50-272

June 28, 1993

MEMORANDUM FOR: Robert C. Jones, Chief
Reactor Systems Branch
Division of Systems Safety and Analysis

See Reports

THRU: Timothy E. Collins, Section Chief
BWR Reactor Systems Section
Reactor Systems Branch
Division of Systems Safety and Analysis

FROM: Margaret S. Chatterton, Reactor Engineer
BWR Reactor Systems Section
Reactor Systems Branch
Division of Systems Safety and Analysis

SUBJECT: MEETING WITH WOG ON ROD CONTROL SYSTEM

A meeting was held in the NRC Headquarters Phillips Building in Bethesda, Maryland on June 14, 1993 with the Westinghouse Owners Group and NRC staff to discuss the safety implications of the Salem Rod Control and Indication System malfunction. The staff had activated the Westinghouse Regulatory Response Group on June 8, 1993 and posed questions concerning (1) generic aspects of the issue (2) the consequences of uncontrolled rod withdrawals, (3) interim actions and operating restrictions recommended by Westinghouse, and (4) long term actions.

The Owners Group presented background information, including an overview of the rod control system, description of the Salem event, and failure analysis. The Owners Group presented discussions on the regulatory bases, classification and analysis of postulated events, equipment performance history and the safety assessment. The Owners Group confirmed that this failure mechanism applies to all Westinghouse plants except Haddam Neck. The Owners Group analysis show that asymmetric RCCA withdrawal at power and from a subcritical condition are the limiting cases. For both of these cases conservative bounding evaluations indicate that a small percentage (less than 5%) of the rods experience a calculated DNBR below the limit value. Little or no actual fuel failure is predicted. The Owners Group argued that on the basis of the small probability of these events, they should be considered Condition III events (infrequent fault that could result in a small fraction of failed fuel) and that plants should continue operation and/or startup without restrictions. This may be less conservative than the current licensing basis for some plants in terms of classification of frequency and consequences. The Owners Group committed to evaluate the root cause of the event, and to investigate Rod Control System performance history. Furthermore, the Owners Group asserted that a more detailed 3-D analysis would most likely show no rods in DNB and that the analysis bounds base loaded and load follow plants.

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At the conclusion of the Owners Group presentation, the staff stated its position that this did not appear to be a significant safety issue in view of the following:

- all automatic safety functions will perform as designed
- for the worst cases only a small number of fuel rods will be in DNB and perhaps none
- not all events will lead to rods in DNB

Furthermore these events do not provide a challenge to the reactor coolant system or the containment boundary. However, the staff stated that compliance with GDC 25 had not been demonstrated, and that data used for probabilistic estimated was incomplete. The staff indicated that based on the low safety significance, it is appropiate to take no immediate actions to restrict plant operation. However, the compliance concern may warrant acquiring certain information from licensees as to their basis for concluding that they are in compliance with GDC 25.

A transcript of the meeting including the Owners Group Handout is in the Public Document Room. The list of meeting attendees is attached.

Margaret S Chatterton

Margaret S. Chatterton, Reactor Engineer
BWR Reactor Systems Section
Reactor Systems Branch
Division of Systems Safety and Analysis

Attachment:
As stated

SRXB:DSSA	SRXB:DSSA TC	SRXB:DSSA
MCHATTERTON:jh MSC	TCOLLINS	RJONES
6/28/93	6/24/93	6/ /93

DOCUMENT NAME: G:\MTGSUM.MC

June 28, 1993

MEETING SUMMARY DISTRIBUTION

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GPA/PA (2G-5)
JWermiel (8-H3)
JStone (14-E21)
TMartin (RGN-I/ORA)
WHodges (RGN-I/ORS)
WRuland (RGN-1/EB)
RJones
TCollins
MChatterton

WOG MEETING ON ROD CONTROL SYSTEM

MEETING OF THE 6/14/93

FULL COMMITTEE MEETING

ATTENDEES - PLEASE SIGN BELOW

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NAME	AFFILIATION
HARRY WALSH	NARSC (WOG)
Jim Hardy	FPL- Turkey Point Plant
TOM CARRIER	PSE+G
HAROLD MAGUIRE	WESTINGHOUSE, NATD
NICK LIPARULO	WESTINGHOUSE, NATD
E.J. WEINKAM	FPL/Turkey Point, WOG RRG
Allen Hansen	NRC/NRR
David Smith	FPL
Jeff Bass	Westinghouse NATD Licensing
FRANK THOMSON	PSE & G
STAN LA BRUNA	PSE & G.
STEVE MILTENBERGER	PSE&G
Jose Ibarra	NRC / AEOD
Bill Beckley	NRR/DRPW
Roger Newton	WEPCo / WOG
James Stone	NRC/NRR/ PD I-2
DUKE WHEELER	NRC/OEDO
L. Robert [illegible]	NRC/OEDO/RES
Glenn Heberle	Westinghouse NATD
Steve Fowler	Westinghouse NATD
Chris Vertes	Westinghouse NATD
Ashok Thadani	NRC/NRR/DSSA

