UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Title: BRIEFING ON SYSTEM RELIABILITY STUDIES - PUBLIC MEETING

Location: Rockville, Maryland

Date: Wednesday, February 7, 1996

Pages: 1 - 61

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

DISCLAIMER

This is an unofficial transcript of a meeting of the United States Nuclear Regulatory Commission held on February 7, 1996 in the Commission's office at One White Flint North, Rockville, Maryland. The meeting was open to public attendance and observation. This transcript has not been reviewed, corrected or edited, and it may contain inaccuracies.

The transcript is intended solely for general informational purposes. As provided by 10 CFR 9.103, it is not part of the formal or informal record of decision of the matters discussed. Expressions of opinion in this transcript do not necessarily reflect final determination or beliefs. No pleading or other paper may be filed with the Commission in any proceeding as the result of, or addressed to, any statement or argument contained herein, except as the Commission may authorize.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

****

BRIEFING ON SYSTEM RELIABILITY STUDIES

****

PUBLIC MEETING

****

U.S. Nuclear Regulatory Commission
One White Flint North
Rockville, Maryland
Wednesday, February 7, 1996

The Commission met, pursuant to notice, at 10:00 a.m., the Honorable Shirley A. Jackson, chairman, presiding.

COMMISSIONERS PRESENT:

SHIRLEY A. JACKSON, CHAIRMAN
KENNETH C. ROGERS, COMMISSIONER

STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

JOHN C. HOYLE, SECRETARY
MARTIN MALSCY, DEPUTY GENERAL COUNSEL
JAMES TAYLOR, EDO
EDWARD JORDAN, Director, AEOD
ASHOK THADANI, NRR
PATRICK BARANOWSKY, Chief, Reliability and Risk Assessment Branch, AEOD
STEVEN MAYS, Section Chief, Risk Assessment Branch, AEOD

P R O C E E D I N G S

[10:00 a.m.]

CHAIRMAN JACKSON: Good morning, ladies and gentlemen. The purpose of today's meeting is for the staff to brief the Commission on the use of operational data to estimate the unavailability of risk significant systems in U.S. power plants. Even though the overall trends have levelled off in recent years, the performance of the nuclear industry has shown a decline in the occurrence of operational events. As the number of events decrease, we must look for alternative performance measures to monitor and track plant performance.

In addition there is a need for predictive risk informed measures to the extent possible. As an alternative approach the staff is pursuing system reliability and unavailability studies for selected risk significant systems. As part of today's briefing the staff will describe some of its reliability studies, as well as any generic implications or conclusions derived from these studies.

I am also interested in knowing what progress has been made to add or to replace some of the conventional performance indicators, with risk informed indicators. As you know I have been a proponent of risk informed performance based regulation, which allows the NRC to focus,

as well as licensees, on the most safety significant aspects of reactor operations. I recently, in fact, gave two PRA seminars, one at MIT and the other at the University of Maryland, where I actually used results from the staff's HPCI study to illustrate some the basic PRA concepts. So you better watch me. So I may have a few questions for you on these concepts.

I understand to copies of the presentation slides are available at the entrance to the room.

Commissioner Rogers, do you have anything?

COMMISSIONER ROGERS: Not at this time.

CHAIRMAN JACKSON: If not, Mr. Taylor, you and your team may proceed.

MR. TAYLOR: Good morning.

The purpose of this briefing is to convey the staff's results of its reliability analysis of two safety related systems at U.S. plants. The staff will explain how these data fit into the overall probable risk assessment program plan and specific AEOD activities in support of that plan.

With me at the table are Ashok Thadani of NRR, Ed Jordan, Par Baranowsky and Steve Mays of AEOD. Ed Jordan will continue.

MR. JORDAN: Good morning.

CHAIRMAN JACKSON: Good morning.

MR. JORDAN: The briefings that we have given over the past year connect together and I would like to try to make that connection for you. The April 26th briefing on the development of the proposed rule for reliability data is the source of credible performance data that we expect to use for this type of work and that rulemaking has gone through the review process and is about ready for publication.

We briefed the Commission in August of 1995 on a transition of the existing set of checked performance indicators to make them more risked based and to reduce the costs of compiling the data. My staff has provided me with a program plan on that ongoing development. At the time we briefed the Commission we were proposing a discontinuity or considering a discontinuity in performance indicators while we developed the risked based. We are no longer doing that as we described and we have an orderly transition, but our goal clearly is to shift towards the risk based.

In November we explained the role of the revolving accident sequence precursor program as an element of the transition and as a part of describing individual and industry safety performance in defendable risk terms.

Today we are here to provide a reliability and availability results for emergency diesel generators and BWR high pressure injection systems. Using available data

sources and state-of-the-art methods. This is the same methodology we plan to use once we have the routine collection of plant specific data. Although today we are data limited, there are already some useful insights from this analysis. The final slide will briefly describe our program plan for this activity through 1997 and beyond.

Mr. Steve Mays will conduct the briefing.

MR. BARANOWSKY: Although I will give an introductory discussion.

MR. JORDAN: I am sorry.

MR. BARANOWSKY: It is really an overview to put the system reliability studies into context with our whole program to use reliability and risk analysis to look at operating experience.

[Slide.]

MR. BARANOWSKY: We are using, of course, insights from PRA to identify what we should look at and then we are using PRA methods and extensions of PRA methods to perform the analysis. Now, we know that operating experience alone can't give us the full risk picture, but certainly using risk and reliability techniques to analyze operating experience is, I think, a good way to focus your analysis and evaluation of operational data. So that is where we are coming from, at least philosophically.

[Slide.]

MR. BARANOWSKY: The overall program's objectives are to use the operating experience to assess and trend risk indicators, to compare results of this analysis with IPEs and PRAs, to identify the technical insights that come out of those analysis, especially those that are important with regard to equipment reliability and to provide the insights to both industry and to NRC programs.

As sort of an additional added extra that comes along with this we will be providing scrutable data sources and failure rate estimates that can be used by the NRC for reliability and risk applications.

CHAIRMAN JACKSON: You did say scrutable?

MR. BARANOWSKY: Scrutable, as opposed to inscrutable. I think that is an important part of our analysis, is to make it all tractable in some way.

Let me move to view graph three, please?

[Slide.]

MR. BARANOWSKY: As I had mentioned we did talk to you in August and we provided a picture of our thinking on how we were looking at industry wide risk and decomposing it into its elements, both plant specific and also in terms of the elements that go into plant specific risk. This chart is a condensed summary of what we told you at that time and it shows a train of thought that goes and connects the system reliability studies that we are going to talk about

today to core damage frequency plant risk and ultimately some indication of industry risk.

The elements of this diagram, then, are the building blocks for what we think would be the risk based indicators that we would develop in the future.

Let me move to view graph four?

[Slide.]

MR. BARANOWSKY: This view graph shows the full set of activities that we either have planned or ongoing right now that are relevant to our perceptions of how we should go about analyzing the operational data. We talked to you, I think it was in November, about the accident sequence precursor program, so I won't mention too much about that now, except to say that both plant specific and industry wide risk perspectives can be derived from that program.

We are also in the process of compiling a reference document for initiating events, which I am not going to talk about today, but that is an important part, of course, of the whole accident sequence progression.

The system reliability studies that we are going to talk about today, were also discussed with the ACRS in November and I think they were received, the presentation was received, favorably by the ACRS.

If I could go to number five, please?

[Slide.]

MR. BARANOWSKY: Recently, we distributed a common cause failure database and some generic analysis that we had been performing for review, trial use and comment. We sent this to the staff and we also sent it to INPO. The database contains a limited amount of proprietary information from the Nuclear Plant Reliability Data System, and we have asked INPO if we could distribute this information to NPRDS users that already have access to proprietary data, because I think it is the most comprehensive set of data on common cause failure that is available now in the world.

In August we talked about performance indicators and moving towards risk and reliability data. We still have that activity going on in both the classical or traditional sense that they are currently produced in and part of this work today is an indication of where we are heading in the future.

Lastly, as I said, what goes along with all this work is, you have to have data systems to support the analysis. We did talk about the sequence coding and surge system and NPRDS earlier, and also, as you are aware from recent activity, we have been promulgating the reliability data rule which would supplement our data in a way that would allow us to perform more complete analysis of the types of systems that we are talking about today.

CHAIRMAN JACKSON: Before you go on let me ask you a quick question under the common cause failures. Where do things stand or how are they progressing with respect to the international exchange effort on common cause?

MR. BARANOWSKY: We have a couple of meetings that we have attended with some European countries and we are now trying to agree on a format for exchanging data. One of the things I want to make sure of is that it is a two way street so that we get something too. It has been a very good cooperative activity, because of the importance of common cause failure for highly redundant systems like three and four trains, the Europeans are quite interested in this since they have many multi train systems. I am hoping that this summer we can have an agreement on how to exchange that data and what protocols would be involved.

CHAIRMAN JACKSON: That would be very good. I noted that you said that we had a comprehensive data base, but the flow the other way is useful.

MR. BARANOWSKY: Yes.

MR. THADANI: If I may add to that, this is clearly one of the limitations in the technology today and for these selected components this is an important piece of work. We are also looking at that to see, in a number of day-to-day decisions that we make, how well we have captured this common cause failure data and information. So that is

one piece. The second piece is, as you noted, the PRA implementation plan and one element in that plan is the framework and part of the framework is to make sure we have methods data. So this information will be focused in that activity as well.

[Slide.]

MR. BARANOWSKY: So that is the overview of our operational data activities that are risk and reliability based.

Now, I would like to move into the topic for today, which primarily has to do with the system reliability studies that we have been working on. The intent of that work is to evaluate the reliability and provide engineering insights for risk important systems, based on operating experience. We have a set of objectives which includes trying to use actual demands or demands that are as close as possible to actual demands, along with the associated failures or unavailabilities associated with those demands to estimate reliability.

One reason for doing that is so that we cannot worry so much about problems in using piece part data in building up a model, especially when some of the interactions that might occur between equipment might not necessarily be easy to detect from some of the piece part data until one has a full integrated type of demand. In

some cases demands that are placed on equipment are not all equivalent in terms of the severity of the conditions that the equipment sees. So from the data that was available to us through LER we want to focus on actual demands.

Other elements of our objectives include, we wanted to look at trends and the uncertainty in trends so that we wouldn't be fooled by data fluctuations. Then, of course, compare our findings with the kinds of results that both PRAs and IDEs have indicated, look for any plant specific differences and see what the engineering insights that fall out of this might be.

Currently we are evaluating the reliability of systems at power and if we are to look at shutdown reliability and availability, that would have to come, I think, in the future when we have a better picture of the risk significant elements that are associated with that condition.

If I could move to view graph seven.

[Slide.]

MR. BARANOWSKY: We selected a number of systems for this program based on our observations in PRA, considering both their risk reduction and, to some extent, their risk achievement potential. So the list I show on this view graph indicates that for boiling water reactors we have a number of the high pressure coolant injection and

cooling systems that we are looking at. For PWRs we are looking at auxiliary feed water and high pressure safety injection. Then there are some systems, like low pressure injection, reactor trip systems and emergency diesel generators, that we are looking at for all plants.

Once a base line study is completed, then future updates can be prepared periodically and with a lot less effort once we have established the approach and how to sort the data.

So, with that introduction having been completed, I will turn the hard work over to Steve Mays, our Section Chief for the Reliability and Risk Analysis Section, who will discuss the methods and some of our results.

MR. MAYS: Thank you.

It is a pleasure to be back again. As it has been commented on before we started today, there is a large package of slides here. I think the number of slides are inverse proportional to salary.

CHAIRMAN JACKSON: Yours or ours?

MR. MAYS: Mine.

[Laughter.]

MR. MAYS: So I will try to get through these as quickly as I can, but I want to make sure we have the opportunity to discuss any issues that come out.

[Slide.]

MR. MAYS: The first slide we are going to talk about here is the methodology overview and what I am trying to show you here is, we have got a well thought out process. It can be applied to look into the reliability of any system. This just isn't, how many things do we have, can we put together a report type of process. So we have looked at this stuff to come up with standard methods to use things. We are doing very detailed evaluation of the events and we are using a risk perspective when we are doing that and that will become clear as we talk about some more things later on.

So we have looked at this stuff to come up with standard methods to use things. We are doing very detailed evaluation of the events and we are using a risk perspective when we are doing that and that will become clear as we talk about some more things later on. We are having a rigorous mathematical treatment of the data and we have detailed analysis reviews, including peer review both as part of our contractor reports that are being done as well as internal to the agency and also sending information to the industry as part of this process.

CHAIRMAN JACKSON: When you say independent peer review, is that through the usual publication route or do you actually have --

MR. MAYS: We have a panel of resource experts

that we have contracted outside of the normal work on this to come in and review the work and give us insights and comments and we have used that as part of our process as well as meeting with other people in the agency. We sending our reports, as we get them, out for comment to industry groups as well.

CHAIRMAN JACKSON: Have you had any interactions with the ACRS?

MR. MAYS: We have made the presentation last year at the ACRS and gave them basically the HPCI presentation which you are going to see in this. That was fairly well received.

Going on to the next slide.

[Slide.]

MR. MAYS: On more detail about the methodology approach, you will see this pattern develop in the slides that follow as well as in the reports that we provide. We start with defining what our system boundary is, or defining we are going to get data and what data we are going to consider. Then we get the information from licensee reports and characterize it.

