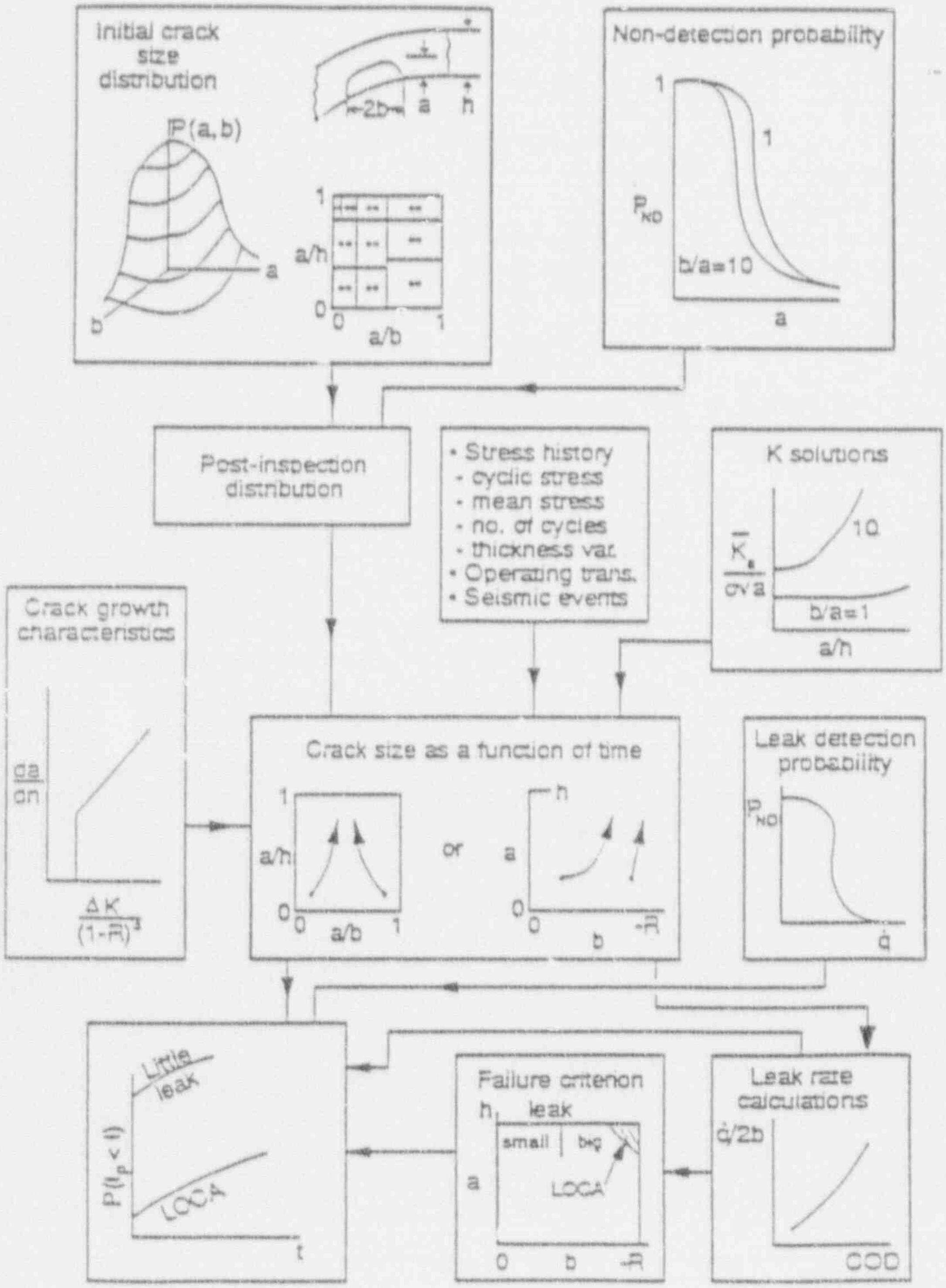
NDE Reliability - Recent Trends

- Data on NDE reliability have increased dramatically (from round robins and performance demonstrations)
- Codes and standards have improved and more reliable NDE is practiced in the field
- Impact on plant safety requires inspections at proper locations and frequencies
- Risk-based methods will use NDE reliability data as input to develop improved inspection plans

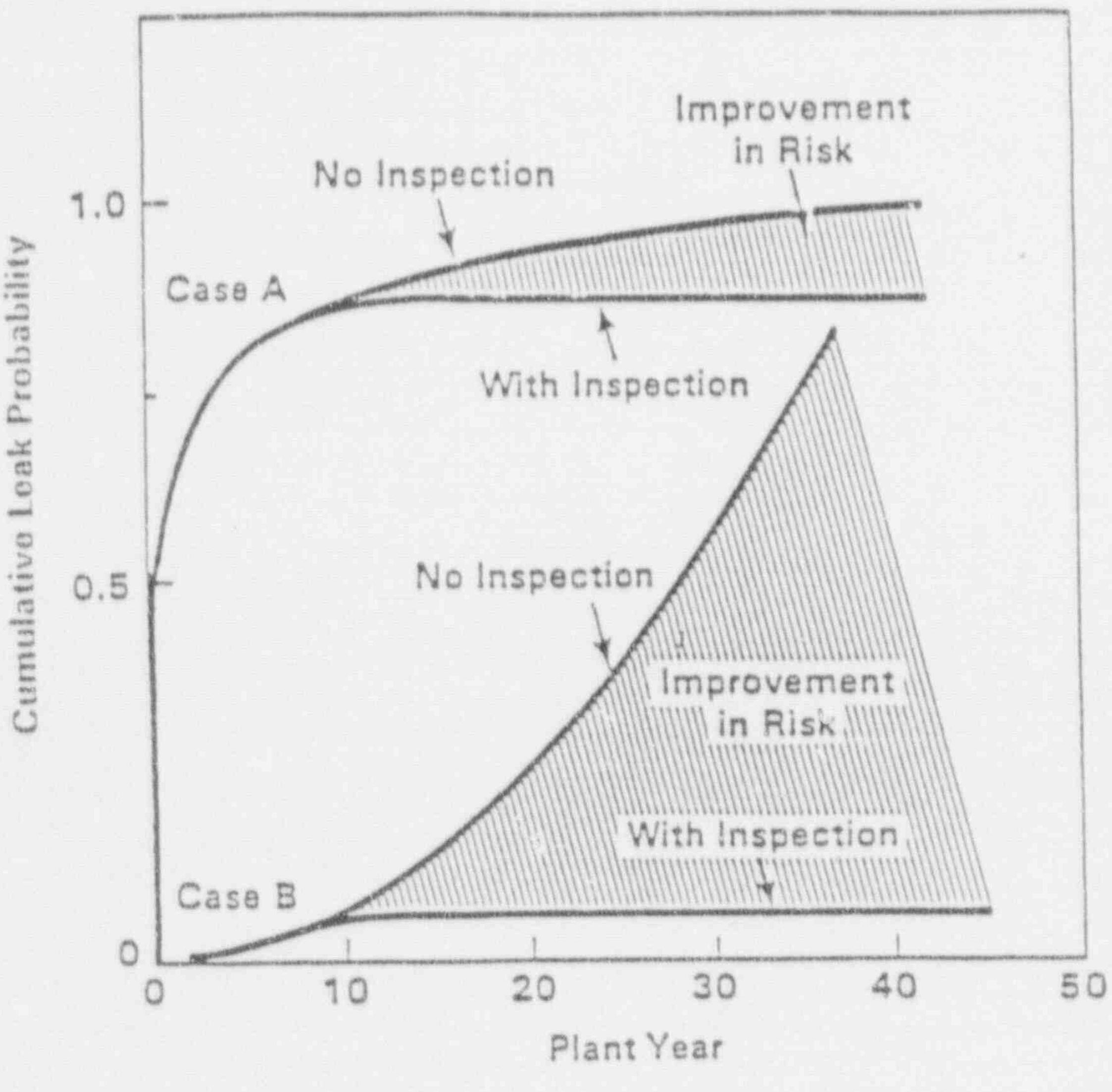
Plot of POD Versus Crack Depth for Clad Ferritic, Wrought Austenitic and Cast Austenitic Pipe



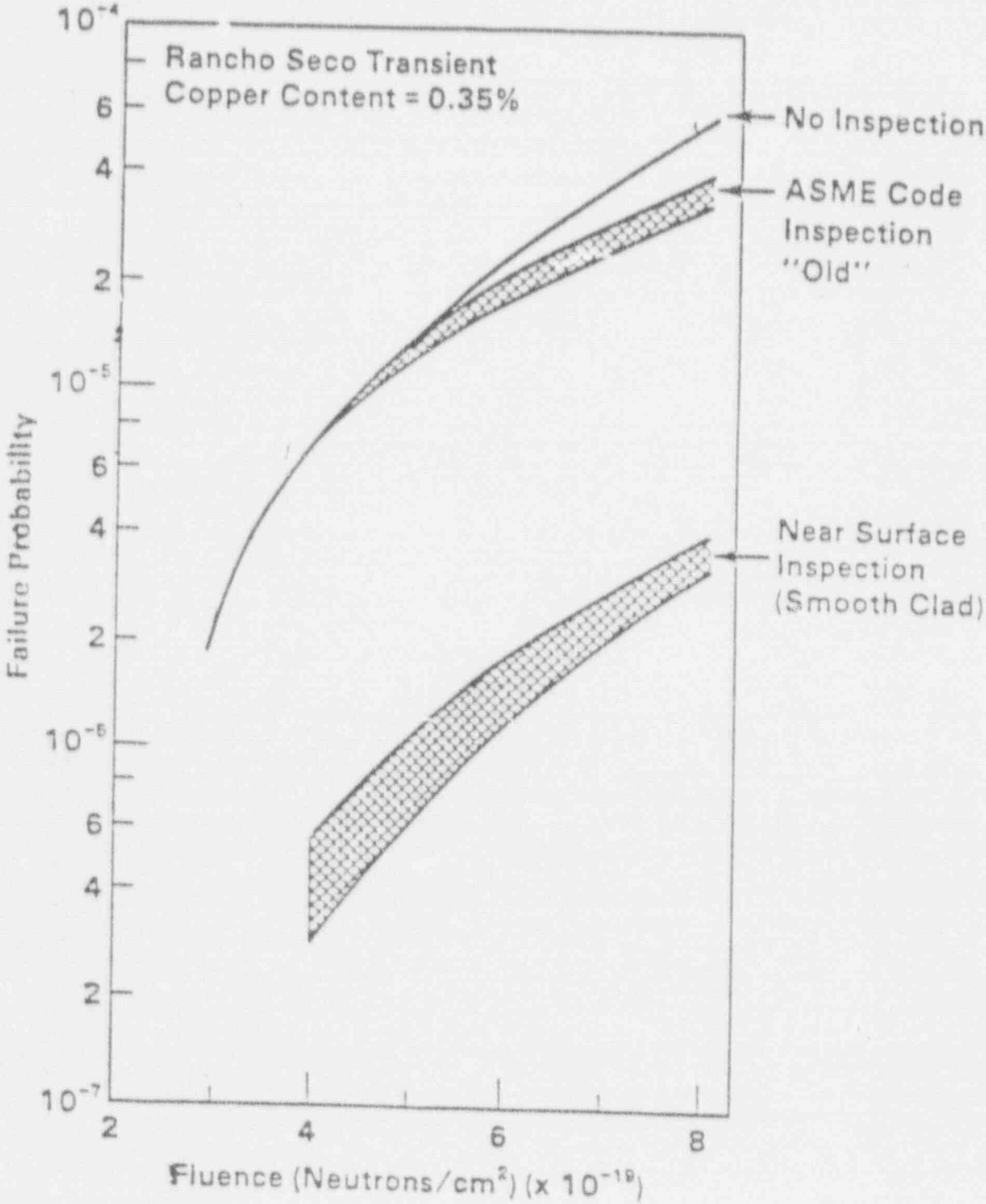
SRRA Process for Evaluating Piping Reliability