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WOG MEETING ON ROD CONTROL SYSTEM

MEETING OF THE 6/14/93

FULL COMMITTEE MEETING

ATTENDEES - PLEASE SIGN BELOW

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NAME	AFFILIATION
Nancy Closky	Westinghouse NATD
BAARD JOHANSEN	Westinghouse NMD
Glenn Lang	Westinghouse
KEN BUDDENBOHN	DELMARVA Power
CARLO CASO	Westinghouse
HANK SEPP	Westinghouse
James [illegible]	PSE&G
ARUN P. SAHASRABUDHE	WESTINGHOUSE
JOHN McINERNEY	WESTINGHOUSE
TONY BAKER	WESTINGHOUSE
Robert Jones	NRC/SRXB
Timothy Collins	NRC/SRXB
M. V. Virgilio	NRC/DSSA
E.C Marinos	NRC/NRR/DRCH
MARK Proviano	Westinghouse
John McInerney	Westinghouse
Terry Harpster	NAESCO
Al DeAgazio	NRR/DRPE
H.C. GARG	NRR/HICB
W Ruland	NRC/RT
A.C. [illegible]	[illegible] Electric [illegible])

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WOG MEETING ON ROD CONTROL SYSTEM

MEETING OF THE 6/14/93

FULL COMMITTEE MEETING

ATTENDEES - PLEASE SIGN BELOW

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NAME	AFFILIATION
BOB STANEY	WESTINGHOUSE EMD
Margaret Chatterton	NRC/SRXB
[illegible] Marcus	NRC/NRR
Marc Harper	NRC/NRR/OGCB
DAVE CAMPBELL	WESTINGHOUSE
JIM RALEIGH	STS. INC.
JAMES BOATWRIGHT	TU ELECTRIC
JOHN GALEMBUSH	WESTINGHOUSE
Charles Miller	NRC/NRR
Jose' Calvo	NRC/NRR
JOSEPH JANOCHA	ATLANTIC ELECTRIC
Jared Wermiel	NRC/NRR/DRCH/HICB
ROGER HUSTON	TVA
DAVE BEST	PSE&G

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MEETING WITH WOG ON ROD CONTROL SYSTEM

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-NOTICE-

ORIGINAL

OFFICIAL TRANSCRIPT OF PROCEEDINGS

Agency: Nuclear Regulatory Commission

Title: Generic Assessment of the Salem Event

Docket No.

LOCATION: Bethesda, Maryland

DATE: Monday, June 14, 1993 **PAGES:** 1 - 147

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

***

NRC PRESENTATION

***

GENERIC ASSESSMENT OF

THE SALEM EVENT

***

Nuclear Regulatory Commission

Conference Room P-110

7920 Norfolk Avenue

Bethesda, Maryland

Monday, June 14, 1993

PARTICIPANTS:

A. Thadani, NRC/NRR

T. Collins, NRC/NRR

R. Jones, NRC/NRR

M. Virgilio, NRC/NRR

W. Ruland, NRC Region I, AIT Team Leader

A. Chaffie, NRC/NRR

J. Wermiel, NRC/NRR

J. Calvo, NRC/NRR

R. Newton, WOG

L. Walsh, WOG

N. Liparulo, Westinghouse

J. McInerney, Westinghouse

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F. Thomson, PSE&G

T. Carrier, PSE&G

S. Fowler, Westinghouse

G. Lang, Westinghouse

C. Vertes, Westinghouse

B. Johansen, Westinghouse

N. Closky, Westinghouse

PROCEEDINGS

[1:10 p.m.]

MR. COLLINS: Let's begin this meeting between NRC and the Westinghouse Owner's Group. The purpose of the meeting is to discuss generic safety implications of malfunctions in the rod control system which have been experienced at the Salem plant.

This is an open meeting, meaning that it's open for observation by members of the public. We have received no requests from the public to speak at this meeting. However, if members of the public wish to question the NRC staff at the end of the meeting, the staff will be available for a short time after the meeting.

This meeting is being transcribed and, therefore, persons who are not at the table here, if they speak, please go to a microphone and give your name and your affiliation at the beginning of whatever you're going to say.

Everyone present should sign in on sheets at the back of the room. We need those to keep track of who was here.

I believe I can turn this over to Ashok Thadani at this point.