There are three sub-bullets under the characterization heading. We found that data tends to be reported as either inoperabilities and then there are among those inoperabilities where you actually lose the safety

function. Then there is another subset of that which is safety functions are lost, where we can corresponding what counts excesses and demands. I will talk about that a little bit more on the next line.

We also then determined the failure probabilities and we do this using Bayesian techniques and we wanted to characterize the uncertainties, not just come up with maximum likelihood estimators. We combine that information in simplified fault trees to produce our results. Then we do our trending and our comparison analysis after that. You will see examples of all of these as we go through the slides.

[Slide.]

MR. MAYS: This is a slide that I want to make some emphasis on about the data set relationships. That is slide ten.

If you look at this thin diagram, which we kind of refer to it as the reliability egg when we talk about it, there are three areas in which failure in information comes in.

The first one is, cases where it is declared to be inoperable in an LER and not all inoperabilities are equal. Sometimes you will get inoperability because somebody hasn't done their surveillance testing in the required interval. That doesn't mean the system couldn't have worked. It means

we had a technical inoperability. So we have to go through and screen the inoperabilities to get down to the cases in that Area B there, where the safety function of the system is actually lost, it is not going to work because it is just broken.

This is an important point also. When you are doing reliability analysis, it is a function of both the failures and the successes. So having failure information is a necessary contributor, but it is not a sufficient contributor in order to do reliability. So we have to go down to a subset of that data. That data is failures where the function is lost, but where we can also have a corresponding demand count, so that we can count the successes as well as the failures. That is to have us have an unbiased sample of these data so that we can produce reliability analysis that make sense.

Of course as you get to smaller and smaller data you have sparser data and that causes you to have a greater uncertainty balance associated with your estimates.

[Slide.]

MR. MAYS: Moving down to the next thing, I want to talk a little bit about techniques that are employed throughout these analysis. We are using Bayesian and updating techniques to estimate our parameters for reliability and the associated uncertainty. There are three

basic methods of using Bayes techniques that we use and I will discuss each of them a little bit for people.

The simple Bayesian method is where we start with a noninformative prior and take that information and use the actual plant failures and success counts to come up with an estimate of the uncertainty. We do that because the noninformative prior allows us to have uncertainty intervals that are predominantly due to the data density of the information network we are gathering, rather than some other artificial constraint.

COMMISSIONER ROGERS: Could you just explain that term a little bit? When I read that I couldn't think of anything except somebody who lived in a monastery.

MR. MAYS: Actually, Reverend Bayes did live in a monastery. As you know, he was both a theologist and a mathematician in the 1700s. The Bayesian approach to updating is an inference approach that says that you can determine the likelihood of some event based on your prior knowledge as well as your current information that you know. A mathematical technique was developed by Reverend Bayes and published in about 1764, I believe, two years after he died, actually.

The noninformative prior means that you start off with a distribution that does not give you any specific information about what the failure probability is, It is

equally distributed between zero and one, which means is basically has a mean value of .5. Subsequently, because of the spread and the uncertainty, when you do the update, the resulting posterior distribution has an uncertainty that is primarily a result of the density of the data you have.

For example, if you had one failure in ten events you would have a mean estimate of .1 and you would have an uncertainty associated with that. If you had 100 failures in 1,000 estimates you would have the same mean estimate, but because you had a greater data density, the uncertainty around that estimate would be much smaller. So this is the technique for being able to do that properly.

CHAIRMAN JACKSON: You know, in doing these calculations there is some, I guess, choice or flexibility in terms of probability distributions. I am familiar with the gamma distributions and the beta distributions. So what you are talking about really has to do with the way these parameters get fixed and that not only tells you what the means are, or tied to the means, but tells you what the confidence in them would be. I guess, I was going to ask this later, once you talked about the HPCI system and the diesel generators, but more HPCI because that is the one that I am more familiar with. That is, how sensitive are the results to distributional assumptions, in terms of either the type of distribution that is chosen or how the

parameterization of the given distribution is determined? What I am trying to say is, if one went from using the sort of standard gamma/beta distributions that people use, to Wyble or some other distribution, the question is, how much change?

MR. MAYS: What change to the results are going to take place? That is a good question and, quite frankly, we haven't done a sensitivity analysis of that type. We used beta distributions for demand type information and gammas for hourly type distributions. That is a fairly standard process and we didn't go back and look at Wyble or other distributions as a function of that. I would have to get back to you. We haven't gotten to that point.

CHAIRMAN JACKSON: No, that was a question. I was just wondering. Maybe if you could when you go through with talking about the HPCI studies, given the distributions you did use, how sensitive are they to how they are parameterized, but I'll just listen.

MR. MAYS: We did look at how to look at the uncertainty in a way that would maximize it, for instance. Then we also looked at differences between using simple Bayes and empirical Bayes. So we did a number of calculations and we also asked ourselves does this result pass the sanity test, because you can put in any prior distribution that you want and, therefore, you can make the

result come out any way you want. So what you have to come out with is a result that makes some sense, too, and we did some of those kinds of analyses.

CHAIRMAN JACKSON: Okay.

MR. MAYS: The next technique that we used in the analyses was empirical Bayes approach. Basically what we did here was we started with a population information which would generally come from the simple Bayes analysis of an individual group and then we would discover and look for variations within the group that would indicate that there was some significant plant-to-plant or failure-mode-to-failure-mode or other types of variation within that population. When we found evidence of that information we would go and use an empirical Bayesian update to do the plant specific or the year-to-year variation. So we start with the population information and then we take the plant specific information and do an update of that population information to come up with the plant specific estimates.

One of the things that we are trying to do here is do trending information as well. We found that the constrained noninformative prior approach, which is described in the reports, was what we wanted to do there, because if you use either the simple Bayes or the empirical Bayes you can get some misleading information about either the mean estimates or the uncertainties when you do

trending. You start with a population in information which can have a fairly tight uncertainty band associated with it, because there is a fairly high density for seven years worth of operating experience. If you then want to go back and look at the variation in the performance on a year-to-year basis, each year has a very limited amount of operating experience compared to the total. So if you used an empirical Bayes approach you would be artificially constrained by that uncertainty from that data density.

So what we would do is we would use the mean estimate that came out of the population results and then we would diffuse the prior, so that we would have the maximum uncertainty associated around with that mean, so the subsequent updates would be a function of the density of the year-to-year data rather than a function of the density of the total. So we used that process to do trending analysis.

With that brief introduction to Bayesian techniques, incomplete as it is, I would like to go on and talk about the high pressure coolant injection results.

[Slide.]

MR. MAYS: The first view graph here is just a picture of the system with dotted lines around the areas for which failures were not included in the data analysis and that is a fairly straightforward look at what we did.

[Slide.]

MR. MAYS: The next slide illustrates the reliability evaluation model we did. There are a couple of points I would like to make about this because they are important to how we do this in this evaluation as well as in the diesel generators. This isn't a standard fault tree. It doesn't list every component in the system. This is a hierarchical model of how the system would operate and we only break it down to the level in which we have data that indicates there is a significant difference in the population of the data and how they perform.

We start off with a basic system model, it says. It doesn't start, it doesn't run or it was out of service and wasn't available, that is our basic starting point. In the HPCI case we looked at the data and found we had to break that down further, because we found differences in the population information about injection valve operation as opposed to the rest of the valves and pumps in the system and we found differences between the run information and the start information. So we had to break the model a little further down than the more basic one, but that is the basic concept that we use for doing this.

Our concept when we pool information together in the populations requires three things. It has to have the same statistical population when you look for the failure rates. We also have to have similar demand requirements for

groups of components. So if something has a tremendously different demand than another one, you wouldn't group them even if they statistically looked like they had the same failure rate.

The other one is, we have to see similar failure experience so that the nature of the failures in a population appear to be common to one another. So those are the requirements we have for pooling or breaking apart information from the data.

[Slide.]

MR. MAYS: The next slide talks about the actual data information that we derived from the failures and success information we were able to find and the associated Bayesian intervals and this is the information that gets fed into the basic events in this reliability model to come up with the overall system unreliability estimates.

CHAIRMAN JACKSON: You are using gamma?

MR. MAYS: The starting point on these was the simple Bayes with noninformative prior for these estimates. So you can see from this, for example, that we had about 63 actual unplanned demands for the HPCI system over the seven year period to actually start and inject into the reactor. During that time we had one maintenance out of service event where it wasn't available to do so.

The significant other differences I would like to

pull out in this, if you notice, under the failure to start, other than the injection valve, there is a significantly higher number of demands. That is because we were able to determine that the cyclic, once every 18-month, test of the system where you put an actual emergency system on to the system and start it up into full flow through the re-circ line, was very similar to the kinds of things that were happening from an engineering and a statistical standpoint, from the actual unplanned demand. So that gave us more data that was appropriately poolable. So under those conditions we have a higher number of demand and we have failures that are listed for that set and the Bayesian intervals are on the right-hand side.

There were a couple of other things we found as well. We found that the failure to start associated with the injection valve represented a different population so we separated that.

A couple of other points that are important are, we looked at the fact that the operating experience told us that many of these failures had some recovery probability associated with them and recovery in this case was recovery in a PRA sense. The recovery was fairly quick, it was from the control room, it would be part of a simple process.

For example, the recoveries associated with failure to start in this case, or three of the cases, where

the turbine control valve was operating erratically so they put it in manual and that solved the problem. That was done from the control room very quickly and it didn't cause the system to trip off. So we also included in the model the information about whether or not the failures were recoverable based on the operating experience and included that as well.

We had failure to run information, although most of the runs of the HPCI system in the operating experience were fairly short duration. So we used basically a demand probability type evaluation for failure to run on the HPCI system.

The last one at the bottom of the page was something we found from the operating experience and was interesting to us as well. We found that there was a different population and a different experience associated with the injection valve reopening.

Some HPCI systems get used in a pressure control mode or an intermittent injection mode, in which it will inject the first time and the injection valve is closed the recirc valve is opened and then will subsequently be reopened later. We found that that had a different reliability associated with that.

We also looked at the PRAs and found that most of the PRAs model the HPCI system in a single injection mode.

So when you go to do comparisons you have to make sure you have the right comparison information in order to do that.

[Slide.]

MR. MAYS: So the next slide represents the HPCI system unreliability results that we found from this application of the data. What you can see is that the overall unreliability was about .056 and the major contributors to the unreliability based on the operating experience were maintenance events and failure to run events that were not readily recoverable.

Again, there is an issue that comes up here, because of the data density we only had one event in which we had a maintenance out of service out of 63 demands. So that is fairly sparse data, but we were capturing the uncertainty associated with that because we were using the appropriate techniques to indicate that that wasn't very dense data and we were combining this stuff with the uncertainty so that we get an appropriate estimate of the unreliability.

Subsequent to that we were looking at trend information about the reliability of the HPCI system. This next view graph shows three different trending efforts that we did.

[Slide.]

MR. MAYS: The one on the top left is to look at

the unplanned demand rates that the plants were experiencing during this time period. The top right is the failure rates, which is the number of failures per year without regard to whether there was a demand. The one at the bottom is the unreliability, where we are pairing up and matching failures with demands and successes to calculate unreliability.

The trends that you see for both unplanned demand rates and system failure rates decreases were statistically significant trends, indicating that was not just fluctuations in the data. When you get to the system unreliability calculation you find that the reliability trend is fairly flat and there is no statistically significant difference between what is shown on this diagram and the assumption of a completely constant failure rate over the time period.

The unplanned demand rate and the failure rate are similar information to what we have in the PI reports. We report safety system failures and safety system actuations. In the performance indicator reports we had seen both of those indicators going down over previous years. So this information tends to support that the HPCI system was behaving in a similar way that the total population was from the PIs, but the unreliability is saying that in spite of the fact that we are having some of these things go down,

the reliability hasn't really been changing over this period of time.

The next thing we went to do was take the reliability information that we had from the HPCI report and compare it to what kind of information we were seeing in the PRAs and the IPEs. This block, which is fairly busy, but it was the best way to put the information together completely, I guess. We had to go and look back at our data and look at the information that was in the IPEs and come up with a set of comparable models. So we had to do some manipulation.

So the first caveat I want to say is that, if some plant comes in and says, from this graph, you said my HPCI system was such-and-such, but my PRA said it was different, my answer is, you are probably right. Because what we did was, we went into their IPEs and PRAs and pulled out the equivalent failure to start, failure to run and maintenance out of service information from their data and put it into the similar model that we had and did the comparison there. So we would be comparing apples to apples rather than apples to oranges. We found that different plants would have different rules for how they would do things, such as consider recovery, how they would model whether something was a failure or not. So we had to go back in and pull information out of the IPE submittals to do this. So I want to make sure you understand this is a synthesis, not a

direct pull out of the unreliability from their PRAs.

In doing so, you can see at the bottom of the chart there is the industry population value that we calculated and the dotted line up the chart gives you the mean of that distribution that we calculated. The diamonds on the chart and their bars are the empirical Bayesian update of the plant specific information and the asterisks with the bars are the information derived from the IPEs and PRAs.

What we found was that there was fairly good agreement on very many of these comparisons, but we did note that there were several where the mean values either didn't have uncertainties associated with them or both that and the mean values were falling outside of the intervals that we were seeing from the operating experience. What that tells us is that there is something different about what was in there and what we have. That doesn't mean that either one of them are necessarily wrong. It means that there is something that needs to be understood.

If you are going to be taking actions in the regulatory sense, that is based on something on PRA associated with those plants, you need to know what the basis for the models and the reliability were. That was beyond the scope of what we could do in this analysis, but at least points us in the right direction if there is an

issue that comes up with respect to any of these particular plants or systems.