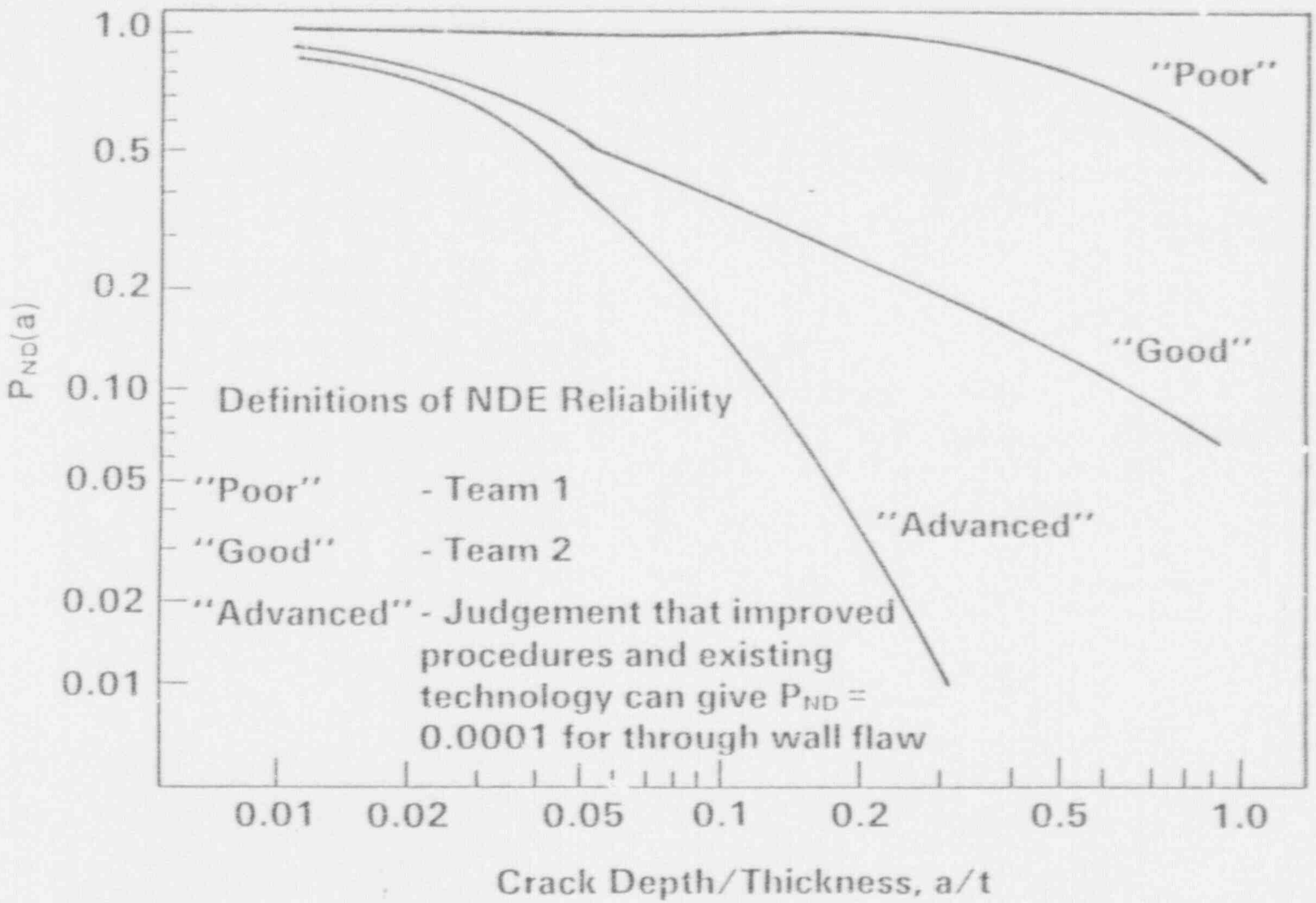
Impact of Inspection on Systems with Decreasing Failure Rate (Case A) versus Increasing Failure Rate (Case B)



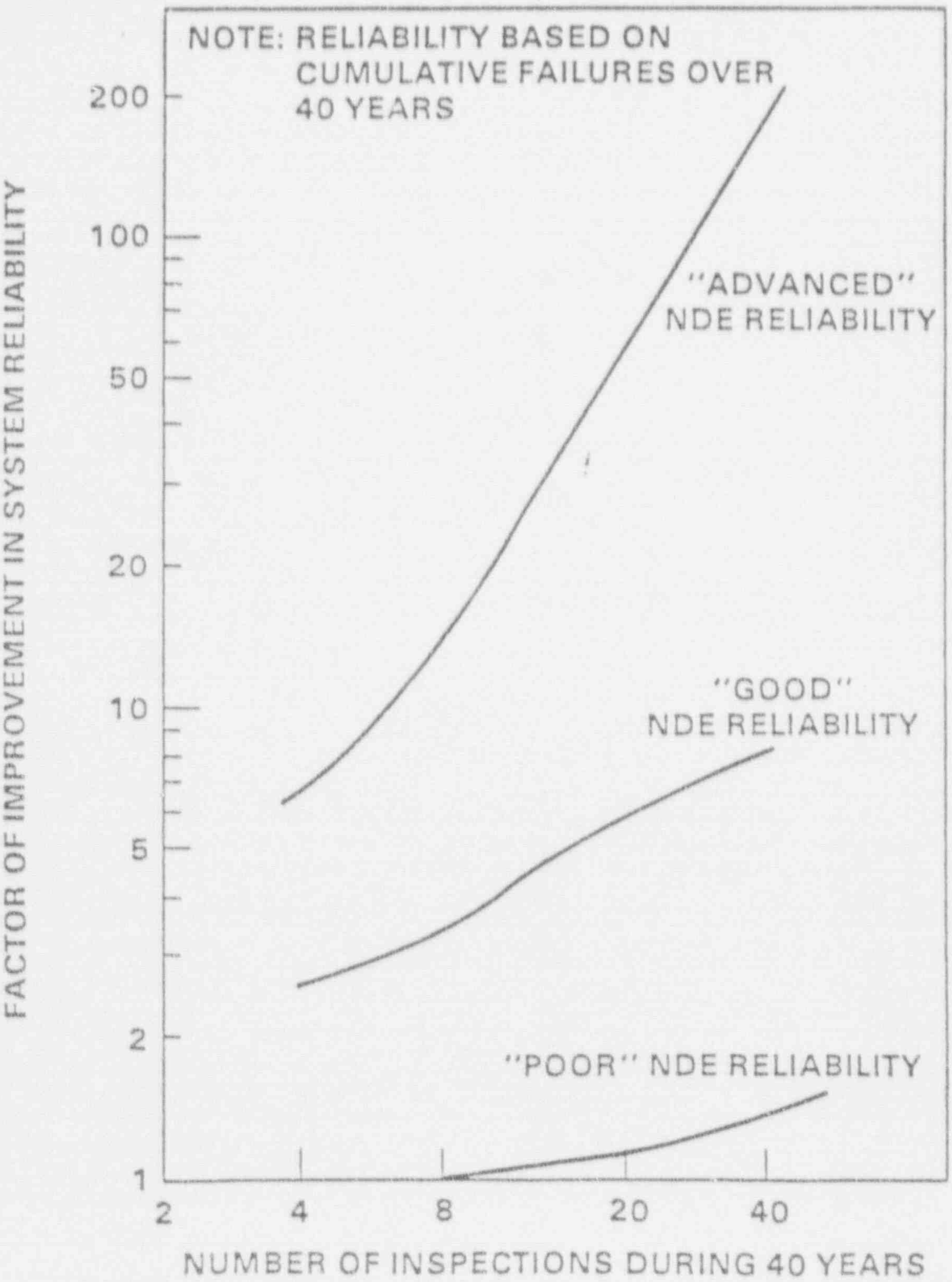
Impact of NDE on Pressure Vessel Failure Probability



Detection of IGSCC in 10-Inch Stainless Steel Pipe from Round Robin



Predicted Impact of NDE on IGSCC



Next Steps with SRRA Models

- o Address high priority components and the failure mechanisms as identified by expert elicitations
- o Develop SRRA models to evaluate alternative inspection scenarios
- o Perform parametric studies (e.g. with PRAISE code)
- o Apply simplified approaches to generalize results
- o Quantify benefits of ISI (i.e. factor of improvement, inspection efficiency, etc.) for use in decision-risk analyses