MR. THADANI: Thank you, Tim. As Tim said, we're here to discuss with the Westinghouse Owner's Group the regulatory response of the safety implications of malfunctions that were experienced in the control rod system at Salem.

We activated the regulatory response group last Tuesday, although the staff investigations into an event that occurred at Salem are still ongoing. At Salem, while starting up, a control rod withdrew in response to an insert signal. A similar rod control system is used at nearly all Westinghouse-designed pressurized water reactors.

Initial assessments by the staff concluded that a single failure in the rod control system could result in un-demanded rod withdrawal movement and multiple control rods. While the staff recognizes that the reactor protection system is independent of the rod control system logic and, therefore, the scram function is not compromised, there remains an important concern in that a previously unanticipated single failure mechanism may exist in the control system which can initiate or aggravate reactivity excursions and result in fuel failure.

This is of particular importance since the frequency of demand on the rod control system, particularly for power adjustments, is very high; in some cases, on a daily basis.

The staff expects that single failure mechanisms in the rod control system should be eliminated or the consequences minimized in accordance with General Design

Criterion 25 and reactor protection system requirements for reactivity control malfunctions.

For the meeting today, we have requested that the Westinghouse Owner's Group presentation include the following topics; a brief description of the rod control system, its operation, and the event at Salem Unit 2; a discussion of what rod motions are possible as a result of a single failure at any power level; a discussion of applicable regulatory requirements, particularly General Design Criterion 25; analyses that have been performed, including all power levels from subcritical to full power; definition of initial conditions and the bases for selection fo those initial conditions; the impact of load following demand signals; transients that would result in demand for rod insertion; impact of initial conditions outside the actual flux demand, the band; and then impact of manual versus automatic mode of operation.

The next topic we'd like to hear about is the operability considerations and the requirements of the technical specifications. We are also, as I indicated to you last Friday, interested in getting a really good understanding of the failure rates; that is, what kind of data is available, how many failures have been experienced, quality of data, source of the data, failure rates, and, again, as I indicated to you, we are interested in understanding if there are any age-related facts on these components.

Finally, and this is an extremely important part of the discussion also, is the basis for continued operation of the Westinghouse-designed plants. We'd like to hear your views on compliance with GDC-25, what short-term compensatory actions are needed, mechanism and schedule for short-term action implementation. This is important, so we can then decide if we need to go out and take action ourselves.

So it's very important that we hear from you what the individual owners might be doing as a result of recommendations that might flow out of the Owner's Group. Finally, what the long-term actions will be and what the schedule will be for those corrective actions.

This is basically what we discussed last Friday. Roger, you're going to start out.

MR. COLLINS: Excuse me, Roger, before you do that. There may be some members of the public here who are not familiar with the players. So let's go around the head table and just announce who we are. We'll start with you, Roger.

MR. NEWTON: I'm Roger Newton of Westinghouse Owner's Group. I'm Chairman of the Regulatory Response Group.

MR. WALSH: I'm Larry Walsh. I'm the Chairman of the Westinghouse Owner's Group.

MR. LIPARULO: I'm Nick Liparulo. I'm Manager of Nuclear Safety and Regulatory Activities.

MR. McINERNEY: John McInerney, Westinghouse, Manager of Nuclear Safety Licensing.

MR. LaBRUNA: Stan LaBruna, Vice President-Nuclear Engineering for PSE&G for Salem and Hope Creek Stations.

MR. THOMSON: Frank Thomson, Manager of Licensing and Regulation for PSE&G.

MR. CHAFFIE: I'm Al Chaffie. I'm with the Nuclear Regulatory Commission. I'm the Chief of the Events Assessments Branch.

MR. WERMIEL: I'm Jared Wermiel. I'm Chief of the Instrumentation and Controls Branch, NRC.

MR. RULAND: I'm Bill Ruland. I'm the AIT, the Salem AIT Team Leader and I'm Section Chief of the Electrical Section in Region I.

MR. VIRGILIO: Marty Virgilio, Deputy Director, DSSA.

MR. THADANI: Ashok Thadani, Director of Division of Systems Safety and Analysis.

MR. COLLINS: Tim Collins, Section Chief in Reactor Systems Branch.

MR. JONES: Bob Jones, Chief of the Reactor

Systems Branch.

[Slide.]

MR. NEWTON: I will try to use no microphone so I can move around and I will endeavor to do that. If you can't hear in the back of the room, let me know and I will try to speak louder.

The meeting is to discuss the generic aspects of the Salem event. As was mentioned here, it's the Westinghouse Owner's Group. The purpose of the meeting is to discuss the generic aspects of the Salem event; in particular, as it impacts the Westinghouse Owner's Group.

[Slide.]