CHAIRMAN JACKSON: So what are your plans relative to, that you are just noting that these differences exist? Have you in any cases been able to discern what the source of the deviation's sources are?

MR. MAYS: We haven't gone back and expended a lot of energy trying to determine what the differences were in this analysis. We did in our transmittal letter, to both NRR and research, when we transmitted this report for information and use, note that there were the differences and indicate that for the research people who would be doing IPE reports to use that would be interesting information. For the NRR people who would be making a decision about whether somebody could or couldn't do something based on some risk argument associated with these systems, we felt that it was important to let them know that they had some information additional to use other than just whether or not somebody had done a PRA.

I think it is an issue that we haven't decided yet what the overall process is going to be, but we have been talking with the NRR and research people as we get these results and transmit them over as to what the implications of this is.

CHAIRMAN JACKSON: Dr. Thadani is preempting me,

he knew I would ask him the question.

MR. THADANI: Let me comment on that. I think there is a lot of very important information on this just one single chart. First, it raises obvious questions about how the plant specific data are used or generic data are used and how these data are actually manipulated in the models, in these IPEs. I think, in my view, on HPCI there are enough differences here, 7 out of 23 plants are clear outliers. I mean, there is a real question about those plants as the minimum as to how they handle the specific scenarios. HPCI system in these plants is a very important system. So we have got to home in on that issue, as one piece.

The second piece is, we use this information and we haven't got to HPCI in a big way, but we did do that with the exterior feedwater system study that AEOD had done earlier, to focus our inspection attention for areas where we saw some problems. So we decided to go do some focused inspections for our auxiliary feedwater systems.

Another way we used this information is, if there are plants where there are a number of issues that indicate we need to pay more attention to those plants, this element just adds to that need to focus on some of those plants. In fact, we at the recent senior management meeting there were some plants on this list we talked about and we indicated

the need. There is an action item that came out of the senior management meeting that NRR needs to follow up on this issue.

This is the issue related to not just HPCI, but HPCI, reactor core isolation cooling system, which is the other high pressure single train system that earlier BWRs have and then the emergency diesel generators. You have to look at these in total, because that is your protection from some scenarios.

CHAIRMAN JACKSON: Can I sort of try to, for my own purposes, paraphrase what you said? You are saying that particularly in the cases where the data indicates outliers, that gives you an ability to focus a number of activities?

MR. THADANI: Exactly.

CHAIRMAN JACKSON: It is both inspection efforts, as well as, where there were plants that were under discussion anyway, to kind of do a cross feed?

MR. THADANI: Yes, the sensitivity goes up.

[Slide.]

MR. MAYS: Going on to the next slide, one of the other things that we did in each of these studies was to look at the trends associated with the age of the plant. What we did here was we mapped out the failures per operating year associated with the plant low power date over this period, as well as the unreliability estimate on a

plant specific basis. Then we plotted it out against its low power license data and fitted the trends to it.

Neither one of these trends is significant. We found that the unreliability was not significantly different for either the older or the new plants and the failure rates were not significantly different among the older and the newer plants, over the seven year period for which this study data was put together.

[Slide.]

MR. MAYS: The next slide looks at something we did when we started looking at the nature of the failures and the kinds of breakdown that they have. We found that there were differences between the method of discovery of the failures and what proportions they were coming out at.

Doing that, I want to make a caveat in here. The unplanned demand information is about, depending on which system you go to, anywhere from 5 to 20 times less opportunities than there are in the surveillance test and other operational occurrences. So you need to be aware that the percentages here are relative to the number of events in each category.

What we did find was that among the unplanned demands for the HPCI system to operate and the failures that occurred during those unplanned demands, they were split about 60/40 between turbine and control valve issues and

other valve issue and other parts of the piping system.

We had no unplanned demand failures in which the instrumentation and control systems contributed.

When we looked at the surveillance test and operational occurrences, the relative nature of the failures found by those particular types of discoveries were different from what we were seeing in unplanned demands. What that indicates to us and we indicated when we transmitted the report was that, it seems to me that there is a potential for looking at what the focus of the inspections are and the other operational occurrences are, with respect to the events that are effecting the reliability.

We have been talking with the inspection people as we have gone through this. We don't have enough information just from HPCI and diesels to know whether this is s systemic issue or one that only effects a particular system or a group of systems. We have been meeting with them and going over the results of what we have had so we can try to come up with an understanding of what this stuff means and whether or not there is something we need to do with respect to either our inspection programs or the way we go about looking for failures.

CHAIRMAN JACKSON: That is an interesting set of comments, because the thing that would leap out at me, that this is your business, but you look at a surveillance test

and the question is, is the surveillance test making the same kind of demand as what might occur in an actual unplanned demand.

MR. MAYS: That's true and there are different natures of tests and demands that you can go through. There are tests that determine maximum capability. There are tests to determine just the fact that it is still on an operable state and isn't totally failed and there are tests associated with reliability and they are not always the same thing. So failures associated with those may be telling you different information and that is what we think we are seeing here. That is why it is important to understand what those things are telling us and we are going to be working with the inspection program branch to go over and look at those things.

MR. TAYLOR: We worry about that, because the surveillance test is supposed to provide the type of start. Let's not have preconditioning so to speak. Let's face, will the equipment operate? So it is a very interesting line of thought.

MR. THADANI: I think Mr. Taylor is exactly right. For HPCI, for example, I think to illustrate this issue, there are basically three surveillance tests that are done. HPCI is a turbine driven pump, single train, and every three months you are supposed to make sure that the pump can come

up to speed and deliver the rate of flow. You can do that in different ways. The injection valve just doesn't open like a real demand. You can crack it open. It is not the real challenge during that quarterly test. The other test you do is at lower pressure, because you want to make sure that you can deliver flow when the pressure goes down. You can only do that when the plant is going down, shutting down.

The real test that challenges the system is, quite frankly, done only once during shut down, because that challenges all pieces of the high pressure coolant injection system. What we need to do at this point, so that perhaps everything we are doing in the area of INC is well focused, it seems to be leading to some real good results, but maybe other areas we had better probe a little better than we have done.

[Slide.]

MR. MAYS: The next chart is just another break out of the HPCI discovery and instead of by pieces of equipment is whether it was fail to start or fail to run issues. Similar conclusions were reached about that information.

[Slide.]

MR. MAYS: To move now to slide 21, and talk about the overall HPCI insights. We have discussed most of these

already, but this is just a list of the significant issues that we discovered. There wasn't a discernable trend in reliability, even though the failure rates and the unplanned demand rates were going down and we didn't find any variation in reliability due to the age of the plants.

We had some exceptions from the IPE/PRA comparisons, but there were a lot of them where they were comparable. We found differences, as we just discussed, between the actual demands and surveillance inspections.

Another interesting piece was that during the unplanned demands, all failures to start that actually failed during unplanned demands, all of them were recovered. The maintenance and testing out of service was important, but again that was 1 failure out of 63 demands, so there is some uncertainty associated with that. The injection valves and the turbine failure to run were dominant contributors to the unreliability.

With that I would like to move on to the emergency diesel generator.

CHAIRMAN JACKSON: May I make two comments?

MR. MAYS: Yes, ma'am, or three if you would like.

CHAIRMAN JACKSON: Thank you. Actually, the insights are also interesting. I mean, as you say, you have sparseness of data relative to the maintenance and testing out of service, but that and the bullet above are

interesting, because, as you point out all the failures to start from actual demands were recovered. Many times that requires operator intervention and, of course, that is why people run plants. It does point out the sensitivity of both maintenance and people in all of this.

[Slide.]

MR. MAYS: The diesel generator information will follow the same format we had for the HPCI information. The first diagram there is just an explanation of where failures would occur that would have been considered in the analysis of events.

[Slide.]

MR. MAYS: The next slide is the diesel generator evaluation model. The biggest difference between this and the HPCI model is that we basically didn't need breakdown within failure to start and failure to run any particular components that showed a different population experience. There were some other issues that came up in the diesel generator report and evaluation that are important. They have to do with the data reportability.

There were some differences in the data between plants and it turns out, thanks to some help we got from NRR in understanding what we were seeing, we were able to determine that it had to do with the reportability requirements associated with diesel generators, which

affected not only the reportability but also the nature and kind of tests that were being done. Reg. Guide 1108, which was promulgated in 1997 --

CHAIRMAN JACKSON: 1997?

MR. MAYS: Excuse me, 1977, I can't even read straight. In 1977, it discussed the testing and reportability of diesel generators. Of course, as it came out in 1977 it didn't apply to all plants, because there were plants that already had licenses. It was subsequently incorporated into Reg. Guide 1.9 in July of 1993. What we found was that there were differences in the population of plants and the nature of the failures associated with testing.

So we had to divide the group of plants up into those who were reporting under Reg. Guide 1108 and those that were not. So those who were not reporting under Reg. Guide 1108 had significantly less information for which we could do analysis. So this again, doesn't mean that the data wasn't existing. It just means that if we needed to get it we would have to go out to each individual site and pull out information out of logs. For those of us who have done that in PRAs in the past, that is called data dog. So it is difficult and time consuming work to do at that level.

This also points out one of the issues that we raised in the reliability rule. You will notice that the

structure we asked for in the reliability rule about the nature of the demands, the failures associated with those demands, there is a consistent theme throughout all of this information. Here is an example about how the reportability requirements can effect the ability to do that, because you may not be able to associate demands and failures in an appropriate way to do unreliability. Subsequently, the results of the numerical analysis I am going to give you after this are all associated with the plants reporting under Reg. Guide 1108, which is about half the plants.

[Slide.]

MR. MAYS: The next slide gives an indication similar to the table from HPCI about the failures and demands and the associated Bayesian intervals. There are a couple of differences on here that I would like to point out and some similarities. You will notice that failure to start, for example, we were able to use the cyclic tests that are done once every refueling outage to start the diesel, load it and have the sequencer go through all of its steps to verify that the diesel can start under an emergency start condition and load all the appropriate loads.

So we have many more demands for failure to start associated with that than we do for actual unplanned demands, of which are about a factor of ten to one difference. We had two actual failures to start during

actual unplanned demands, neither one of which was recovered. So that affects our recovery probability number. We did also find three different failure rates associated with the failure to run information that we were able to generate and so the numbers on the right-hand side, the Bayesian intervals, are actually failure rates derived from the information about the failures per demand within each time period.

During the failure to run events, we had three events where there was a diesel that was required to be operating and it failed while it was running and in all three of those the diesel was recovered. That led us to the results that we have here on the next slide.

[Slide.]

MR. MAYS: The population of the plants reporting under Reg. Guide 1108 have an unreliability of about .44. That is a 95.6 population reliability average. There is a couple of important things to look at in here. You will notice that the maintenance out of service in this case is 3 percent of the total of the 4.4 percent unreliability in here. So that is a fairly large contributor. If you take that 3 percent out, then the reliability of the diesel generators in this population is around 98.6 percent. That tells us that the machines, when they are available, are operating fairly reliably.

There are some station blackout implications, station blackout rule implications that we can talk about either now or when we get to the end of the slide.

CHAIRMAN JACKSON: Just won't forget.

MR. MAYS: I won't forget. It is on there, I won't forget. So let me press on to some of the other things, because I think that is an interesting discussion that we need to talk about.

We did the similar trending information with the diesel generator information as with respect to the unplanned demand rates and failure rates and unreliability. We again found the same thing, unplanned demands and failures were going down in a significant fashion, but the unreliability estimates over the same time period were flat. So this is another indication of how you need to have both failures and successes in order to understand the reliability and risk implications of operation.

[Slide.]

MR. MAYS: The next slide demonstrates the different failure to run rates that we found by plotting out the failures associated with the time within the runs in which the failures occurred. You will notice within the first half-hour there is a number of failures that indicates a different failure rate than the other three periods. That was the basis of this plot for coming up with three

different periods for evaluating the failure to run information.

Most PRAs either use a single failure to run number or they will use one for short and a second one for later time periods and there will be an effect of that you will see on the next slide.

COMMISSIONER ROGERS: Just before leaving this, I thought this was a very interesting slide, but I certainly didn't understand it. I mean, I can understand the first half-hour situation, but why after a diesel generator has started and loaded -- I assume to run involves loading as well?

MR. MAYS: Yes, sir.

COMMISSIONER ROGERS: That there is an increase in the failures, I mean, once it is running, these things, the generators, are very reliable once they start running. So the failures are coming from what? Not from the generator itself, presumably, but from some of the other loaded equipment or what? I mean, I just don't understand what is happening here, because once you start a generator and it starts running, five hours is nothing.

MR. MAYS: Actually, the failure rate is going down as you go up in time, the rate is going down. We did experience some failures. We found they were broken off in a couple of groups. Some of them had to do with voltage

regulator and controls of that nature, that after a certain number of hours would start to degrade. We found some issues associated with cooling water or lubrication oil that would be leaking or perhaps become a problem later on down the line. There were a number of different causes associated with this information. I don't have the specifics of that with me right now, but that information is in the report that we have, to discuss where the fail to runs came from.

COMMISSIONER ROGERS: But the diesel generators are more reliable, in terms of running reliability, as time goes on, not less reliable. This is a cumulative plot which could be misleading. The failure rates are dropping off in time.

CHAIRMAN JACKSON: Well, the slopes tell you that.

COMMISSIONER ROGERS: Right, okay.

[Slide.]