DECISION-RISK ANALYSIS

ASME Risk-Based Inspection Guidelines Research Project

U. S. Nuclear Regulatory Commission

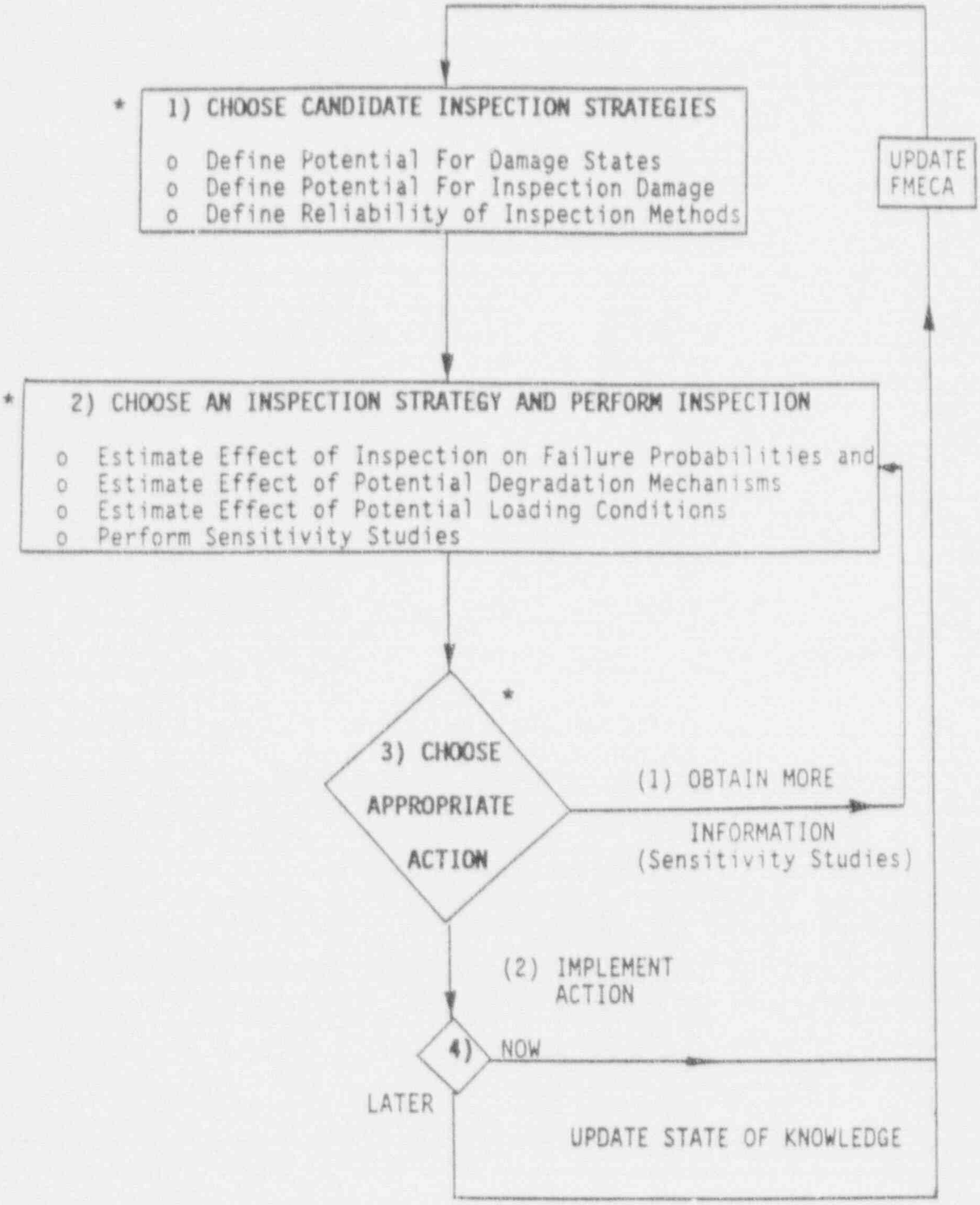
Advisory Committee on Reactor Safeguards

Subcommittee on Metal Components

Ken Balkey

Bethesda, Maryland
February 13, 1992

FIGURE 2-17. INSPECTION PROGRAM DEVELOPMENT



* Decision Risk Analysis

DECISION ANALYSIS

... A Structured Approach For The Analysis Of Business And Technical Situations Impacted By Uncertainty And Risk.

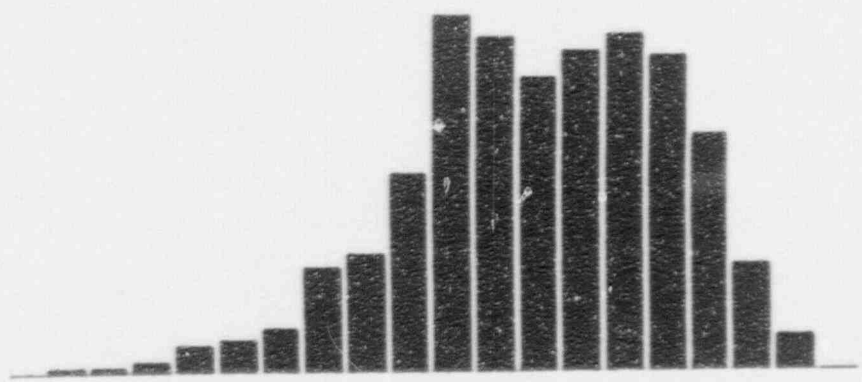
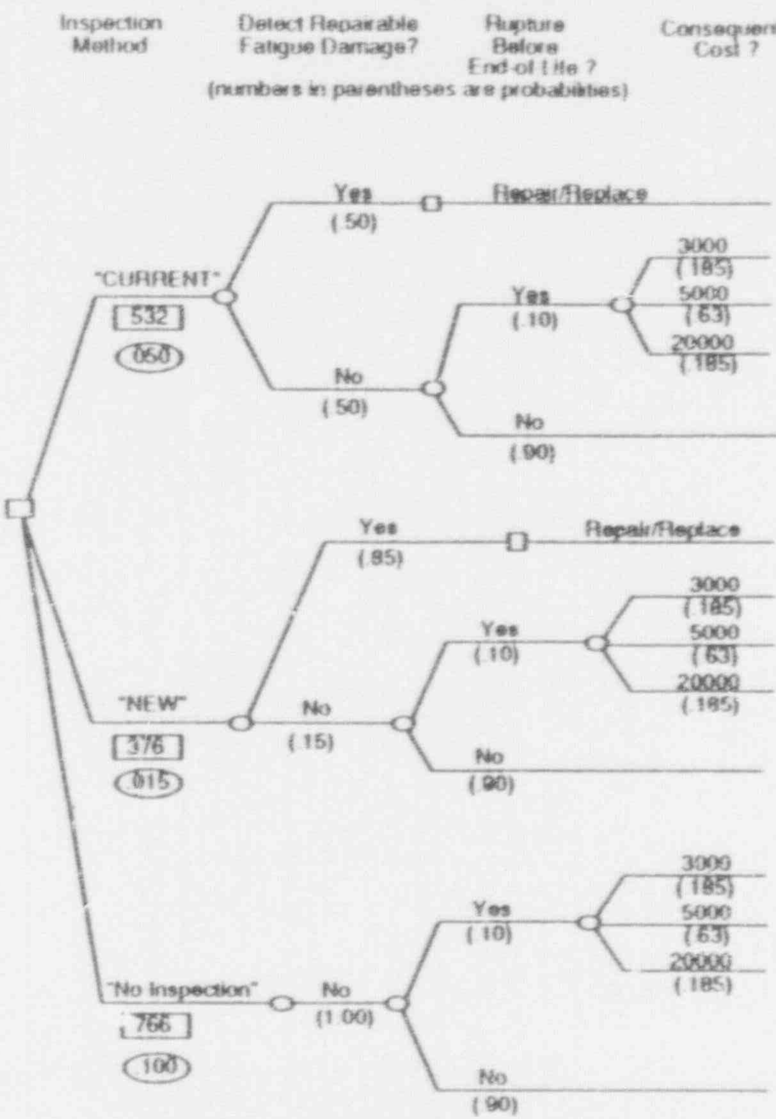


FIGURE 2-21. ILLUSTRATIVE DECISION TREE FOR CHOOSING AN INSP^ECTION STRATEGY



PRESENT VALUE OF COSTS (000$)

Inspection Cost	+ Repair Cost	= Total Cost	x Scenario Probability†	= Probability Weighted Scenario Cost *
25	250	275	.5000	138
25	250	3275	.0092	30
25	250	5275	.0315	166
25	250	20275	.0092	187
			.050	
25	0	25	.4500	11
				532
50	250	300	.8500	255
50	250	3300	.0027	9
50	250	5300	.0095	50
50	250	20300	.0027	55
			.015	
50	0	50	.1350	7
				376
0	250	3250	.0185	60
0	250	5250	.0630	331
0	250	20250	.0185	375
			.100	
0	0	0	.9000	0
				766

KEY

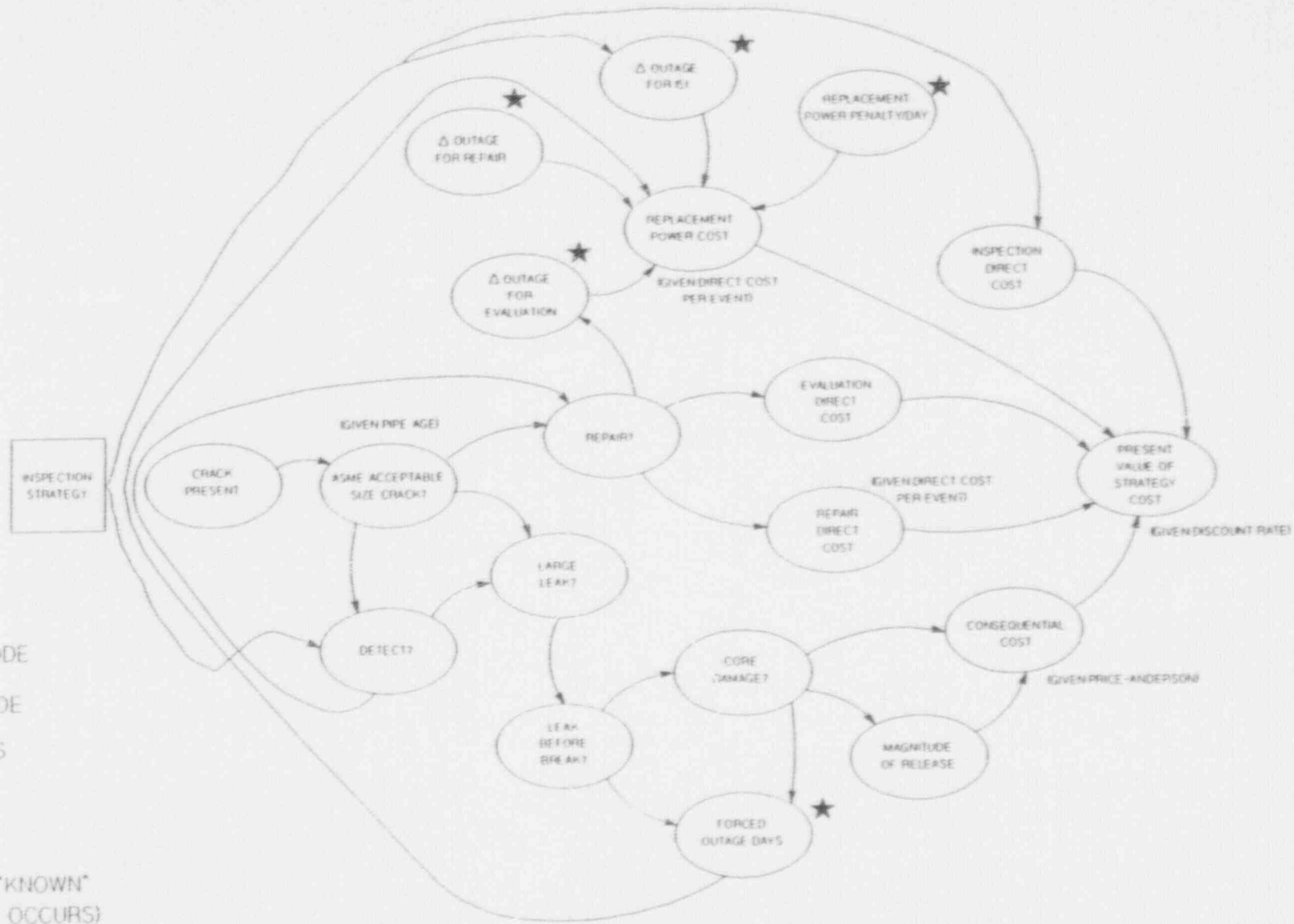
□ = decision node

○ = chance node

* Boxed cost is expected cost of alternative = sum of probability weighted scenario costs