MR. NEWTON: As previously mentioned, the purpose is to meet with the NRC. They did activate the RRG, the Regulatory Response Group. After Three Mile Island, the Owner's Group set up a Regulatory Response Group to be able to respond to issues that are generic to a particular vendor's activities. It can be activated by the Owner's Group itself, a utility, or the NRC, or even NUMARC if an issue comes up to activate it.

I'm not going to go into details of the operation of the RRG, but it allows the generic aspects of an issue to be focused on from a broader perspective and a broader outlook of utilities. We have a Chairman, a Vice Chairman and four or five utilities that stand on this committee all the time. Should the need arise, we're there to convene and discuss the issue.

The other objective of the meeting is to provide an open forum in which to discuss this issue that surrounds the control rod system event. To date, the NRC -- we've been keeping the NRC informed as to the status. We've had several phone calls. Also, they've been working through Salem.

We hope to be able to address the questions with respect to plant safety and operability today. We have a sequence of events to go through. We anticipate that, with minimal questions, it will take about an hour-and-a-half to get through our material.

We may not have covered every -- we may not be able to address -- your list is pretty long of items that you've had there and hopefully we can knock most of them off and then look at which ones we still have to address.

I think, from an overall standpoint, we approached it from the larger envelope of defining the issues and then we may be able to focus on some of the smaller ones as an action item from this meeting. So I don't guarantee that list will be covered line-by-line, but hopefully we can address most of them.

At the end, we expect there will be items to address. We have planned some future actions ourselves.

Issues that come up during this meeting, we'll try to keep track of them and make sure we understand what are the issues that we still need to define and answer more thoroughly.

We have three groups that are coordinated here. We have the Westinghouse Owner's Group that represents the generic aspects. We have Westinghouse, that is the vendor. We have the utility, Salem Public Service Electric and Gas, that's specific to the event.

Most of the issues are aimed at the generic aspects. So the WOG and Westinghouse will be doing most of the presentation, but Salem will be called upon should a specific issue head in that direction. I will probably point to Westinghouse or Salem and they'll have to direct the right person to respond to the question or the issue.

From our perspective, we've got four or five presenters that will be coming up here to present a portion of the program, and I'm going to go through that agenda and show you how that's going to flow.

[Slide.]

MR. NEWTON: I've got just some opening remarks, reviewing the agenda, which I'm doing now, and just some status items of where we are. We'd like to get into the Westinghouse presentation and the description of the event will be done by a Salem person. Then we start to get into more of the aspects of the failure analysis.

[Slide.]

MR. NEWTON: Regulatory basis classifications, analysis of the events that we envision could possibly occur. We are looking at some of the performance of the equipment and the history of that to give us some insights as to what is happening here and how to interpret that.

We have an overall safety assessment that we're drawing conclusions from, the previous work. Then we'll get into where we think the operability and where we're going on this issue. Hopefully, we will have addressed most of the items you talked about.

[Slide.]

MR. NEWTON: The status from the WOG/RRG perspective. The Salem plant-specific evaluation is underway. We are following that, but we are not participating in that as an active member. That's really a utility-specific item, working with Westinghouse and the NRC on that, as you have already been doing that.

We obviously are very interested in what's happening there. We are getting the benefit of the work they're doing and factoring it into what you see here today.

Westinghouse and the Westinghouse Owner's Group are continuing to evaluate the generic aspects. From our perspective, this is less than a week old. The RRG charter requests or identifies that within five working days, we're to look at an issue and try to define a plan, and that's kind of what this meeting is here. It culminates the initial work that we've done, defines the issue and sets the course for where we're going.

Westinghouse has prepared a reasonable assurance of safe operation. We feel that adequately addresses the concerns regarding plant operability and the health and safety of the public. That was mailed out last Friday as part of an information notice to the utilities.

The overall conclusion from that, and we'll hopefully be able to demonstrate that as we go through the afternoon, is that all plants should be able to continue to operate and should be able to start up. We don't envision that what happened at Salem is indicative of a frequent event that causes a problem that's non-detectable and results in an undue risk to the public health and safety. We hope that we'll be able to demonstrate that this afternoon.

[Slide.]

MR. NEWTON: Just a short summary of what has taken place already, and this is only from the Owner's Group RRG perspective. We really just became aware of this late on Monday a week ago. So we're relatively new to the issue. So we've done a lot of catch-up on that.

As mentioned, Ashok called the Westinghouse Owner's Group Chairman on Tuesday morning, and it was early. Larry is in the east coast time zone, so he's more available. We were faxed five questions that were of immediate concern to the NRC.

At the conclusion of the meeting, we're going to put those five questions up and see what the answers are to those questions as of today and see where we stand. It will be based on everything that is presented before that. So this will pop up again at the very end.