MR. MAYS: A comparison with the diesel generator reliability information from operating experience and the information we were able to pull out of the IPE/PRAs are shown on the next view graph. There are three distinct groups there. The bottom is those in which the PRAs indicated a six-hour mission time for their diesel generators. The middle one is for those with PRAs that had eight-hour mission times and the ones at the top are for 24-

hour mission times.

You notice that the information from the PRAs matches up fairly well with the operating experience that we were able to observe. The differences are all primarily in the 24-hour ones in which the PRAs generally had a worse reliability number in their models than what we were seeing from the operating experience. We went back and looked at that and it appears that the failure to run numbers that they were using for 24-hour mission times were more along the lines of what we were seeing in the middle period rather than in the period from 14 to 24 hours. We believe that is primarily the reason why those are lower.

Looking at the trends associated with the age of the plants, we found some really interesting information here. What we found was that, when you plot the failures per diesel generator year, you will notice a trend that is going upward as the low power license date gets closer to the present, meaning that we were seeing statistically higher failures per year for the newer plants than we were seeing for the older plants.

When we went back and looked at that there is a couple of factors that influenced that. The first one is that this data set that we were using was from '87 to '93 and there were a significant number of new plants that come online in about that time period, or were new just before

that. Also, when we looked at the plants that had the higher failure rates we discovered that a lot of them had situations where there were designer installation errors that were being detected early on and were subsequently, because it was under 1.108, had to do accelerated testing. So we were finding a lot of failures that were occurring early in the period of analysis and were subsequently, in the later years, not reoccurring.

So we would see two or three different failures of a similar nature in the first year or two and then, subsequently, we would see less. That is another reason why some of the plants in the '80 to '90 time period were showing higher failure rates there. When you go back and take the failures and match them up with the successes and demands and plot the unreliabilities and put the trend through there, you don't see any statistical information that indicates that the reliability of the older plants in this population was any different than the reliability of the new plants.

Again, it is another case of where you need to look at the whole picture and not just the failures in order to be able to understand what is going on.

[Slide.]

MR. MAYS: The insights that we drew from the diesel generator report were, again, that there was no

discernable trend in the reliability over the period of study, even though failure rates and unplanned demands were both decreasing and we did notice a higher failure rate for the plants that were in the 1980 to 1990 licensing period.

We did discover the three distinct failure to run rates and we felt we had pretty good agreement between our operating experience and the information from the IPEs and the PRAs. We did find some similar differences between the actual unplanned demand failures and the routine surveillance inspections as we did with the HPCI system. We did find that the failures to start on actual unplanned demands for the diesel generators were not readily recoverable based on the operating experience as compared to what HPCI was.

We did also look, because the diesel generator analysis here is on a train basis, the plants all have one or more of them or two or more of them I should say, and so an important part of our look was to look for common cause failures associated with this data. We found no common cause failures in multiple diesels during actual unplanned demands. Of course, with only 100-and-some-odd unplanned demands we weren't expecting to see any, based on what our current assumptions are about common cause failure probabilities. We did see some common cause failure events in some of the surveillance testing information and that

information is incorporated in the analysis and in the results.

The demand reliability, failure to start failure to run information is consistent with the station blackout rule assumptions for the plants reporting under Reg. Guide 1108. The interesting part of that is, when the Reg. Guide was written and the analysis was done for the station blackout rule, the indications were that unavailability due to maintenance out of service for testing was in the ballpark of 7 times to -3. We are seeing 3 percent, which is about four times higher than that.

However, the 95 percent reliability targets and the 97-and-a-half percent reliability targets were based on the assumption that the maintenance out of service was fairly low and we are seeing a higher maintenance out of service, but we are seeing a lower failure to start failure to run contribution now than what was present when the analysis was done to station blackout rule.

The net effect is that it is about a wash in terms of individual train reliability, but I think it is important to know, also, that maintenance out of service to the overall mission when you have multiple diesel generators, because you don't have the same common cause contribution associated with maintenance out of service that you would from failure to start or failure to run events. So it is a

complicated situation with respect to how much maintenance out of service is allowable or tolerable, because you have to go again and go back and put the whole model together in order to be able to appropriately deal with that issue.

COMMISSIONER ROGERS: That seems to say that that is a tough job for a licensee to do.

MR. MAYS: Actually, what it seems like they are doing is balancing off maintenance out of service versus reliability, such that you do more maintenance while the diesels and the plant is operating to keep it in a reliable state so that on demand it is fairly reliable. That is somewhat speculative on my part, but it is not surprising to see things like that occur.

MR. THADANI: There are two parts. Clearly, one part is the issue of station blackout and what were the assumptions. The end results may turn out to be okay, but nevertheless there are plants, as Steve said, which have established goals of higher reliability, such as 97.5 percent. The maintenance rule requires that the licensees balance unavailability and unreliability.

That is, if you have a system that who's unreliability is ten to the minus three and you are maintaining it 30 days in a year there is something wrong, because you are very likely going to get in trouble when that system is under maintenance. So there is explicit

requirement under part 8.3 of the maintenance rule. Each licensee is to track data basically, information, to see are they seeing trends is unavailable due to maintenance well above what they would want. They need to balance these. I think time will tell how well that is really working. We need a little more experience with that to see how well it really works in practice.

MR. MAYS: When we compared the results of the plant specific unreliability estimates excluding the maintenance out of service portion, we compared the failure to start failure to run probabilities against what the plants had committed to, whether the 95 or the 97.5 percent targets, we found that when you don't consider the maintenance out of service aspect all the plants would meet a 95 percent target, based on the mean value of the plant specific distribution from the operating experience and that 18 of the 19 plants over this period of time would meet the 97.5 percent target. The one plant whose mean value of its distribution was below 97.5 was at 97.1 and the range of the distribution was up to 99 and down to 94. So it is not that terribly significant a difference.

We also looked at the maintenance out of service associated with shut down as opposed to operation and we found that there was about a three to four times higher maintenance out of service on demand, on reliability

associated with diesel generators and shut down, as opposed to in operation.

So having looked at those two system reliability and performance information, we would want to talk a little bit about where we see this information going and we discussed a little bit of it as we went along already.

We think that the reliability information from these system studies can be used directly in risk assessments and licensee performance whenever we have this information and want to look at how somebody is performing on any particular issue. As we talked to you back in August, this is the kind of information we had in mind when we talked about going to more risk based performance indicators.

The other thing we want to do is, both the agency and the industry often have programs to improve the performance of systems or components or other parts of the plants. This kind of analysis technique is useful for determining whether the risk and reliability really have been effected by what the program is hoping to accomplish. So this is a process by which we can track data and see whether or not we are getting the gains we were hoping to get or whether or not we have a different problem.

We have been talking before. We have been meeting with the people from the inspection branch and giving We

have been talking before, we have been meeting with the people from the inspection branch and giving input into them as to what we are seeing in these reports so we can have a basis for investigating further into the data to determine how this information might feed into inspection programs and other activities associated with that.

Also, as we talked last year in the accident sequence precursor meeting, we are moving towards more plant specific and better, more detailed models in doing our action sequence precursor program and those models are being used in other applications as well and we anticipate plant specific type risk information would be appropriate to put in those kinds of models.

CHAIRMAN JACKSON: Before you go on, and you did allude to this in an earlier comment, but I note that with your uses you have talked about the input to the inspection and licensing program of NRR and you alluded to sharing information with research and it strikes me that that is an important use that merits being on your view graph, in the sense that this has the potential for enhancing the quality of PRA methodology and so that kind of a transfer of knowledge, as the research people are the ones reviewing the IPEs and PRAs. I think it is very important. So I urge you to post facto add that.

MR. JORDAN: It was a mention in words as opposed

to --

CHAIRMAN JACKSON: I don't know if he said it in words, actually. I am just urging him.

MR. JORDAN: Right, well, I want to emphasize that it is one of the elements of the PRA program plan and so we are bringing you one of those pieces.

CHAIRMAN JACKSON: Go on.

[Slide.]

MR. MAYS: The last slide we have here talks about the overall program plan for this information and how it fits with the other activities we are doing that Pat mentioned earlier. In fiscal year '96 we are expecting to complete the diesel generator, aux feed water, high pressure core spray, reactor cool and isolation system and the isolation condenser and initiating event reports information. We intend to plan out and map out what kind of a data base we would put together for receiving the reliability rule information and subsequently distributing that information.

As you are aware, we are also moving to an annual report on the performance indicators and we anticipate completing the common cause failure database and reports and to update the accident sequence program and the SCSS database is part of our fiscal year '96 activities.

In '97 we intend to update the update the previous

reports and also complete the reactor protection system, low pressure systems for BWRs and PWRs, and to start taking this information from this system stuff and being able to take that to research and have them put into one of the simplified plant models. We are also expecting at that point to construct and start implementing the reliability rule database for how we would do that.

After that, the process is fairly repetitive, in that we would update the previous analysis to get the information for the reliability data rule and begin putting that into the analysis instead of relying only on the LAR information. That would have the impact of having us being able to further reduce some of our contractor support needed and being able to do more of this work in-house.

CHAIRMAN JACKSON: Let me bring you back to that. What kind of balance do we have in terms of capability in-house? You seem very knowledgeable and if you got run over by a truck, what would happen?

MR. MAYS: That is why Pat and I never travel in the same vehicle. No, actually, we as part of our program plan looked at both the amount of work we have to do and the contracting work and dollars. We are planning on going from somewhere in the ballpark of $4 million this year in contract work, to in the year 2000 being about $2 million in potential contract support with a staff, FTE commitment, of

about 10 FTEs. What would happen during that period of time is we are taking the opportunity, both from the project management standpoint and the training standpoint, to bring our staff to the point where they can take over more of this work.

That's all I have.

MR. JORDAN: I want to make sure that Pat has an opportunity to make any summary statements since I put him around.

MR. MAYS: Or corrections.

[Laughter.]

MR. JORDAN: I have just a couple of comments to make, sort of based on perceptions. I was surprised by the analysis to find that unreliability or reliability hasn't a trend over this period of time. My perception was that there was a trend improvement and it was misled by the frequency of events rather than reliability. So that is sort of defuncts a perception that me and other members of the staff, I think, had. We haven't really changed the reliability of these equipment during this timeframe.

To slip further to the idea that the unavailability due to maintenance or testing is an important part and is a very heavy contributor for both diesels and high pressure injection system, we had an event yesterday in which a plant had a loss of off-site power. One of two

diesels was in maintenance when the event occurred. So these are real.

MR. JORDAN: There are also differences between the nature of failures during actual demands versus those in surveillance.

CHAIRMAN JACKSON: That is what jumped out at me on that.

MR. JORDAN: We have other work to look at to reexamine surveillance testing as far as its validity and value and are we really testing the right things. I think this indicates that we have to put that risk perspective into that work. Dr. Rossi is involved in managing that in the other branch.

Finally, I was also struck by the likelihood of recovering a turbine driven piece of equipment and the diesel generator. The turbine driven pump, which we call a water wheel in some discussions, is a fairly simple device and it is quite recoverable. The diesel, once it fails or it doesn't start, is much more difficult to resume. So, for instance, in accident management, I think, it is interesting to keep those kinds of thoughts in the back of your mind in terms of how likely you are to recover the diesel and how likely you are to restart the HPCI.

Maybe Ashok has some comments also?

MR. THADANI: No, I think I quite agree with what

you said. I just want to make another comment. That is, I think a lot of this information accident sequence precursor activity is absolutely critical. If we are going to learn from experience and will continue to learn from experience, we had better pay attention to what is happening. So these analysis tools, I think, are very important tools. In fact, what we are doing, as you know, we have established senior reactor analyst positions in each of the regions. These people come here for training and we make sure that they are exposed to assessing events using these tools as part of their training program. So that I think the sensitivity and understanding will be greater.

MR. TAYLOR: That concludes our brief.

CHAIRMAN JACKSON: Thank you.

Do you have any other questions, Commissioner Rogers?

COMMISSIONER ROGERS: Well, just first, I thought that was a very interesting briefing. I think it is really reveals, I think much more clearly the value of the data that we seek. I think it is beginning to show how important that data really is. I think that was very important.

MR. JORDAN: I think it is valuable to the industry to look at this type of analysis, too. I mean, it is their equipment.

COMMISSIONER ROGERS: I just had a couple of

little questions. One is the SCSS database, where does that stand? At one time I think you were talking about reducing the effort in that direction and starting to relook at that again. Where does that stand now?

MR. JORDAN: I'll ask Pat to respond.

MR. BARANOWSKY: We are, of course, looking to optimize our resources, but the SCSS is still in existence and what we are doing is we are transferring from the mainframe to a minicomputer or workstation and then trying to make it available it available on the LAN. It is still a significant source of information for us in system reliability studies and getting common cause failure data.

CHAIRMAN JACKSON: This transfer will also help in resource?

MR. BARANOWSKY: Yes, the other system is quite expensive and I think we are going to have that completed this summer, approximately.

COMMISSIONER ROGERS: So that database will be maintained?

MR. BARANOWSKY: It will be maintained, yes. We were able to come up with funds to save it.

COMMISSIONER ROGERS: Good. The other refers to the simplified plant models. To what extent are you subjecting those to some kind of an outside review process, the models themselves, these simplified models?

MR. BARANOWSKY: I don't know if I can answer. Dr. O'Reilly who is more familiar with this can answer that.

MR. O'REILLY: I am Pat O'Reilly from AEOD. Commissioner Rogers we are going to have the revision two models put through a systematic quality assurance and checkout program, sponsored by the Office of Nuclear Regulatory Research. That contract has been put in place and should get started fairly soon. We have not had the revision one models subjected to a systematic QA program. What we have been doing is, ad hoc checking out of the model as we review a specific event.