† Circled number is failure probability – sum of probabilities for scenarios leading to failure

FIGURE 2-38 INFLUENCE DIAGRAM FOR DEVELOPING AN INSPECTION PROGRAM FOR A LOW PRESSURE SAFETY INJECTION SYSTEM



KEY:

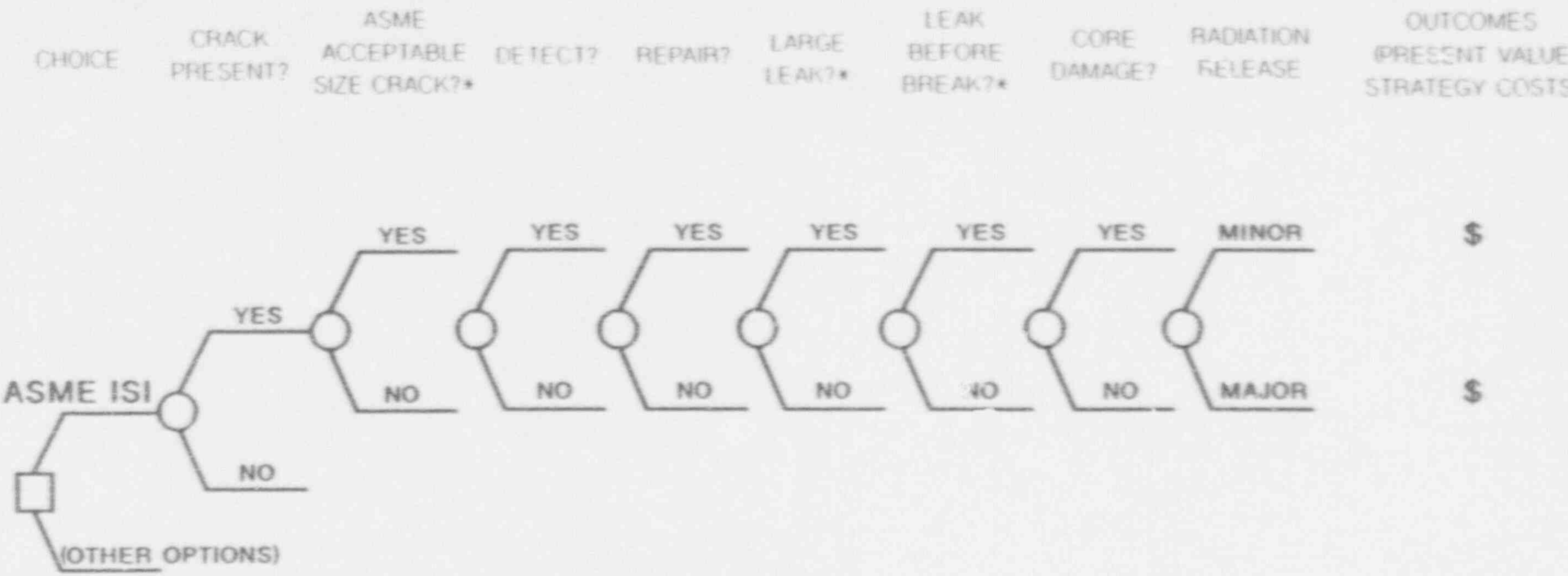
□ = DECISION NODE

○ = CHANCE NODE

① ⟶ ② IMPLIES 1 INFLUENCES UNCERTAINTY ABOUT 2

★ TREATED AS "KNOWN" (GIVEN EVENT OCCURS) FOR THIS EXAMPLE

FIGURE 2-39 CONCEPTUAL DECISION TREE FOR DEVELOPING AN INSPECTION PROGRAM FOR A LOW PRESSURE SAFETY INJECTION SYSTEM



* LIKELIHOOD CHANGES WITH PIPE AGE

TABLE 2-15

LOW PRESSURE SAFETY INJECTION LINE PROBABILITY ASSESSMENTS

Chance Node Binary Events	Conditional Probability[1] (Next 30 Years)
Flaw Present	0.19
ASME Unacceptable Size Flaw	0.36
No Repair Versus Repair	0.25 no/0.75 yes
Large Leak	0.04
Break Before Leak	0.001
Core Damage	0.015
Major Radiation Release	0.08
Detection:	
ASME[2] ISI	0.67
Improved NDE	0.94
2 x ASME Frequency	0.90
Half ASME Frequency	0.50

(1) Each probability is conditional on prior events in the decision tree

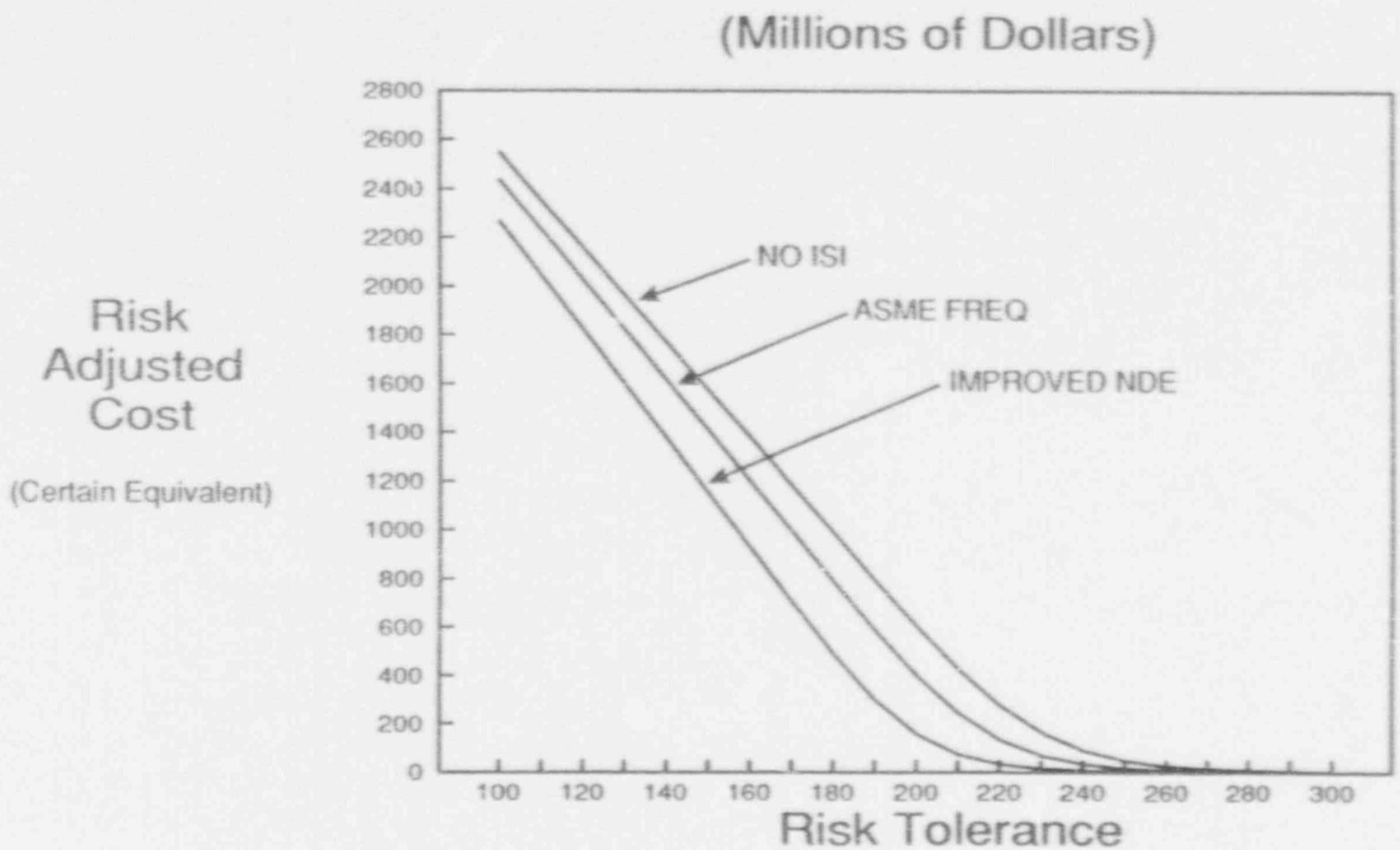
(2) For this example, the term "ASME" refers to the current requirements of ASME BPVC Section XI (1989).

TABLE 2-16

LOW PRESSURE SAFETY INJECTION LINE COST FACTORS

Variable	Unit of Measure	Assumed Value
ISI Direct Cost	$K/10 Year Cycle	500
Evaluation Direct Cost	$K/Indication	80
Repair Direct Cost	$K/Crack	200
Incremental Outage for Evaluation	Days	2
Incremental Outage for Repair	Days	5
Forced Outage for Leak	Days	40
Forced Outage for Break	Days	120
Incremental Outage for Improved NDE Methods	Days	1
Replacement Power Penalty	$K/Day	500
Discount Rate	Constant $, Risk Free (%)	4
Minor Radiation Release	$M/Release	4000
Major Radiation Release	$M/Release	10000