On Wednesday, there should be an "and" in here, the WOG Chairman and the Vice Chairman were at Westinghouse to meet with them, to become familiar with the event. There was a telephone call, not listed on here, in the afternoon. There was also a telephone call with the NRC.

I had some eye surgery on Wednesday. So I was a little bit out of commission, but I did listen to the phone call on Wednesday. It was just kind of an initial phone call. We were more interested in your concerns. We didn't provide you a whole lot of answers on Wednesday, anyway.

On Thursday, from an RRG perspective, we had our first official -- what we called an activation, where the members were brought together in a phone call and we became familiar with what was happening and what to do about it. So this was our first official one. We needed to gather information ourselves before we felt knowledgeable enough to talk about what was happening.

There was an afternoon conference call with the NRC, the WOG, Westinghouse and Salem reps, and at this phone call, I think we provided more information to the NRC, at least. Preliminary as it was, it was much better than the Wednesday afternoon call. It identified what we had looked at and where things were going at that time.

[Slide.]

MR. NEWTON: Also, at that Thursday phone call, we committed to send to the NRC a draft version of what we were going to send to the Westinghouse utility customers. That was in draft form. So in the morning of Friday, we had a second conference call where we evaluated, reviewed with Westinghouse that customer safety -- give me the right words -- advisory letter. For the most part, it was the same, but there were some minor modifications made to it.

That went out Friday afternoon and all of the utility customers -- I don't want to say received it Friday afternoon, but I'm sure by now they've received it. A lot of them -- Nick, I don't know if you can swear that we all received it by Friday afternoon, but it was on its way.

In the afternoon, Friday afternoon, there was another conference call between the NRC, Westinghouse, WOG and Salem, and it was primarily to make you aware of the advisory letter, you had gotten a copy of it, and to go over the agenda for this meeting to cover the items you had addressed.

MR. THADANI: Roger, was the advisory letter modified from the draft that we had received?

MR. LIPARULO: There were some modifications, but the types of modifications didn't change the conclusions or the technology it was based on. We have faxed down a copy of the final memo to you, Ashok.

MR. THADANI: Thank you.

MR. NEWTON: This concludes my part of the introduction, which just lays kind of the foundation of what the involvement of the Westinghouse Owner's Group and RRG is. I'd like to have Nick introduce his people for the rest of the presentation that deals with what happened and all of the other questions that you've asked us concerning the design and safety and so on. Nick?

MR. LIPARULO: Our next speaker will be Steve Fowler, who will take us through an overview of the rod control system. The idea of the way we've laid out the presentation is to go through the system, how it works, then to talk about the Salem event, and then take you to the point where the failure analysis indicates the types of motion that we can see.

I think that was the specific item that you requested at the beginning that you wanted to hear. So Steve Fowler is the next speaker.

[Slide.]

MR. FOWLER: The purpose of my presentation is to provide enough of the background information on the rod control system and its operation to aid in the discussion of the failures, transients and analysis that are going to follow my presentation.

A very basic description of the rod control system. Its purpose is to position the rods, specifically the rod control cluster assemblies or RCCAs, as you'll hear them referred to, in response to demand signals from either the reactor operator or the reactor control system.

The system is a non-Class 1E system. That means it's a non-safety system. A basic description will follow. I'm going to first look at a control rod drive mechanism in terms of the way it normally functions, the normal withdrawal sequence to move RCCAs out, and insert sequence, and the response to the reactor trip signal from the reactor protection system.

Then there will be a look at the control rod arrangement in the core, so we understand some of the concepts of which rods can and can't move; rod groups, how rods move and some bank overlap, and then a very brief look at the rod control system cabinets that are involved in this event; specifically, the slave cycler circuit where the failures were located at the Salem event.

[Slide.]

MR. FOWLER: I'd like you to please look at Figure No. 1. The control rod drive mechanism used in our Westinghouse plants is an electro-mechanical jack mechanism. What's shown here is a drive rod which is connected to the rod control cluster assembly. So that when the drive rod moves, so does the rod control cluster assembly.

To hold the drive rod in position, a stationary coil is energized. In energizing that coil, there's a solenoid effect that pulls up on stationary grippers and makes them grip the rod. That holds the rod in place.

If we want to position the rod and move it out one step, there's a sequence of events as follows. We transfer the holding of the drive rod from the stationary gripper to a moving gripper; that is, we grab it with the moving gripper and let go with the stationary gripper.

Then the left coil is energized and the way the mechanism is designed, when the lift coil is energized, it actually lifts up on the moving gripper five-eights of an inch. Then the stationary gripper is reenergized. We transfer the load back from the moving gripper to the stationary gripper. The moving gripper is then -- or coil is deenergized, the moving gripper can swing away.