COMMISSIONER ROGERS: Has ACRS had an opportunity to comment on those models?

MR. O'REILLY: No, they haven't.

COMMISSIONER ROGERS: Do you expect to do that?

MR. O'REILLY: We will be in conference in research through the technical coordination group to get into that.

COMMISSIONER ROGERS: I think they might have some valuable insight there. That is the scenario that they probably have their lot of expertise in.

MR. O'REILLY: Yes, it would.

COMMISSIONER ROGERS: That's all. Thank you very much. I think it was an excellent briefing.

CHAIRMAN JACKSON: I want to thank you, Mr.

Taylor, Mr. Jordan and the rest of you for a very informative and excellent presentation this morning. I believe that the ongoing review that you are doing with the operational events database against the results of actual PRAs provides very valuable insights, both into the limitations of PRA methodology, but also the utility of it, particularly in the use of reliability data and assumptions and these kinds of surprises, let us say, we find out in terms of actual reliability. I believe that what you are pursuing in terms of looking at any plant specific deviations and how that can give added focus in inspection, it should be thoroughly understood and reconciled.

So I encourage your efforts in that area. I also encourage you along the lines that you have already started in terms of these crossfeeds more broadly from AEOD to NRR and research and encourage you along the lines of this increased focus that you are making the use of in NRR. I look forward to hearing more as you work through your program plan and to have periodic updates and look forward to hearing you report as you are developing the more risk significant performance indicators, as you develop that.

Thank you very much.

We stand adjourned.

[Whereupon, at 11:24 a.m., the briefing was concluded.]

CERTIFICATE

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

TITLE OF MEETING: BRIEFING ON SYSTEM RELIABILITY STUDIES - PUBLIC MEETING

PLACE OF MEETING: Rockville, Maryland

DATE OF MEETING: Wednesday, February 7, 1996

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

Transcriber: Tessa Minson

Reporter: Tessa Minson

OPERATIONAL RELIABILITY OF RISK-SIGNIFICANT SYSTEMS IN U.S. NUCLEAR POWER PLANTS

Edward L. Jordan
Patrick W. Baranowsky
Steven E. Mays

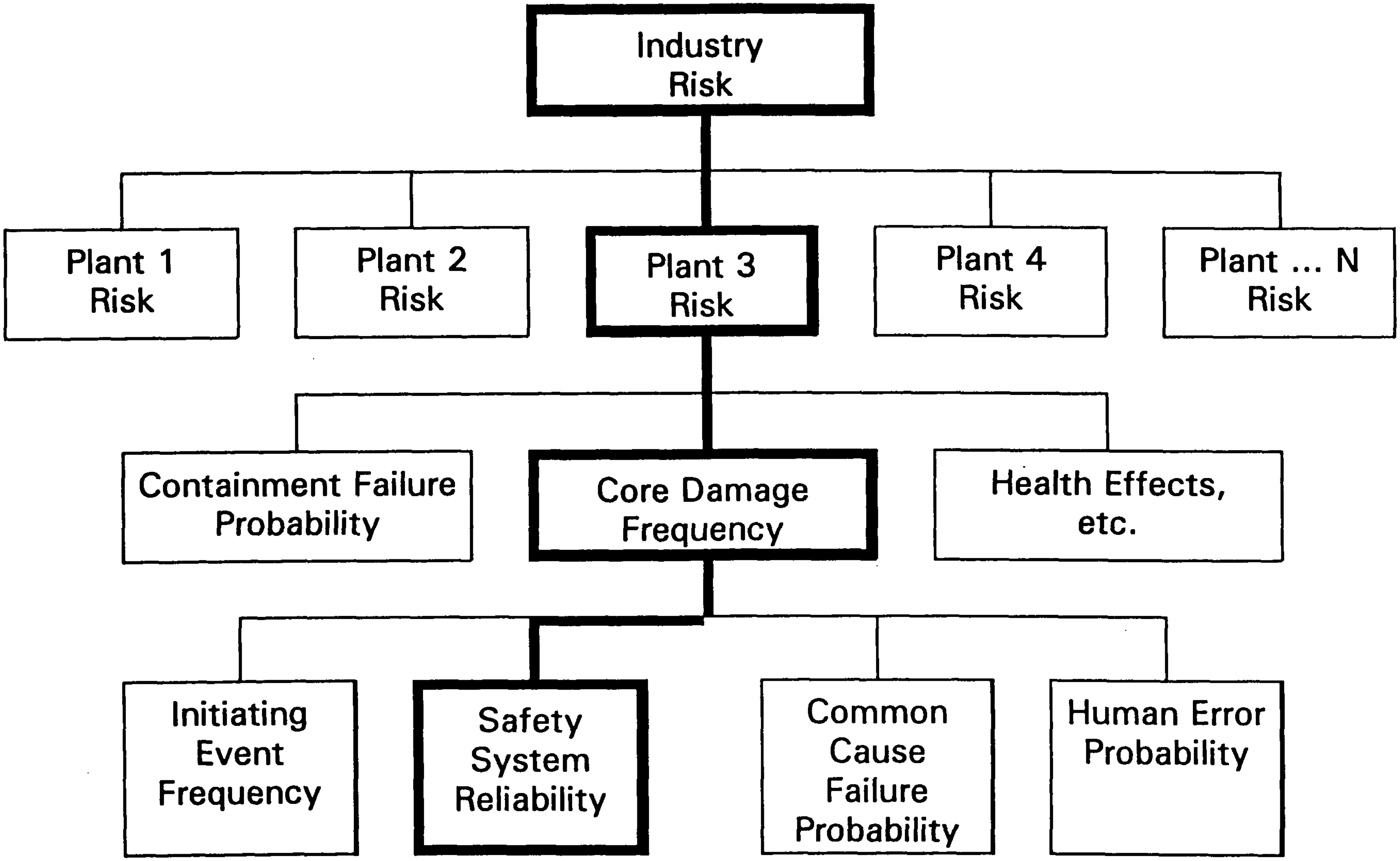
Office for Analysis and Evaluation
of Operational Data

RISK-BASED ANALYSIS OF REACTOR OPERATING EXPERIENCE

Use Reactor Operating Experience to:

- Assess and trend risk indicators
- Compare with probabilistic risk assessments (PRAs) and individual plant examinations (IPEs)
- Identify technical insights relating to risk contributors
- Provide insights to industry and regulatory activities related to risk

DECOMPOSITION OF RISK



PROGRAM ELEMENTS

- Accident Sequence Precursor (ASP) Annual Report
  - ASP methods (Office of Nuclear Regulatory Research)
  - ASP database
- Initiating events periodic report
  - Loss of offsite power (LOOP) database
  - Special initiators (e.g., power-operated relief valves, steam generator tube ruptures, human errors)
- System reliability studies
  - Reliability indicators
  - Component analyses

PROGRAM ELEMENTS (continued)

- Common cause failures (CCFs)
  - Database and analysis software
  - Periodic analysis
  - International common cause data exchange effort
- Performance Indicators (risk/reliability)
- Data Systems
  - Sequence Coding and Search System (SCSS) and Nuclear Plant Reliability Data System (NPRDS)
  - Reliability data

SYSTEM RELIABILITY STUDIES

Purpose:

To evaluate reliability and provide engineering insights of risk-important systems based on operating experience.

Objectives:

- Use actual demands, failures and unavailabilities to estimate reliability
- Analyze trends in reliability
- Quantify uncertainties
- Compare findings with published PRA/IPE values
- Identify plant-specific differences
- Provide engineering insights

STUDIES BEING CONDUCTED

- Boiling Water Reactor (BWR) Systems
  - High Pressure Coolant Injection (HPCI)
  - Reactor Core Isolation Cooling (RCIC)
  - High Pressure Core Spray (HPCS)
  - Isolation Condenser (IC)
- Pressurized Water Reactor (PWR) Systems
  - Auxiliary Feedwater (AFW)
  - High Pressure Safety Injection (HPSI)
- BWR and PWR Low Pressure Injection Systems
- BWR and PWR Reactor Trip Systems (RPS)
- Emergency Diesel Generators (EDGs)

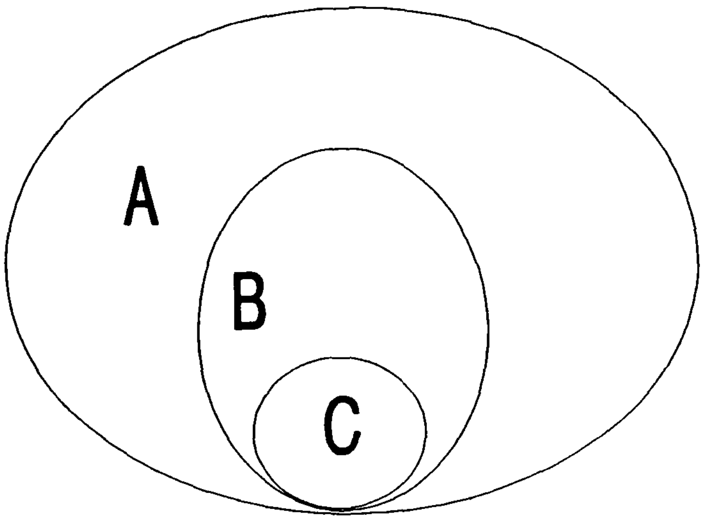
METHODOLOGY OVERVIEW

- Standardized and systematic study procedure
- Detailed evaluation of events using risk analysis methods and models
- Rigorous mathematical treatment of reliability and availability data, including uncertainties
- Detailed analysis of results, including independent peer review

METHODOLOGY APPROACH

- Develop system boundary limits
- Gather operational occurrence data from licensee reports
- Characterize occurrence data
  - Reported inoperabilities
  - Inoperabilities where safety function actually lost
  - Safety function losses where actual demands could be counted
- Determine failure probabilities and uncertainty intervals using Bayesian techniques
- Use simple fault tree model to determine unreliabilities
- Compare results with applicable PRAs and IPEs
- Compare results with applicable regulatory activities
- Analyze data trends

DATA SET RELATIONSHIPS



A The system was not operable as defined by applicable technical specifications or safety analysis reports.

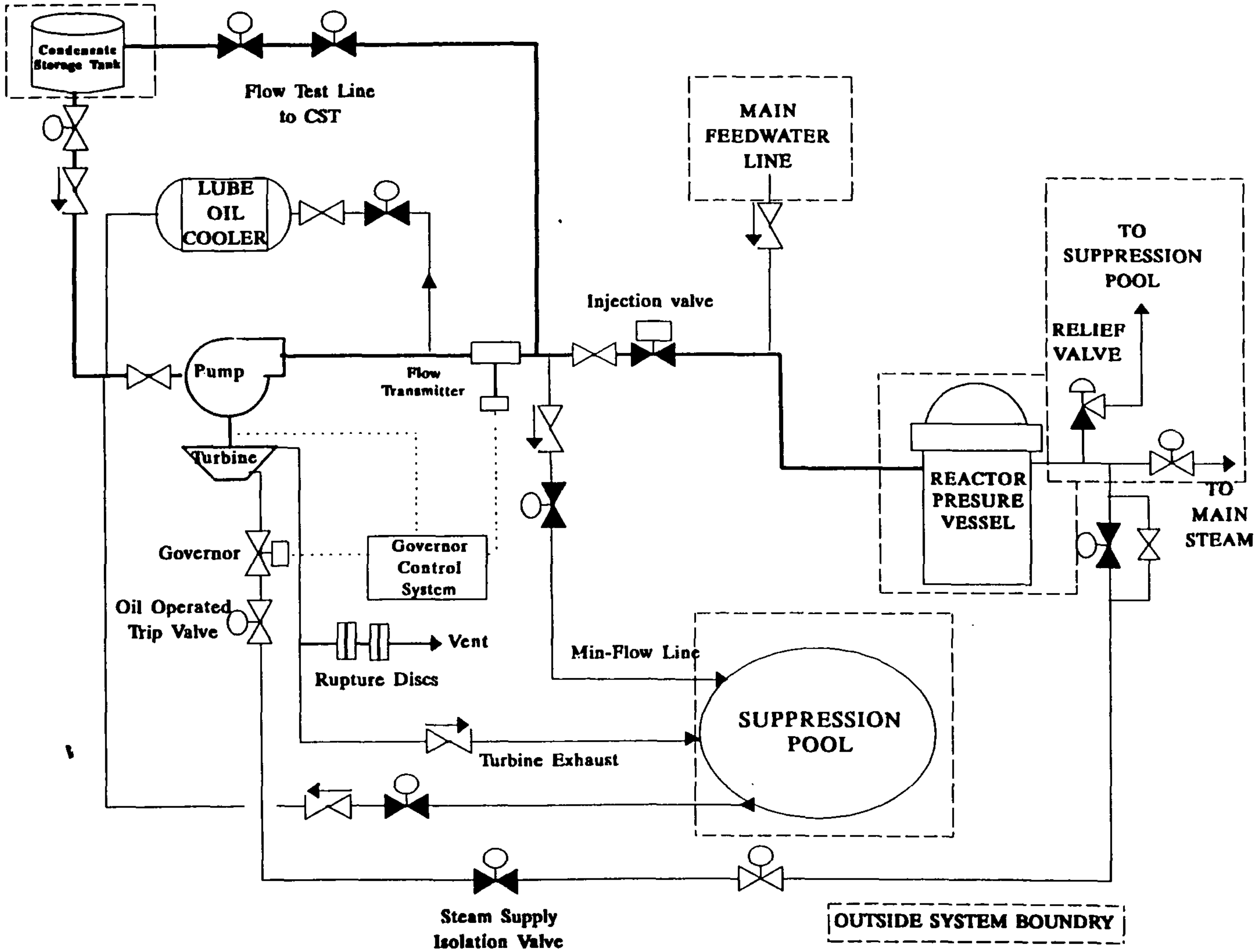
B The safety function of the system was lost.