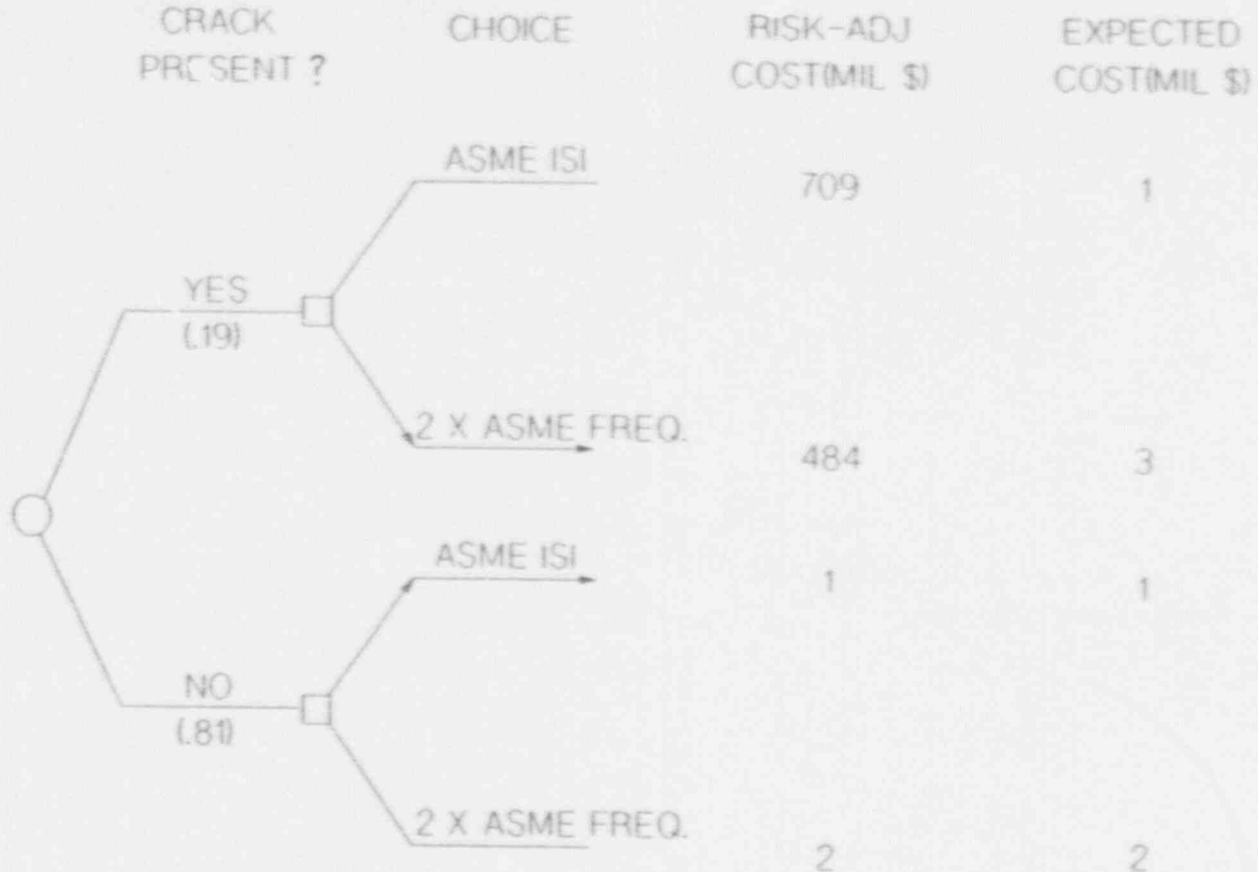
FIGURE 2-38. RISK ADJUSTED COST VERSUS RISK TOLERANCE FOR THREE INSPECTION STRATEGIES



0989D:1D/040291

FIGURE 2-39

VALUE OF INFORMATION ON "CRACK PRESENT"



KEY:

○ = CHANCE NODE

□ = DECISION NODE

→ = OPTIMAL CHOICE

NUMBERS IN PARENTHESIS ARE PROBABILITIES

EXPECTED COST WITHOUT PERFECT INFORMATION = $3.0

EXPECTED COST WITH PERFECT INFORMATION

= .19 X 3 + .81 X 1 = 1.4

EXPECTED VALUE OF PERFECT INFORMATION = $1.6 MILLION

TABLE 2-17

EXAMPLE EVALUATION OF INSPECTION STRATEGIES FOR A LOW PRESSURE SAFETY INJECTION SYSTEM USING DECISION - RISK ANALYSIS

Strategy	Large Leak Probability(1)	Expected Strategy Cost ($M)	Risk Adjusted Strategy Cost(3)(4) ($M)	RAC/No ISI(4)
No ISI	21.7 E-5	< 1	603	1.00
ASME ISI	7.2 E-5	1	401	0.67
2 x ASME BPVC Frequency	2.2 E-5	2	217	0.36
Half ASME BPVC Frequency	10.9 E-5	1	474	0.79
Improved NDE(2) (w/ASME BPVC Freq.)	1.3 E-5	3	156	0.26

(1) This terminology represents the conditional probability of a large leak given that degradation occurs. It is assumed that all of the inspection strategies meet the target failure probability for rupture. The rupture or break probabilities can be obtained by multiplying the large leak probability by 0.001.

(2) Since this case reflects an upper bound on detection probability, a more realistic choice may be 2 x ASME BPVC Frequency

(3) Risk Adjusted Cost (RAC) is represented as -

$$RAC = -R \ln (p_1 e^{-v_1/R} + p_2 e^{-v_2/R} + \ldots + p_i e^{-v_i/R}), \qquad (2\text{-}7)$$

where: R = risk tolerance

p_i = probability of the i^{th} outcome

v_i = value (cost) of the i^{th} outcome

(4) Remember that RAC is not an estimate of out-of-pocket cost. Further, its magnitude, which is a hypothetical construct, is of less interest here than its relative magnitude, which is why the ration "RAC/No ISI" is computed here.

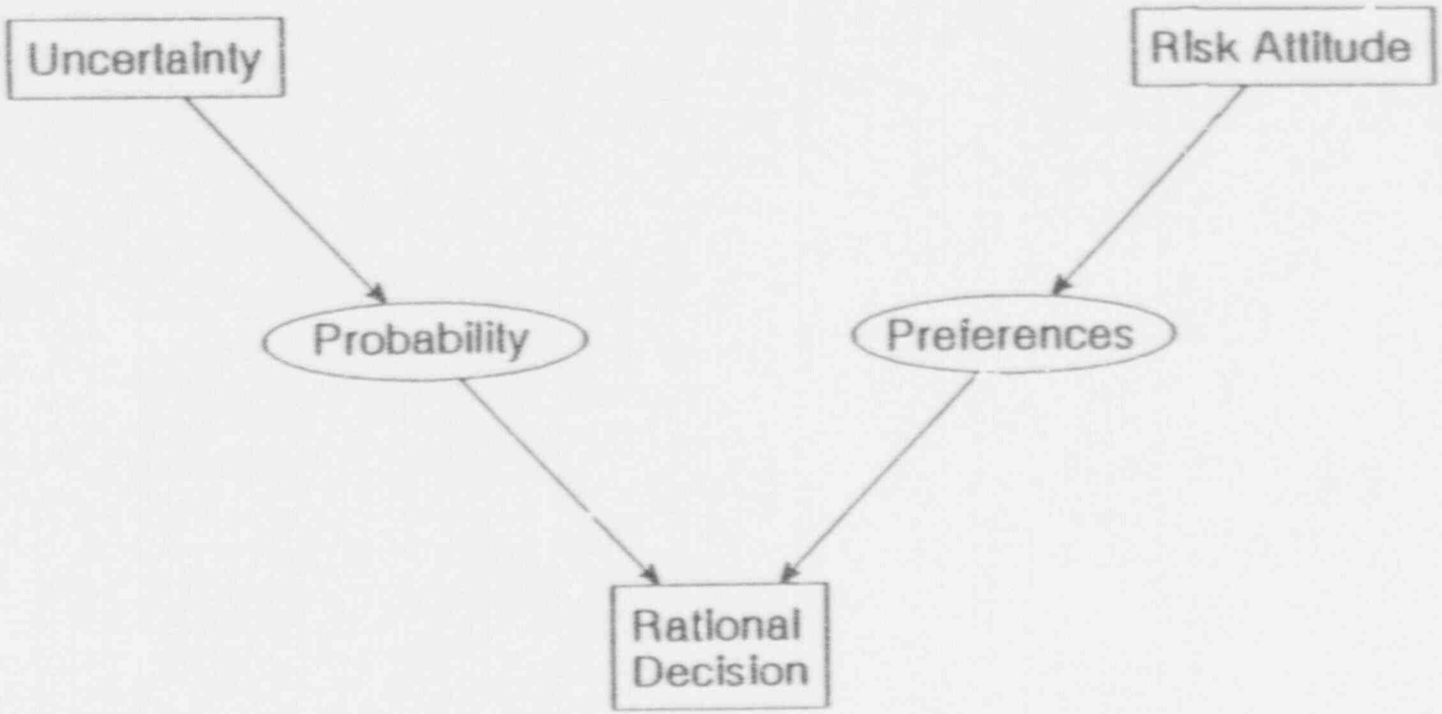
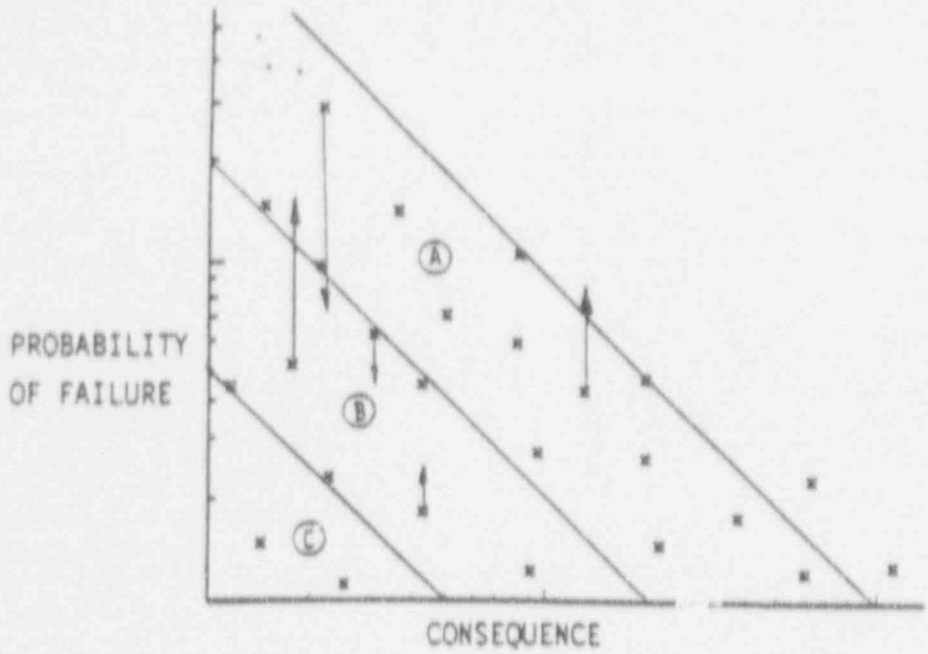
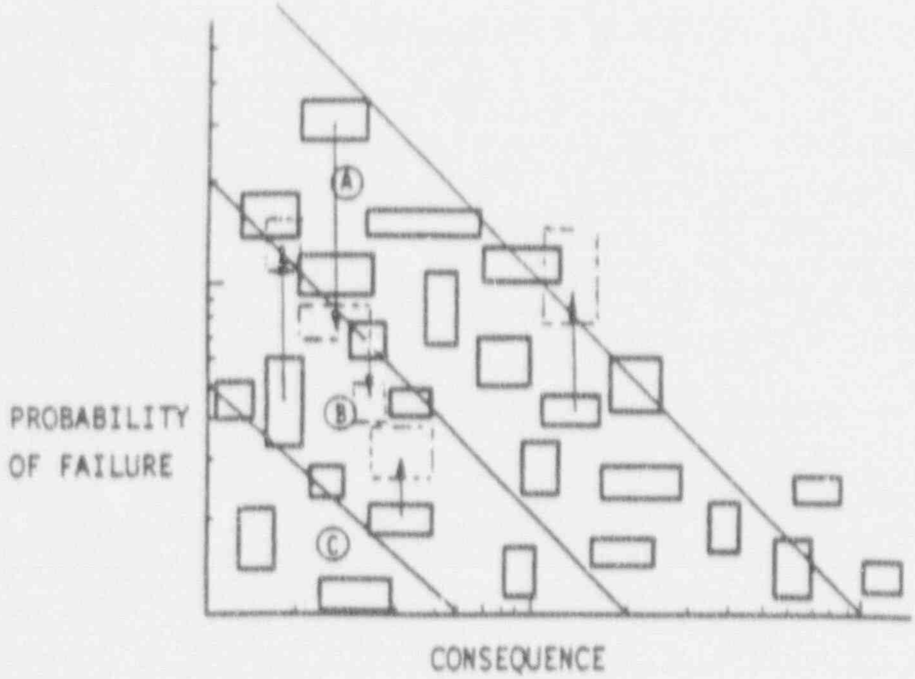

Uncertainty
Risk Attitude
Probability
Preferences
Rational Decision

FIGURE 2-38.