At that point, the rod is now five-eights of an inch higher up. We can then deenergize the lift coil to be ready to respond to another request for movement. To get the rod from the bottom to the top takes 228 of these step motions for a 12-foot core.

There's a very different sequence for moving the rod down. In trying to make the rod insert -- again, starting from the stationary gripper holding the rod -- with the moving grippers deenergized, we energize the lift coil. This pulls up the deenergized moving grippers or the unattached moving grippers and then at that point we grab it with the moving grippers. It's being held by both.

We let go with the stationary grippers. It's being held by the moving gripper. At that point, we deenergize the lift coil and the rod drops down five-eights of an inch. We transfer the drive rod back to the stationary gripper and let go with the moving gripper. At that point, we're back to a hold condition with the rod in five-eights of an inch.

It is important to recognize what happens with this reactor sequence when the reactor trips. No matter which coil is energized, which grippers are holding this rod, in a reactor trip, all of the coils are deenergized, lose power. With the help of springs, any grippers that were holding the rod are pushed open and the rod drops.

[Slide.]

MR. FOWLER: Please turn to Figure No. 2 for a typical arrangement of the control rods, the RCCAs, within a core. This is a four-loop core, but it would be very typical for two or three loops to have some of these same features. One is that the rods are arranged in a symmetric pattern and the rods are broken into banks.

We have shutdown banks and control banks. In a short while, I'll show what the difference between them in terms of controlling the reactor is. But a key feature is that the rods are arranged symmetrically within a bank.

If you look at the shutdown bank A rods, they are the black colored squares around the periphery of the core in a symmetric pattern. The banks are typically divided in half to form two groups of rods, a group one and group two for each bank.

When we do move the rods -- I discussed the single rod movement. When we move rods, we send signals for bank movement. When a bank is requested to move, the whole bank has to move. In fact, what we do, though, is move group one, half the bank, and then group two. We're going out; group one, group two. In other words, the groups move alternately and sequentially to reposition the bank of rods.

There's one other feature about movement of rods that's worth discussing in terms of the analysis that's going to follow, and that is the bank overlap feature.

[Slide.]

MR. FOWLER: For the control banks only, and this is on Figure 3, we use a mode of operation called bank overlap. The rod control cluster assemblies, due to the nuclear physics of the matter, have low reactivity worth when they're near either the bottom of the core or the top of the core. They're most effective in the center of the core.

The system has been arranged such that when a bank is nearing the edge -- the top or the bottom of the core, a second bank begins to move with it for the control banks, and that's what's basically being shown here. As control bank A nears the top of the core, the next sequential bank, control bank B, in this case, begins to move with it, until control bank A reaches the top of the core. Control bank B continues on its own and then there's a similar overlap with control bank C and D.

The order for withdrawal would be control bank A, B, C, D. For insertion, it's the reverse of that. Control bank D inserts first, followed by C, B, and A. What this does is make for a smoother rate of reactivity change.

[Slide.]

MR. FOWLER: Please look at Figure 4 and it will be a brief description of the components of the rod control system. The rod control system consists of a logic cabinet, which is the cabinet that responds to demands for motion and direction from the reactor operator or the reactor control unit.

Power cabinets, as many as five in our plants. The number depends on the number of primary coolant loops in the plant; actually, the number of RCCAs in the core. Power cabinets, which have the job of supplying current to the coils we've discussed for the control rod drive mechanism.

Of minor importance to this discussion is a DC hold cabinet that has the ability to hold one group of rods out of the core in a stationary manner. Of very much importance to this discussion is where the reactor protection system enters the case here.

The reactor trip breakers are between the source of AC power that the power cabinets use to distribute to the control rod drive mechanisms. By opening either of the reactor trip breakers that are located in this spot in series, you disconnect power to the power cabinets, as well as the DC hold cabinet, to ensure that all the coils deenergize and the RCCAs drop into the core.

I do want to just mention a few words about the slave cyclers. Inside the logic cabinet, there are slave cyclers whose purpose is to supply current commands to the stationary lift and moving coils via the power cabinets.

For each power cabinet, there's a slave cycler circuit located in the logic cabinet that produces the current commands.

Those commands from a slave cycler are sent to effect all the rods in a group. They are not separate signals for each control rod drive mechanism. There is a single set of commands sent to a power cabinet to effect all the rods in a group.

The commands for in and out motion, the current commands, are very different in their shape. As I tried to describe in the motion of the control rod, up or down, it takes a different set of current commands to make the rod go up and to go down.

[Slide.]

MR. FOWLER: Would you please return to my outline slide or -- excuse me -- the next in your package should be an outline slide. I'll briefly discuss modes of operation and features of the rod control system.