C The safety function of the system was lost and a corresponding demand count could be determined or estimated

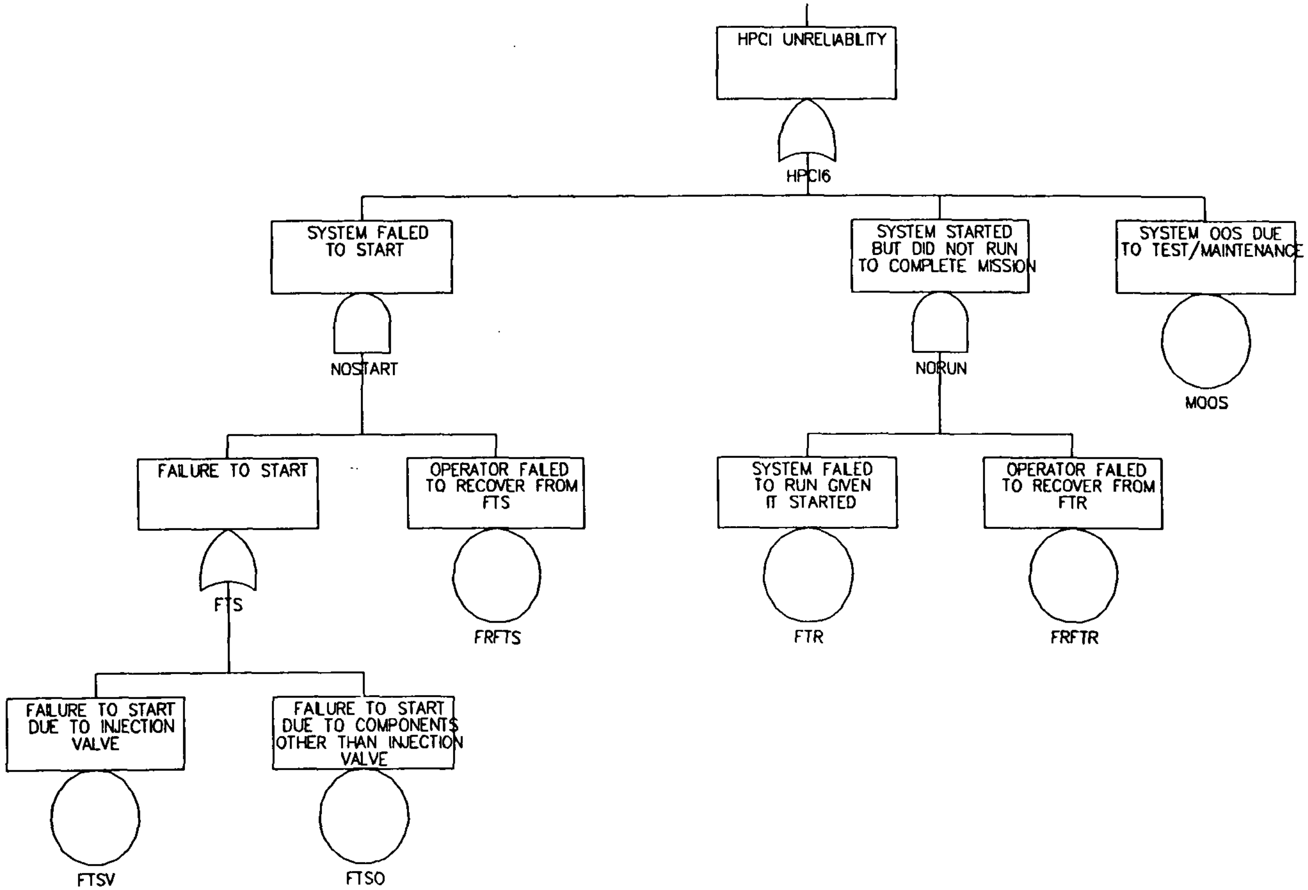
BAYESIAN TECHNIQUES EMPLOYED

- Simple Bayes
- Empirical Bayes
- Constrained non-informative priors

BWR HIGH PRESSURE COOLANT INJECTION SYSTEM BOUNDARIES



HPCI UNRELIABILITY EVALUATION MODEL



Unreliability = Prob{ [(FTSV or FTSO) and FRFTS] or [FTR and FRFTR] or MOOS }

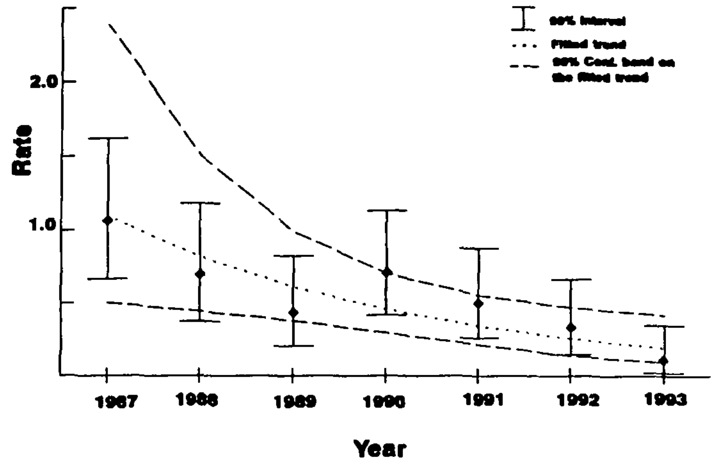
HPCI BASIC EVENT FAILURE DATA AND BAYESIAN PROBABILITY INFORMATION

Basic event	Failures	Demands	Bayes Mean and 90% interval
Maintenance or testing out of service (MOOS)	1	63	(0.0028, 0.023, 0.060)
Failure to start, other than injection valve (FTSO)	11	170	(0.0001, 0.060, 0.24)
Failure to start, injection valve (FTSV)	1	59	(0.0030, 0.025, 0.064)
Failure to recover from FTS (FRFTS)	0	5	(0.0004, 0.083, 0.31)
Failure to run (FTR)	7	167	(0.017 , 0.042, 0.076)
Failure to recover from FTR (FRFTR)	2	3	(0.24 , 0.63 , 0.94)
Failure of injection valve to reopen (FRO)	3	19	(0.046 , 0.20 , 0.41)

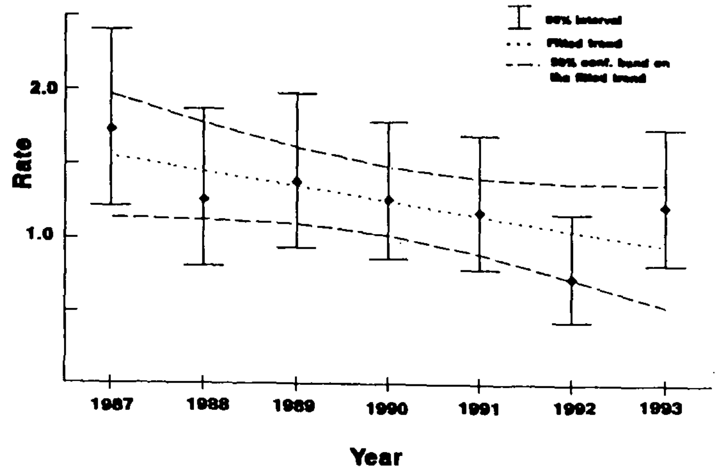
HPCI SYSTEM UNRELIABILITY, WITH RECOVERY ACTIONS

Contributor	Contributor probability	Percentage contribution
FTR*FRFTR	0.026	46
MOOS	0.023	41
FTSO*FRFTS	0.0050	9
FTSV*FRFTS	0.0021	4
Unreliability (90% interval)	0.056 (0.021,0.11)	**100**

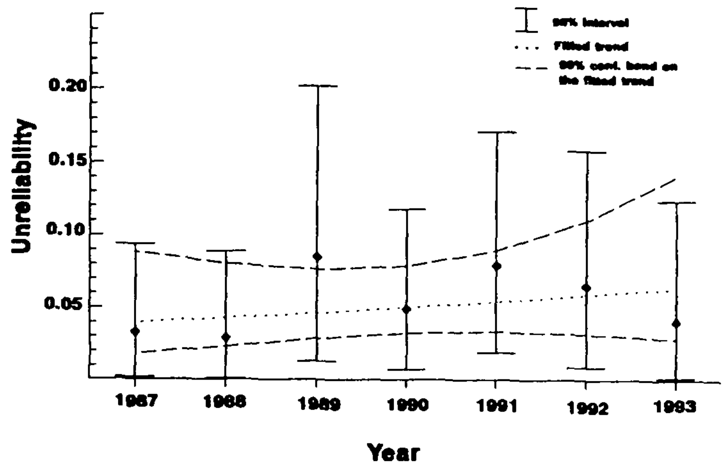
HPCI SYSTEM TRENDS



System unplanned demand rate

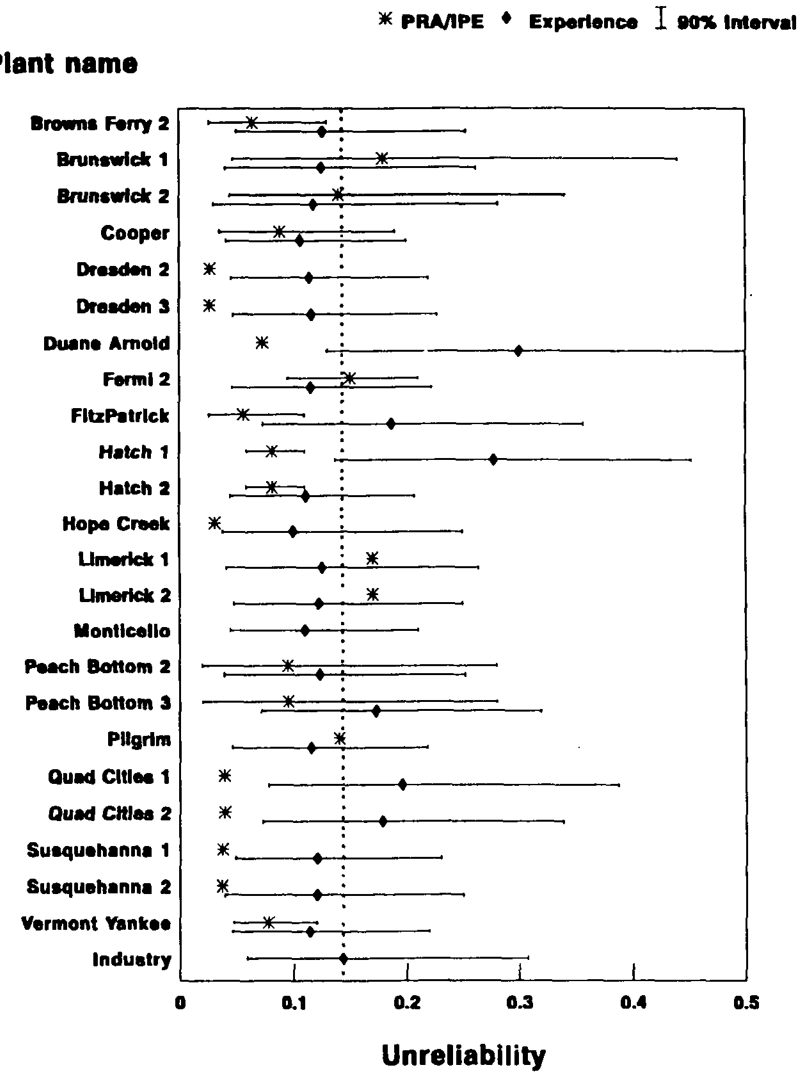


System failure rate

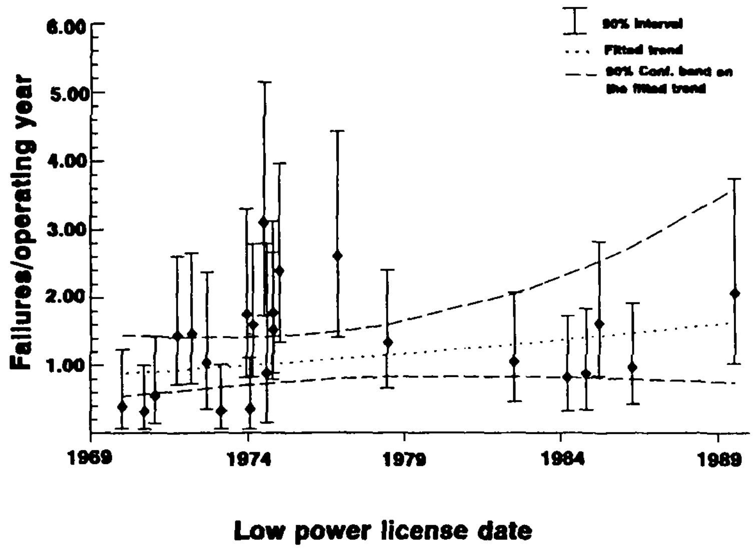


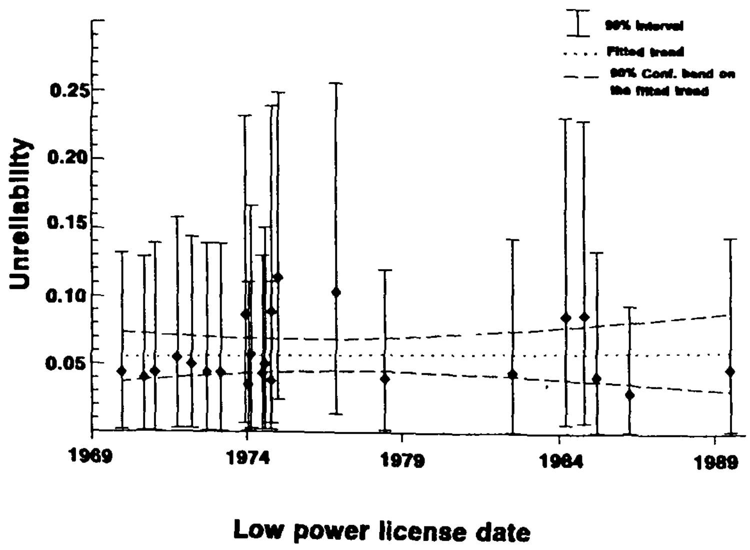
System unreliability

HPCI UNRELIABILITY COMPARISON
ACTUAL EXPERIENCE VERSUS PRA/IPE VALUES



HPCI TRENDS PER YEAR OF OPERATION





HPCI SUBSYSTEM FAILURE CONTRIBUTIONS (BY METHOD OF DISCOVERY)