RISK RANKING (POST INSPECTION)



a. Ranking Using Single Point Estimates Based on Lines of Constant Risk



b. Ranking, Including Uncertainty, Based on Lines of Constant Risk

Reliability Methods Application to Fossil Fuel Power Plants

Niagara Mohawk Power Corp.
by
Lloyd Smith

U.S. Nuclear Regulatory Commission
ACRS Subcommittee on Metal Components
February 13, 1992

Focus

- Why
- Methodology
- Results
- Benefits

Risk Control

Risk Reduction	Minimize Plant Transients
	Increase System Reliability
	Improve Component:
	    Availability
	    Maintainability
	    Testing/Inspection
	Proactive program
	Inspect Major Items

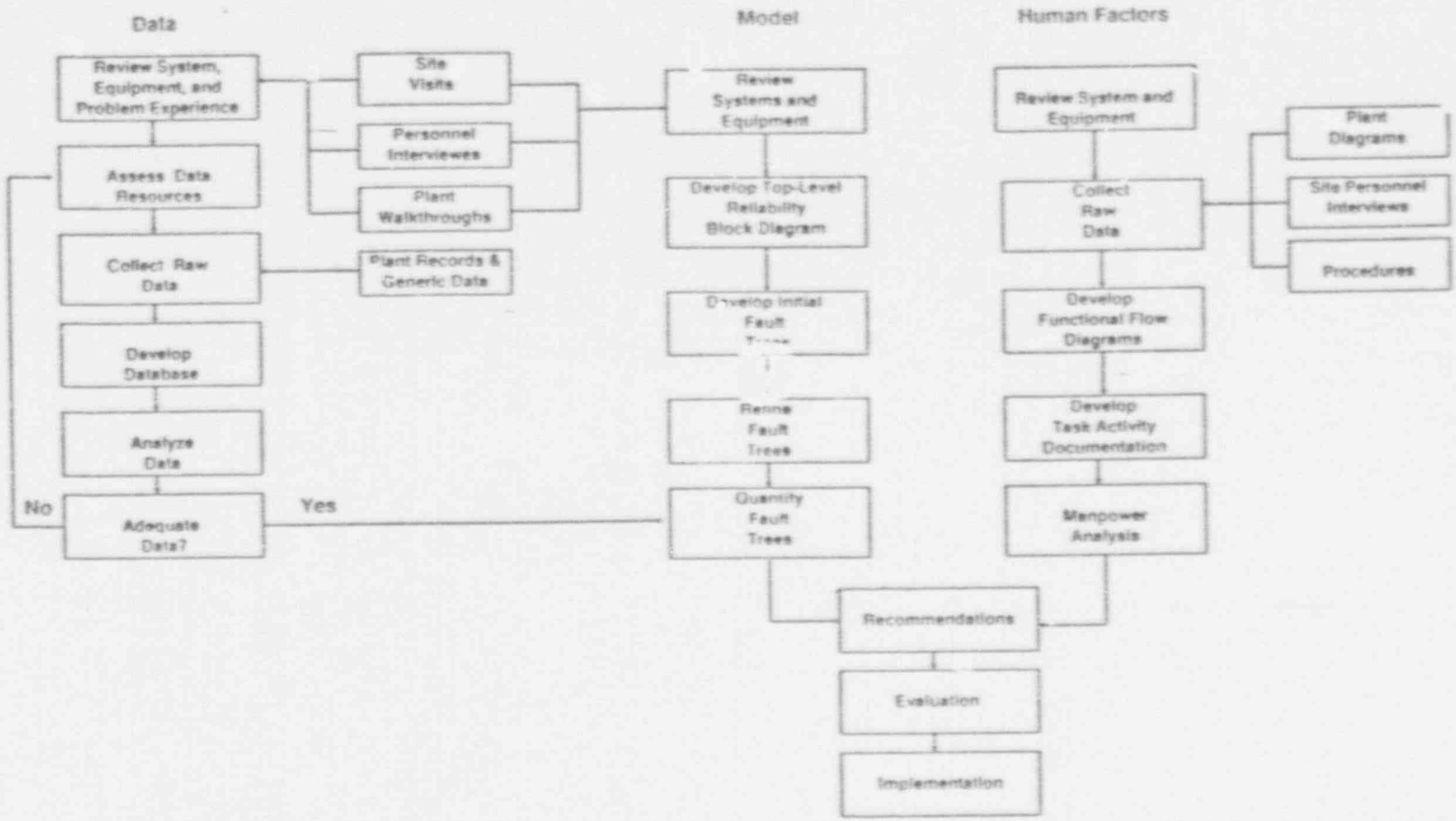
Recent Projects
Probablistic/Reliability

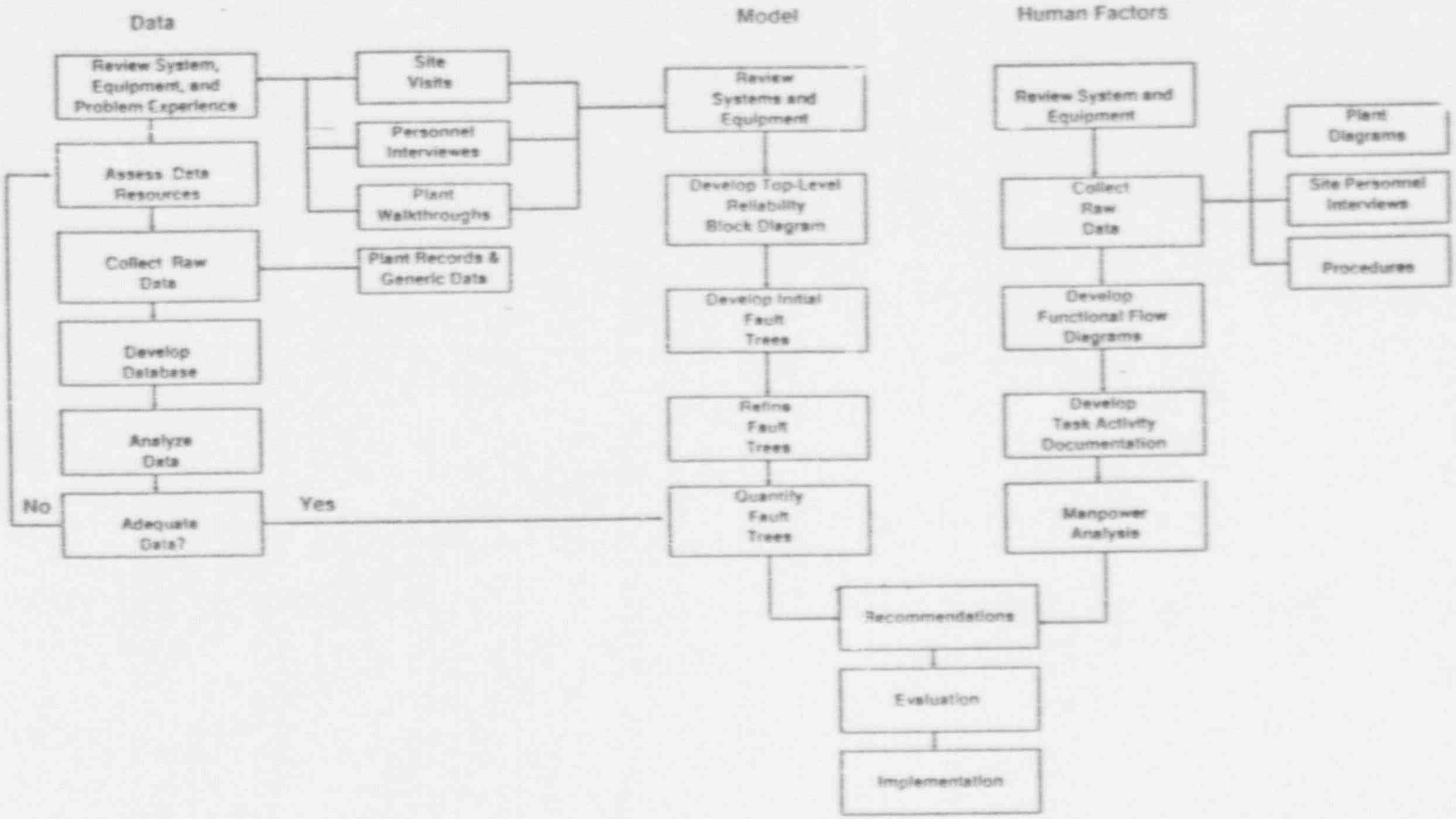
- T/G Protection Schemes

- Limestone Injection System

- Control System Upgrade

- Life Extension


Data
Model
Human Factors
Review System, Equipment, and Problem Experience
Site Visits
Personnel Interviewes
Plant Walkthroughs
Assess Data Resources
Collect Raw Data
Plant Records & Generic Data
Develop Database
Analyze Data
Adequate Data?
No
Yes
Review Systems and Equipment
Develop Top-Level Reliability Block Diagram
Refine Fault Trees
Quantity Fault Trees
Review System and Equipment
Collect Raw Data
Plant Diagrams
Site Personnel Interviews
Procedures
Develop Functional Flow Diagrams
Develop Task Activity Documentation
Manpower Analysis
Recommendations
Evaluation
Implementation


Data
Model
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Site Visits
Personnel Interviewes
Plant Walkthroughs
Assess Data Resources
Collect Raw Data
Plant Records & Generic Data
Develop Database
Analyze Data
Adequate Data?
No
Yes
Review Systems and Equipment
Develop Top-Level Reliability Block Diagram
Develop Initial Fault Trees
Refine Fault Trees
Quantify Fault Trees
Review System and Equipment
Collect Raw Data
Plant Diagrams
Site Personnel Interviews
Procedures
Develop Functional Flow Diagrams
Develop Task Activity Documentation
Manpower Analysis
Recommendations
Evaluation
Implementation