I'd like to take it from startup condition of the reactor through full power with some brief points of interest. Before the reactor is started up, there's a series of startup tests that can be performed where we prove operability of the rod control cluster assemblies. Specifically, we pull each bank of rods out of the core and then drop the control rods back into the core, the RCCAs back into the core to ensure that they drop within the specified time limits; basically, to ensure that we can trip the reactor.

Startup begins with the withdrawal of the shutdown banks. The shutdown banks are withdrawn individually, the whole bank. Shutdown bank A is withdrawn, then shutdown bank B and so on. They're withdrawn sequentially, one at a time.

The operator is in control of that evolution in that he or she moves an in-hold-out switch to withdraw the rods. By holding a switch in the out position, the rods are withdrawn. The operator also selects which banks should move.

The control banks are withdrawn in the bank overlap mode I described. The operator selects a manual mode of operation from the control board bank selector switch and then uses the in-hold-out switch to withdraw the rods. Again, the rods are withdrawn with the bank overlap mode, control bank A first, overlapped with B, then C and D.

The operator stops periodically during this evolution to assess rod movement and the reactivity addition. The manual mode is used until, in most plants, a little above 15 percent power, through criticality and up to about 15 percent power. In the automatic mode of operation, the motion and direction demand signals are provided by a reactor control unit, which is part of the process control in the plant.

The reactor control unit provides its signals in response to changes in the average temperature of the primary system or changes in the demanded power on the reactor, the turbine demand. Basically, the idea is that if the temperature in the reactor is lower than it should be for the given power level, if it's lower than it should be, we push rods in in order to -- excuse me -- we pull rods out in order to raise the temperature back to where it should be.

If the turbine power is increasing, we can withdraw rods to match that new power level and keep temperatures from changing. During these automatic operations, the operator does have indication of automatic operations through several features, including the rod speed demand is indicated. Demand direction lamps let the operator know which direction is being demanded and the changing in the rod position indication, which I'll describe briefly shortly.

It's also important to know that the operator can override any automatic operation by either selecting manual operation or, if necessary, by tripping the reactor.

Rod motion surveillance tests. Periodically, surveillance tests are performed according to the technical specifications of the plant. These tests involve taking each bank individually and moving the bank to ensure that it's operable, that the rods move in the proper direction.

I guess in final review from an operations standpoint of reactor trip, if the reactor protection system or the operator initiates a reactor trip signal, either of two reactor trip breakers can open and drop all of the rod control cluster assemblies into the core. We've removed power from the power cabinet, rods drop into the core.

So it's important to realize that a reactor trip signal will override all rod control system signals.

MR. THADANI: May I ask you a question at this point?

MR. FOWLER: Yes, sir.

MR. THADANI: Have you done enough looking and checking at this failure mode to be confident of that statement?

MR. FOWLER: Yes, sir.

MR. THADANI: Thank you.

[Slide.]

MR. FOWLER: I'd like to put one final slide up, which is to look at the indication alarms associated with the rod control system or the rod control cluster assemblies. For rod position and movement indications, we have the individual rod position indication. This is a system for each rod individually. The position of the rod is indicated to the control room operator.

There are also group step counters that display the demanded position of each group of rods. There are in/out demand lights located also on the control board that display what demand is being placed on the system, whether it's in motion or out motion.

There's a rod insertion limit recorder that shows the bank demand for the control banks, what the bank demand height is versus the technical specification insertion limit for the rods.

MR. THADANI: Can you --

MR. FOWLER: Yes, sir.

MR. THADANI: You've gone through a number of indications and other information that's available to the operators. Can you kind of briefly describe specifically, since rod movements take place almost every day at many of the plants, what do the operators really look for, how closely do they look at that information?

MR. WALSH: Ashok, I think maybe I'd like to try to answer that since I am at the station and Steve is not. I think predominantly an operator's responsibility at a station for any manual rod control would to, at power level, he's looking at basically a temperature versus turbine power from matching. Basically, what he's trying to do is accomplish the matching scheme.

His activities would be to manually control the reactor with rod control to make sure that the turbine power and reactor power are balanced. So his primary concerns are that the rods are moving in a manner which offers him this balance.

We have been trained on several occasions that when you are in front of the reactor control system, there are no other things that should be deferring your attention away from that system. So I think through training, requalification and examinations, that's one of the areas where you understand that the operator pays attention to his indication.

MR. NEWTON: I think the other point to make is that when the reactor is in automatic and a demand signal -- the temperature deviation is such that rods need to go in or out, rod movement occurs automatically, but the operator is usually made aware of that either through the noise of the rod position system motion, the lights that come on and indicate in or out, or, in some cases, some plants have even had an alarm to make sure they alert the operator to motion.