Subsystem	Method of discovery		
	Unplanned demand	Surveillance test	Operational occurrence
Turbine and Turbine Control Valves	58%	61%	32%
Instrumentation and Control	0%	28%	60%
Coolant Piping and Valves	42%	11%	8%

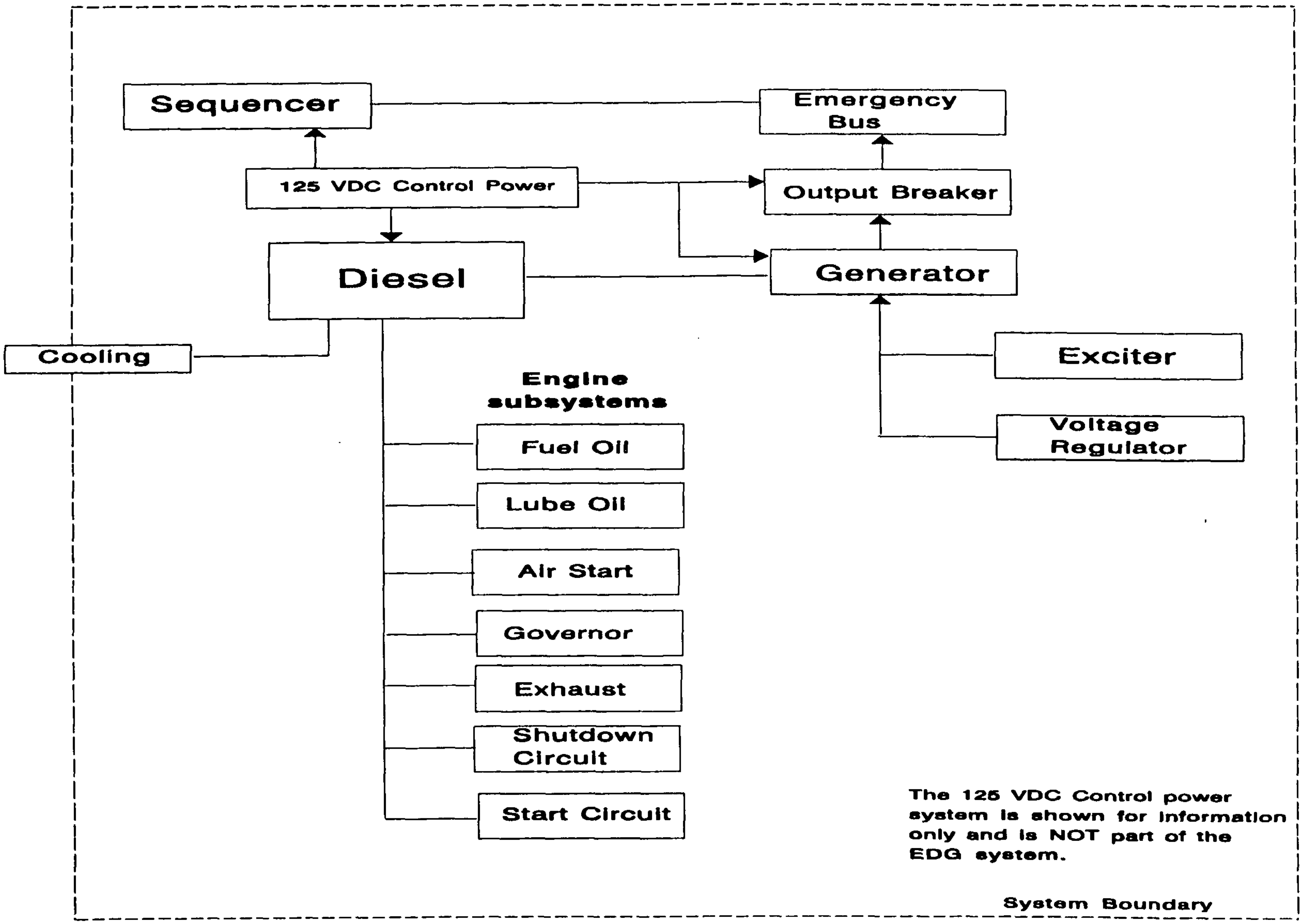
HPCI FAILURE MODES (BY METHOD OF DISCOVERY)

Failure mode (exclude MOOS)	Unplanned demand	Surveillance test	Operational occurrence
Fail-to-start	45%	74%	87%
Fail-to-run	55%	26%	13%

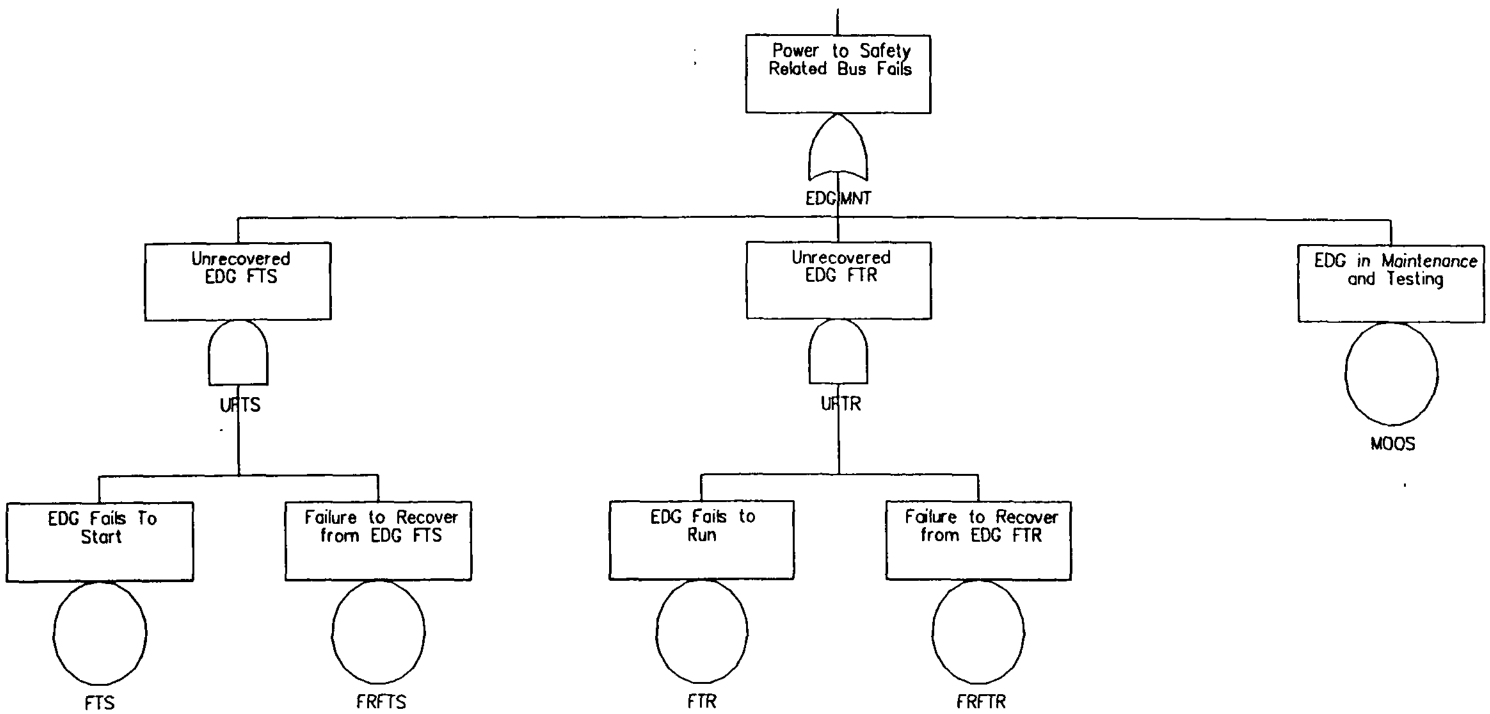
HPCI INSIGHTS

- No discernible trend in reliability
- Failure rate and unplanned demand rate both decreasing
- No significant variation in reliability or failure rates due to the age of the plants
- Generally comparable results to PRA/IPE values with some exceptions which require further investigation
- Failure differences between actual demands and routine surveillance or inspections
- All failures-to-start from actual demands were recovered
- Maintenance or testing out of service was important factor in unreliability but data limited
- Injection MOVs and turbine failure-to-run are dominant failure modes

EMERGENCY DIESEL GENERATOR TRAIN BOUNDARIES



EDG UNRELIABILITY EVALUATION MODEL



Unreliability = Prob{ [FTS and FRFTS] or [FTR and FRFTR] or MOOS }
FTR = FTR per hour X mission time

RELIABILITY DATA REPORTABILITY

- August 1977 - Regulatory Guide 1.108 Revision 1 "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants"

- July 1993 - Regulatory Guide 1.9 Revision 3 "Selection, Design, Qualification, and Testing of Emergency Diesel Generator Units Used as Class 1E Onsite Electric Power Systems at Nuclear Power Plants"

- Statistical data differences between plants reporting under Regulatory Guide 1.108 and those not under Regulatory Guide 1.108 - data not poolable

- Lack of resources to gather plant-specific data

- Reliability data rule information required

PRELIMINARY RESULTS

EDG BASIC EVENT FAILURE DATA AND BAYESIAN PROBABILITY INFORMATION

[Plants reporting per Regulatory Guide 1.108]

Basic event	Failures	Demands	Bayes Mean and 90% interval
Maintenance or testing out of service (MOOS)	3	112	(9.7E-3, 3.1E-2, 6.2E-2)
Failure to start (FTS)	19	1545	(5.0E-4, 1.2E-2, 3.9E-2)
Failure to recover from FTS (FRFTS)	2	2	(4.3E-1, 8.3E-1, 1.0E-0)
Failure to run 0-0.5 hr (FTR)/hr	12	844	(4,2E-7, 2.5E-2, 1.2E-1)
Failure to run 0.5-14 hr (FTR)/hr	15	654	(5.0E-8, 1.8E-3, 8.7E-3)
Failure to run 14-24 Hr (FTR)/hr	1	639	(2.8E-5, 2.5E-4, 6.7E-4)
Failure to recover from FTR (FRFTR)	0	3	(6.0E-4, 1.3E-2, 4.4E-1)

PRELIMINARY RESULTS

EDG TRAIN UNRELIABILITY, WITH RECOVERY ACTIONS

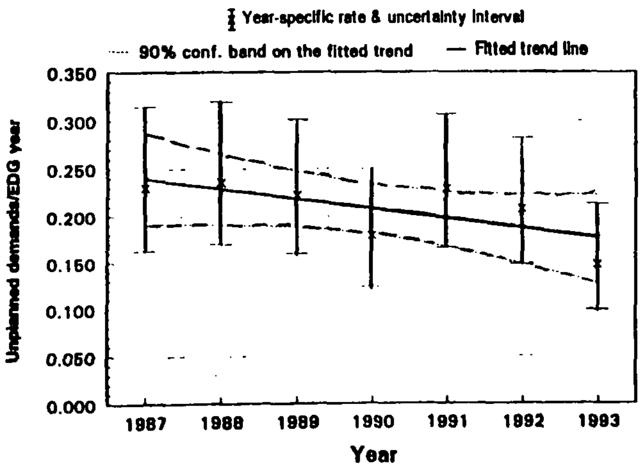
[Nominal 8 hour mission time]
[Plants reporting per Regulatory Guide 1.108]

Contributor	Contributor probability	Percentage contribution
FTR*FRFTR	0.004	9
MOOS	0.030	68
FTS*FRFTS	0.010	23
Unreliability (90% interval)	0.044 (0.016,0.083)	**100**