Failure Database

System

Failure Date

Record Number

Component Identifier

FW 12/08/83 458988 365-0651-BFP Pump C T 14

FW 03/25/85 238709 365-0651-BFP Pump D D 49

FW 04/02/87 638529 365-0651-BFP PUMP I T 75

Component

Failure Severity
- Catastrophic
- Degraded
- Incipient

Failure Mode
- T-Fails while running
- D-Fails to start

Failure Cause

HUNTLEY UNIT 65 MECHANICAL COMPONENT FAILURE DATA
November 1, 1981 to November 16 1986

SYSTEM	DATE	RECORD	IDENTIFICATION	COMPONENT	SEVERITY	MODE	CAUSE
FHDG	12/31/80	415005	365-0652-CONVYR	CONVYR	I	T	7
ASHH	01/03/81	405671	365-0065-FLSHCHT	GATE	I	T	18
ASHH	01/04/81	0	365-0065-FLSHCHT	HOPPER	C	T	7
FUEL	01/05/81	0	365-0651-COALFDR	HOPPER	C	T	20
FUEL	01/06/81	0	365-0652-COALFDR	HOPPER	C	T	14
SUPTEQ	01/06/81	414483	300-0012-CONVYR	CONVYR	I	T	14
BOILER	01/07/81	0	365-0065-BOILER	TUBE	D	T	7
FHDG	01/08/81	415260	365-0654-CONVYR	CONVYR	I	T	13
FHDG	01/08/81	415258	365-0653-CONVYR	CONVYR	I	T	13
FHDG	01/08/81	415257	365-0652-CONVYR	CONVYR	I	T	13
FHDG	01/08/81	415256	365-0651-CONVYR	CONVYR	I	T	13
BOILER	01/09/81	0	365-0065-BOILER	TUBE	D	T	7
FUEL	01/09/81	405686	365-0654-COALBNR	PIPE	I	T	6
FUEL	01/09/81	415020	365-0654-COALBNR	PIPE	I	T	6
BOILER	01/10/81	0	365-0065-BOILER	TUBE	D	T	7
FUEL	01/10/81	0	365-0653-MILL	BRKER	C	T	24
FHDG	01/10/81	0	365-0654-DMPSCL	SCALE	C	T	30
FHDG	01/10/81	404649	365-0651-CONVYR	CONVYR	I	T	13
FUEL	01/10/81	415272	365-0653-MILL	BRKER	D	T	7
BOILER	01/11/81	0	365-0065-BOILER	TUBE	D	T	7
FUEL	01/12/81	415274	365-0653-COALBNR	BURNER	I	T	12
FUEL	01/12/81	405691	365-0654-COALBNR	PIPE	I	T	6
FUEL	01/12/81	405690	365-0654-COALBNR	PIPE	I	T	6
FUEL	01/13/81	0	365-0654-COALBNR	PIPE	C	T	6
FUEL	01/16/81	0	365-0654-COALFDR	HOPPER	C	T	36
FHDG	01/16/81	415281	365-0653-CONVYR	CONVYR	I	T	14
FUEL	01/17/81	0	365-0651-COALFDR	HOPPER	D	T	15
FUEL	01/17/81	0	365-0654-MILL	MILL	C	T	28
FUEL	01/18/81	0	365-0654-COALFDR	HOPPER	D	T	28
FHDG	01/19/81	0	365-0654-CONVYR	CONVYR	C	T	37
BOILER	01/20/81	0	365-0065-BOILER	TUBE	D	T	7
FHDG	01/20/81	0	365-0654-DMPSCL	SCALE	C	T	30
FUEL	01/20/81	415033	365-0652-COALBNR	PIPE	I	T	6
FW	01/20/81	0	365-0065-DESUPER	ATTEMP	D	T	0
FW	01/21/81	0	365-0065-DESUPER	ATTEMP	D	T	0
FW	01/21/81	0	365-0065-DESUPER	ATTEMP	D	T	0
SUPTEQ	01/21/81	414496	300-0004-BRADBKR	BRKR	I	T	6
SUPTEQ	01/21/81	414497	300-0020-CONVYR	CONVYR	I	T	24
SUPTEQ	01/21/81	414500	300-0020-APRFDR	CONVYR	I	T	12
SUPTEQ	01/21/81	414492	300-0016-CONVYR	CONVYR	I	T	14
SUPTEQ	01/21/81	414493	300-0015-CONVYR	CONVYR	I	T	22
SUPTEQ	01/21/81	414494	300-0004-CONVYR	CONVYR	I	T	22
SUPTEQ	01/21/81	414498	300-0013-CONVYR	CONVYR	I	T	12
BOILER	01/22/81	415361	365-65G6-SOOTBLR	STBLWR	D	T	11
FHDG	01/22/81	0	365-0651-CONVYR	CONVYR	C	T	14
FHDG	01/22/81	415038	365-0651-CONVYR	CONVYR	I	T	13
ASHHND	01/23/81	0	365-0065-ASHHPR	HOPPER	C	T	12

Exposure Hours

Major Components

Year	Mil-1	Mil-2	Mil-3	Mil-4	ID-F1	ID-F2	FD-F1	FD-F2	HW-P1	HW-P2	BF-P1	BF-P2	BF-P3	Op Hr	Yr Hr
1981	6455	6649	6626	6237	7371	7331	7358	7274	4897	2489	7295	15	7266	7296	8760
1982	6896	6785	5848	6923	7597	7585	7586	7570	6491	1123	7311	1580	5926	7587	8760
1983	5479	5508	5317	6262	6562	6284	6475	6244	3861	2839	5939	2577	4106	6522	8760
1984	4010	6874	6959	6702	7683	7512	7493	7318	2704	5010	7	7284	7420	7502	8784
1985	4379	5454	5949	6167	7640	7716	7490	7021	141	8057	1585	7302	5175	7812	8760
1986	714	6311	5349	5696	7261	7467	5531	5925	3498	4227	7	5996	5586	7278	8760
1987	5866	5868	7246	6358	8615	8490	7868	8030	6268	2420	4290	7914	4470	8454	8760
1988	3116	3344	2719	3189	4823	4022	3972	3650	2171	2822	2475	1146	3899	3830	8784
1989	6230	6408	7192	7081	8308	8527	7916	7869	60	8506	7861	7	8040	8001	8760
1990	6534	3921	7113	6305	7932	8269	7610	7721	2310	3877	4004	3719	7579	7673	8760
Tot	49679	57122	60218	60920	73792	73003	69299	68622	32401	43370	40774	37510	59467	71955	87648
Ave	4968	5712	6022	6092	7379	7300	6930	6862	3240	4337	4077	3751	5947	71968	8765

Number of Demands

Major Components

Year	Mil-1	Mil-2	Mil-3	Mil-4	ID-F1	ID-F2	FD-F1	FD-F2	HW-P1	HW-P2	BF-P1	BF-P2	BF-P3	Op Hr	Yr Hr
1981	179	139	189	191	11	11	12	11	10	9	12	1	11	7296	8760
1982	119	105	494	109	12	13	10	11	10	3	10	1	12	7587	8760
1983	79	104	221	71	17	17	11	14	8	13	10	11	10	6522	8760
1984	126	83	134	152	21	38	25	35	11	8	2	45	21	7502	8784
1985	245	112	188	199	22	35	39	90	5	6	22	85	113	7812	8760
1986	73	104	197	203	27	21	159	122	8	8	1	104	168	7278	8760
1987	293	89	145	185	15	10	97	63	9	6	[illegible]	19	49	8454	8760
1988	90	86	86	61	19	11	40	17	20	12	13	8	24	3830	8784
1989	73	78	78	63	16	8	25	15	2	9	16	4	17	8001	8760
1990	78	68	68	117	19	11	15	12	7	14	6	47	14	7673	8760
Tot	1352	1497	1497	1351	179	175	433	390	90	88	100	325	439	71955	87648
Ave	135	150	150	135	18	18	43	39	9	9	10	33	44	7196	8765

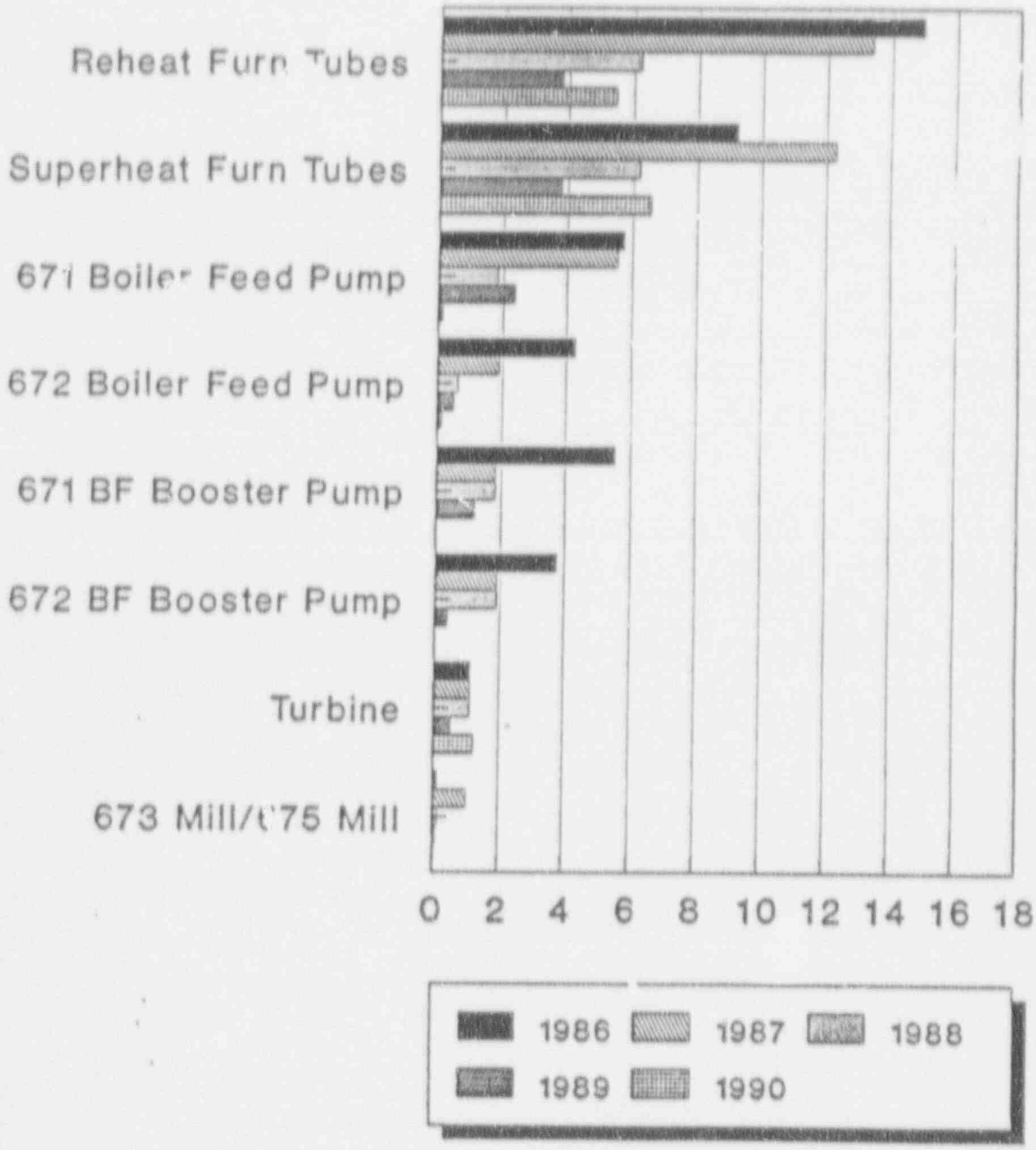
COMPONENTS WITH HIGHEST CALCULATED UNAVAILABILITIES[a]

Component	Unavailability (%)
No. 4 Coal Burner	12.6
Boiler Tubes	7.44
Group 2 sootblower	5.28
No. 2 Mill	3.83
No. 1 Coal Burner	3.68
No. 3 Mill	3.18
No. 2 Coal Feeder/Hopper	2.29
No. 1 Mill	3.13
Group 5 Sootblowers	2.2
Group 3 Sootblowers	1.76
No. 2 Conveyor	1.55
No. 3 Boiler Feed Pump	1.44
No. 2 Coal Burner	1.34
Attemperators	1.2
No. 1 High Pressure Feedwater Heater Bank	1.01
Slag Removal System	1.00
Clinker Grinder	0.98
No. 1 Hot Well Pump	0.91
No. 3 Coal Burner	0.73
No. 4 Primary Air Fan	0.418
No. 3 Primary Air Fan	0.402

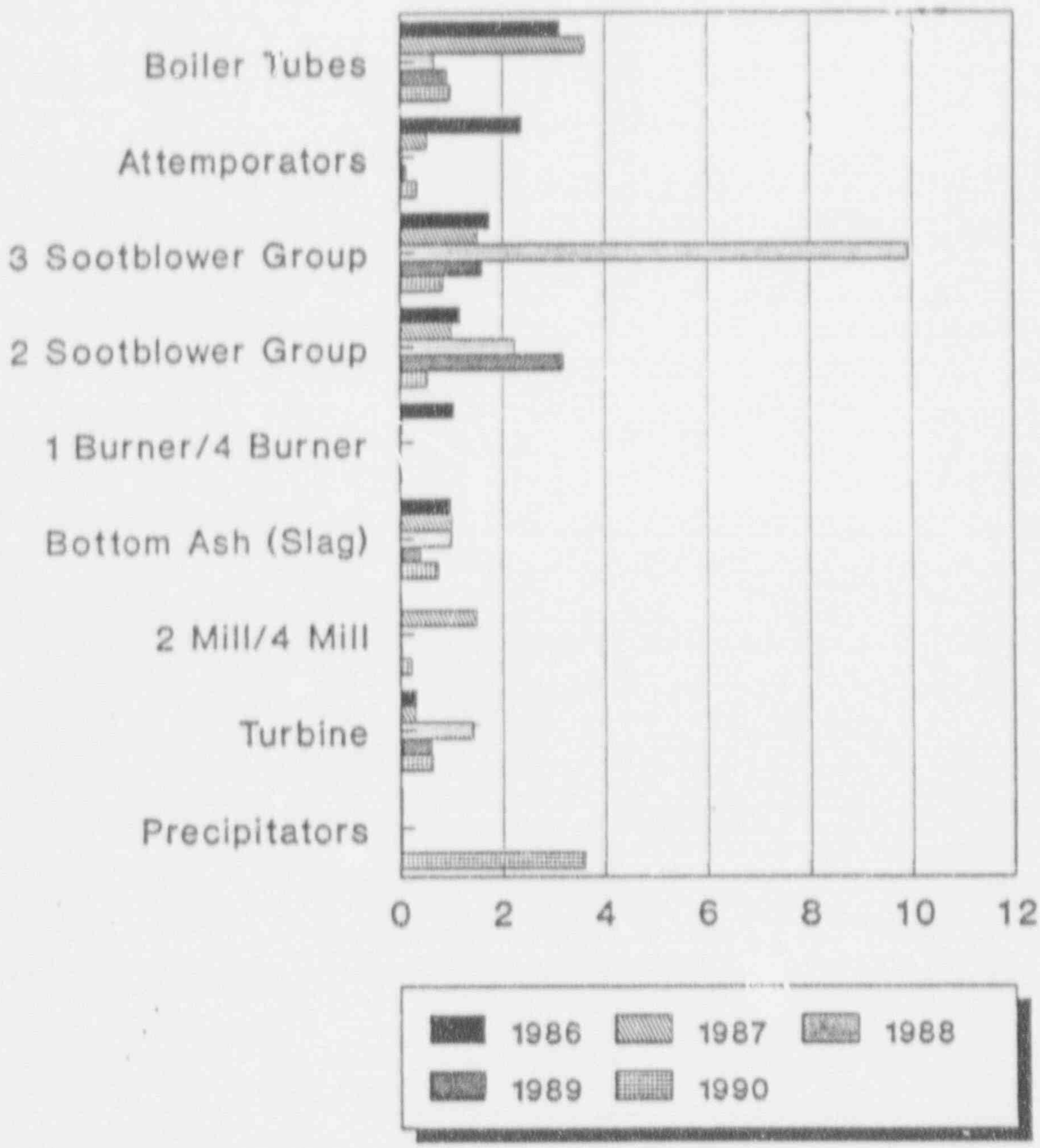
TOP 15 CUT SETS CONTRIBUTING TO 100 PERCENT POWER UNAVAILABILITY

Cut set/Component	Failure Rate (per hr)	MTTR[b] (hr)	Unavailability (%)
Boiler Tubes	0.00097	76.7	7.44
Group 2 Sootblower	0.033	1.6	5.28
Group 3 Sootblower	0.011	1.6	1.76
Attemperators	0.0013	9.2	1.2
No. 1 High Pressure Feedwater Heater	0.0023	44.0	1.01
Slag Removal System	0.010	1.00	1.00
Coal Burner No. 4/ Mill No. 2	0.000118	40.7	0.48
Coal Burner No. 1/ Coal Burner No. 4	0.0000322	144	0.464
Coal Burner No. 4/ Mill No. 3	0.0000984	40.7	0.401
Coal Burner No. 4/ Mill No. 1	0.000097	40.7	0.395
Coal Burner No. 4/ No. 2 Feeder/Hopper	0.00575	5.03	0.289
Deaerator	0.00016	15.0	0.24
Group 5 Sootblower	0.0014	1.6	0.224
No. 2 High Pressure Feed Water Heater	0.000046	44.0	0.202
Coal Burner No. 4/ No. 2 Conveyor	0.000459	4.25	0.195

Unavailability
by Component (Greater than 1%)



Unavailability
by Component (Greater than 1%)



Summary

- Improved maint./operation
- Focus on weakness/strengths
- Increased plant availability
- Reduced risk
- Improved Decisions Process
- Structural/Mech./Elect./Control
- Task Force Integration

NUCLEAR UTILITY PERSPECTIVE

ASME RISK-BASED INSPECTION GUIDELINES RESEARCH PROJECT

U. S. NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON METAL COMPONENTS

CHARLES A. TOMES
WISCONSIN PUBLIC SERVICE CORPORATION

BETHESDA, MARYLAND
FEBRUARY 13, 1992

UTILITY PERSPECTIVE REGARDING DEVELOPMENT OF AN INSPECTION PROGRAM

1ST CONSIDERATION

SAFETY

2ND CONSIDERATION

ECONOMICS

EXISTING CHALLENGE

TO APPROPRIATELY CONSIDER ALL INPUTS TO THE INSPECTION PROCESS

SUCH AS

FREQUENCY, METHOD, POTENTIAL FAILURE MODES, HISTORICAL FAILURES, FABRICATION DEFECTS, MATERIAL BEHAVIOR, LOADING, EXTENT OF EXAMINATION, ACCEPTANCE STANDARDS, SCOPE, INSPECTION SCHEDULES, RADIATION EXPOSURE, PERSONNEL HAZARD, RELIABILITY, REPEATABILITY, ETC.

NUCLEAR UTILITY PERSPECTIVE

ASME RISK-BASED INSPECTION GUIDELINES RESEARCH PROJECT

U. S. NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON METAL COMPONENTS

CHARLES A. TOMES
WISCONSIN PUBLIC SERVICE CORPORATION

BETHESDA, MARYLAND
FEBRUARY 13, 1992

POTENTIAL APPLICATIONS

- REVISION TO ASME CODE SECTION XI
- SAFETY SYSTEM FUNCTIONAL INSPECTIONS
- MAINTENANCE-METHOD, FREQUENCY, AND SCOPE
- DEVELOPMENT OF NON-ASME CODE SECTION XI PROGRAMS, E.G. -
  - Non-QA-1 Snubbers
  - Non-QA-1 Component Supports
  - Rupture Restraints
  - Valve Internals
  - Erosion-Corrosion
  - Service Water (Fouling, Sand, Pitting)
  - Impingement Barriers

UTILITY PERSPECTIVE REGARDING DEVELOPMENT OF AN INSPECTION PROGRAM

1ST CONSIDERATION

SAFETY

2ND CONSIDERATION

ECONOMICS

NUCLEAR UTILITY PERSPECTIVE

ASME Risk-Based Inspection Guidelines Research Project

U. S. Nuclear Regulatory Commission

Advisory Committee on Reactor Safeguards

Subcommittee on Metal Components

Charles A. Tomes
Wisconsin Public Service Corporation

Bethesda, Maryland
February 13, 1992

SUMMARY BENEFITS

- Proven Technology
- Process Complements Existing Requirements
- Facilitates Incorporation of Extra-Code, Regulatory and Economic Factors
- Decision-Making Refinement
- Living Process
- Enhances Strategic Inspection Focus
- Easily Adapted For Non-ASME Section XI Areas
- Can Be Used For Management of Age-Related Degradation

UTILITY PERSPECTIVE REGARDING DEVELOPMENT OF AN INSPECTION PROGRAM

1ST CONSIDERATION

SAFETY

2ND CONSIDERATION

ECONOMICS

Roadmap for ASME Task Force
Phase II - Nuclear Power Plant Components

Steps

1. Establish Safety and Risk Objectives
2. Identify High Priority Components
3. Identify General Groups of Components/Locations
4. Establish Goals for Acceptable Failure Probabilities
5. Identify Those Inspection Strategies That Can Ensure Acceptable Failure Probabilities
6. Final Selection of Inspection Strategies Based on Cost/Effectiveness
7. Identify Generic ISI Requirements (Frequency, Method - Including Probability of Detection Needs) From Trends of Pilot Studies
8. Work With ASME Section XI Members to Achieve Enhanced Inspection Requirements
9. Prepare Volume 2 - Part 2 Document

Supporting Pilot Studies

Steps 2-7 will require the following three activities

1. Risk-Based Rankings Including
   Expert Elicitations for Component Failure Probabilities
2. SRRA Calculations
3. Decision-Risk Analysis Calculations

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