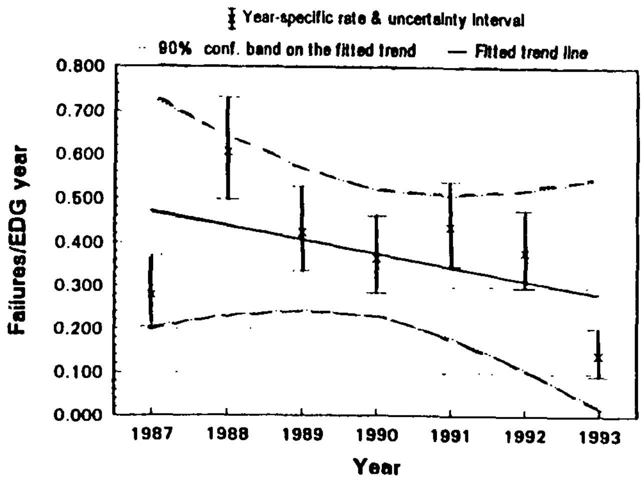
PRELIMINARY RESULTS

EDG TRAIN TRENDS

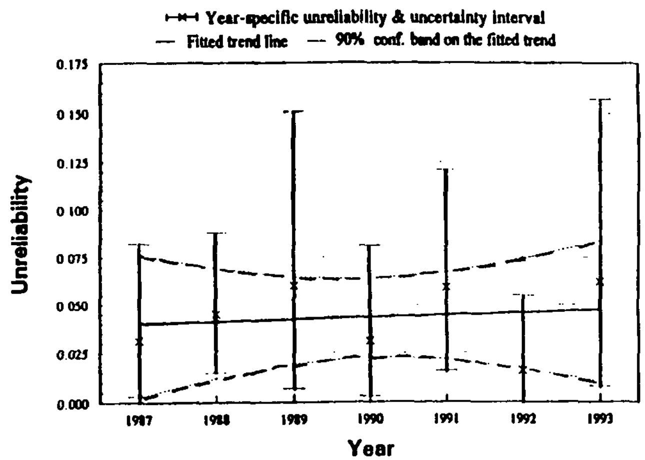
[Plants reporting per R.G. 1.108]



Train unplanned demand rate



Train failure rate

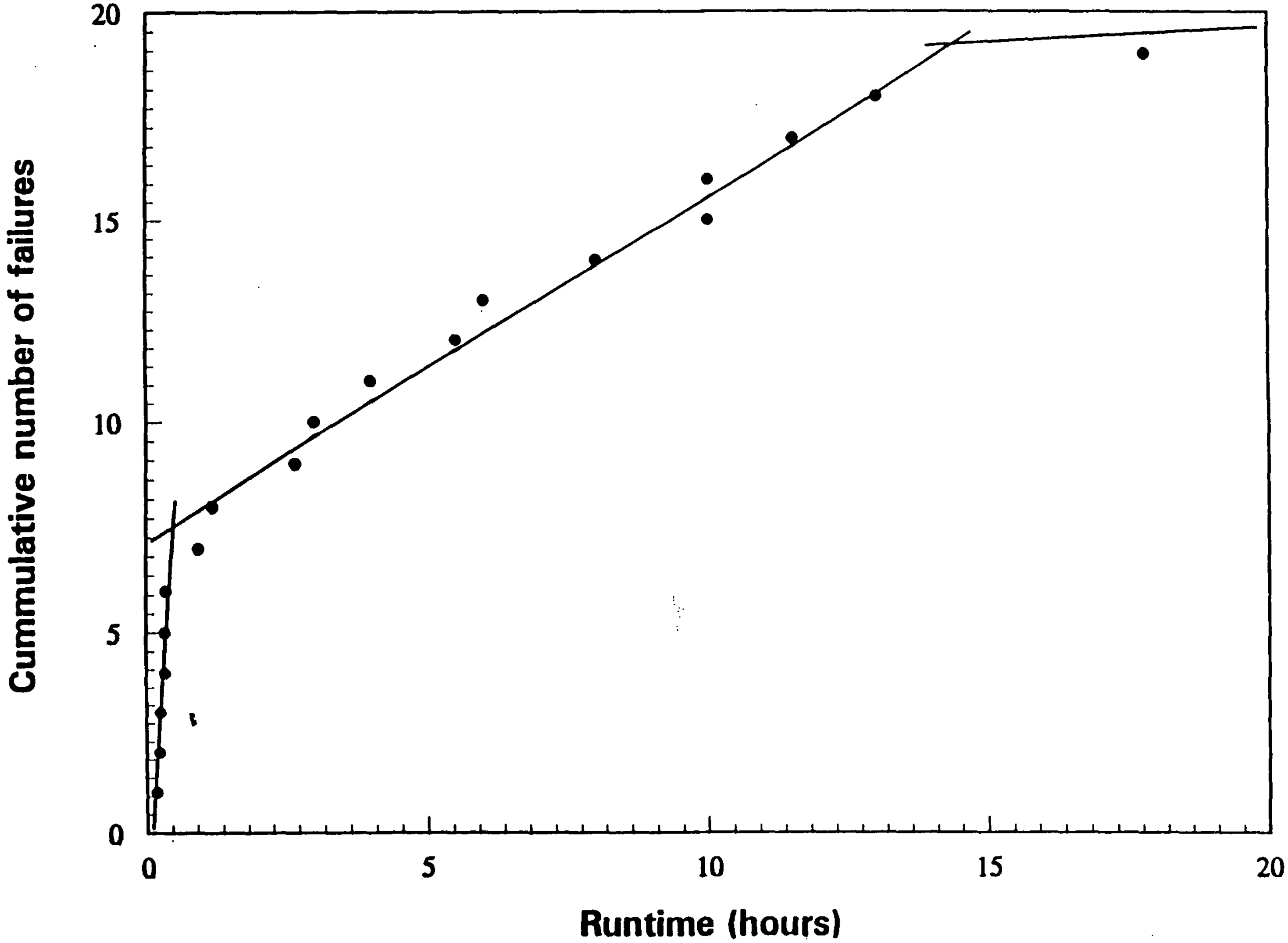


Train unreliability

PRELIMINARY RESULTS

EDG FAILURE-TO-RUN TREND

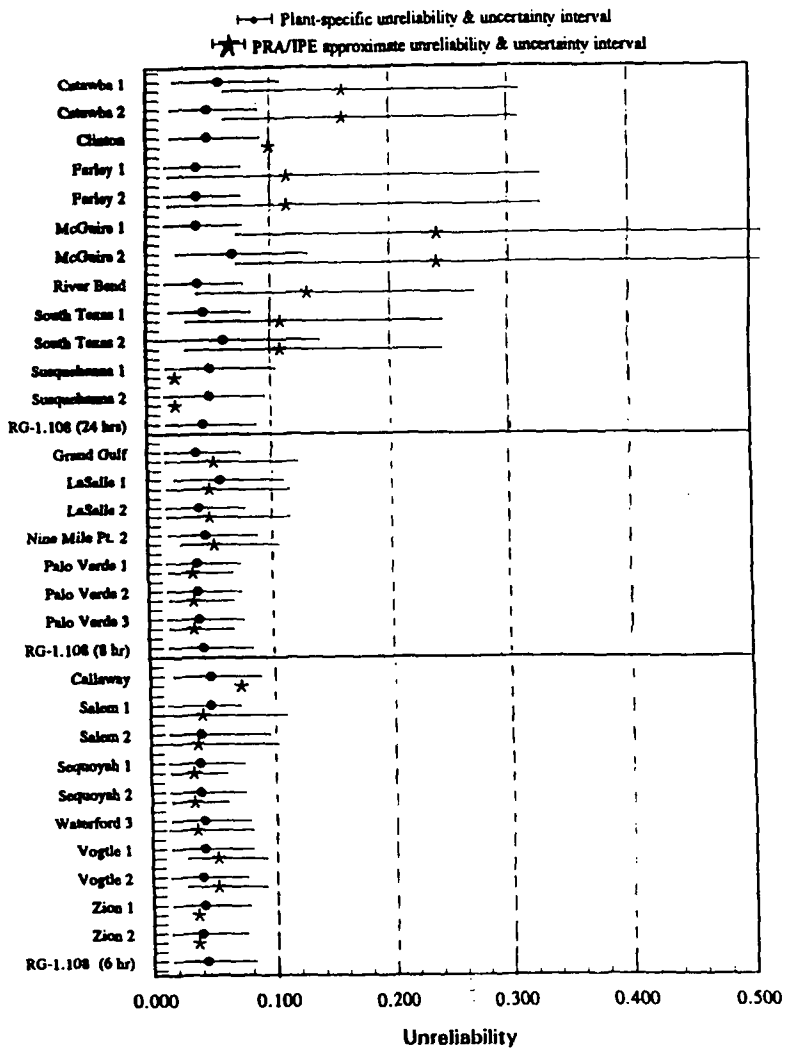
[Plants reporting per R.G. 1.108]



PRELIMINARY RESULTS

EDG UNRELIABILITY COMPARISONS
ACTUAL EXPERIENCE VERSUS PRA/IPE VALUES

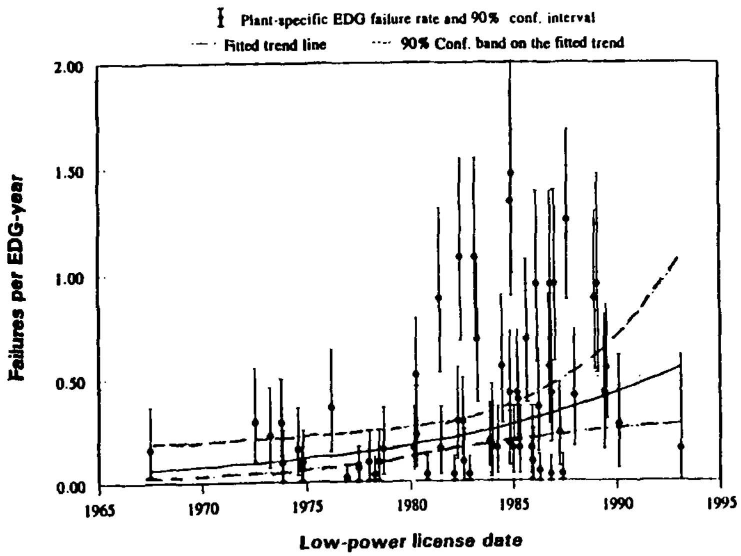
[Plants reporting per R.G. 1.108]



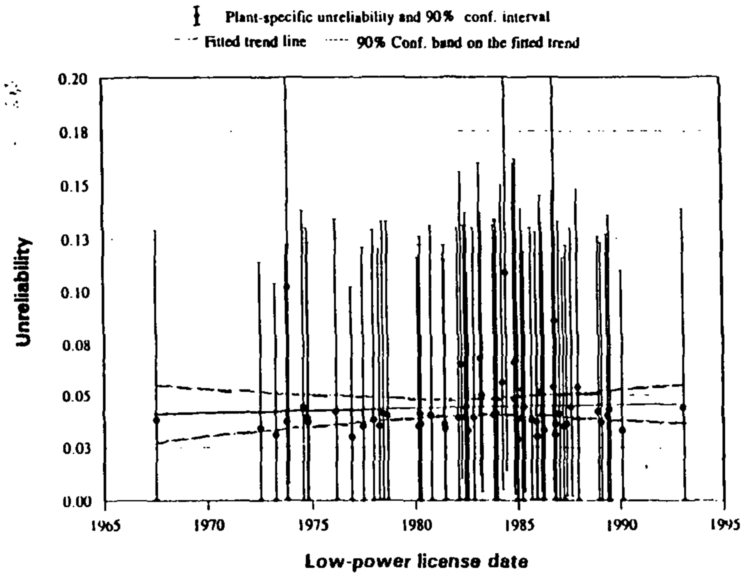
PRELIMINARY RESULTS

EDG TRENDS PER YEAR OF OPERATION

[Plants reporting per R.G. 1.108]



Train failure rate



Train Unreliability

PRELIMINARY RESULTS

EDG INSIGHTS

[Plants reporting per Regulatory Guide 1.108]

- No discernible trend in reliability
- Failure rate and unplanned demand rate both decreasing
- Higher failure rates for plants licensed from 1980 to 1990
- Three distinct failure-to-run rates
- General agreement with PRAs and IPEs
- Failure differences between actual demands and routine surveillance or inspections
- Actual demand failures-to-start not easily recoverable

PRELIMINARY RESULTS

EDG INSIGHTS (continued)

- No common cause failures of multiple diesels observed during actual unplanned demands
- Demand reliability (i.e., FTS and FTR) consistent with station blackout rule for plants reporting per Regulatory Guide 1.108
- MOOS much higher than earlier data used in station blackout rule
- MOOS significantly higher during shutdown than during operation for both Regulatory Guide 1.108 and non-Regulatory Guide 1.108 plants
- Unplanned demand data indicates reliability of plants not reporting per Regulatory Guide 1.108 consistent with Regulatory Guide 1.108 plants

USES

- Programmatic risk assessment of licensee performance
- Revise PI program to incorporate risk-significance indicators
- Independent check of the effectiveness of industry and Agency programs in reducing risk and increasing reliability using actual operating experience
- Input to the inspection and licensing programs of the Office of Nuclear Reactor Regulation (NRR)
- Updating simplified plant models used in Agency risk-significance estimations to make more plant specific

PROGRAM PLAN

<u>Fiscal Year 1996</u>

- Complete EDG, RCIC, IC, and initiating events reports
- Plan reliability rule database
- Issue PI report annually
- Complete CCF and update ASP and SCSS databases

<u>Fiscal Year 1997</u>

- Update FY-1995 and FY-1996 reports
- Complete RPS, BWR and PWR low pressure, PWR high pressure system reports
- Apply system report information to simplified plant models
- Construct and implement reliability rule database

<u>Beyond Fiscal Year 1997</u>

- Update previous analyses
- Incorporate reliability and availability data rule information
- Further reduce contractor support by performing tasks in-house