His responsibility, through his training, is to make sure that the motion and what's happening is correct for what's going on in the plant. Routinely, as part of their training, that's their job to do. So they are aware of motion in automatic. They have to verify that it's responding correctly to what's going on.

MR. THADANI: Is this even when you have such motion taking place fairly frequently? Certainly, for some plants, I imagine it's quite frequent.

MR. NEWTON: All I can speak for is our plant. The operator -- when a control room is in base load, the operator watches rod motion. It's something that's happening. It's something that he has to pay attention to and it also gives him a lot of subtlety indications of what's happening in the plant.

So he's used to looking at that to, indeed, see why did the rods move, did I change boron, did something else happen, is there a frequency change on the grid that is asking for up or down demand on the turbine. It's the first indication he has of what's happening around the reactor and he's used to paying attention to that because that's the first alert he gets to something happening.

MR. FOWLER: I would put in one other comment on that from a senior reactor operator's standpoint with the Navy, as well as training. The operator has been trained to listen to the rods stop moving, as well as start. Once we have motion, it's key that the operator knows that the rods should stop and you're listening and looking to see if that's happening.

MR. THADANI: How about the load following?
MR. FOWLER: Regardless of when the rods move, I think what Roger and Larry have said is a true statement, whether it's during load follow or not. The fact that the rods are moving is very important to the operators.
MR. THADANI: I guess my question -- I'm looking for a more specific response. If I have fairly frequent rod motion taking place, I'm trying to understand specifically what does an operator do. What are the steps that the operator goes through?
MR. WALSH: Well, the steps are one of monitoring --
MR. THADANI: By the way, I understood the control part, the average versus turbine conditions. I understand that part. I'm trying to be a little bit more prescriptive, so to speak. The operator is used to seeing this motion going at some frequency, I imagine.
Is there anything written down that says here is what an operator is supposed to do when control rods move up or down?
MR. NEWTON: I think that's covered by training. There's not a set procedure that he goes to or a normal procedure or alarm procedure. That is covered by training.
MR. WALSH: Within the training documentation, there may be such as training instructor's observation of

operators on the main control board. And one of the things they will observe is not only is the operator paying attention to the activity in front of him, but is there an interrelationship between all operators on the board.

What I mean by that is -- your question was how about load follow. Well, no plants that I know of are allowed to be on automatic load follow with the reactor plant. It has to be a manual mode change. The turbine operator is always told to inform the reactor operator when he is going to make a turbine load change, so that the operator can verify that the change was accurately done and that the reactor is following that change in temperature control.

MR. NEWTON: And the reactor operator, he just doesn't let rods move wherever they want. In most Westinghouse plants, you've got to make sure you're controlling your axial power distribution properly. So during load follow operation, you're adjusting boron concentration to get your rods where you want them to be.

So there's a lot of interaction and attention on the operator to rod position, because it controls the power shape of the reactor and he has to maintain that within set limits.

MR. THADANI: Can you, at some point later on, tie in this issue of the operator attention to what is going on motion for that bank. As it was going in, they noticed one rod, 1SA3 was now moving out. So they stopped.

The next data point we have is where the step counter is at six. This one rod is indicating eight steps. All the other rods in that bank, all of the other rods in the core still indicating zero on the IRPIs.

Next, the operators continued to demand in motion for shutdown bank A and took it from six down to zero. At that point in time, the one rod that they had noted, 1SA3, was now indicating 15 steps. All of the other rods are still indicating zero. Brought in a controls technician, went into the IRPI racks, verified voltages in the racks. That confirmed or agreed with the one rod was at 15 steps and the others are all at zero.

The next step was to open the stationary gripper fuse for 1SA3. The intent was to drop the rod. The expected response was to see the rod drop from 15 steps to zero on the IRPI. So that was observed. We also went into the racks, measured the voltage again. It also was in agreement with what we had observed.

The next thing we did was lift -- the lift coil disconnects were opened to prevent any further rod motion. The next troubleshooting evolution was to make some recordings of the shutdown bank A current orders. When we did that -- I'll move this up so you can see it. When we reviewed those, we observed distorted wave forms.

Subsequent troubleshooting identified two different failures on two circuit boards. This event is still being investigated back at the plant.

MR. LIPARULO: Our next speaker is Steve Fowler, who will discuss the failure analysis and range of rod motions.

[Slide.]

MR. FOWLER: These are conclusions of the failure analysis of the failures that occurred within the logic cabinet at Salem. As Tom mentioned, there were two circuit card failures, both of them located in logic cabinet slave cyclers.

The effect of those failures on the slave cycler current orders, taken both singly and in combination, would have the following effects on system operation. As this table is showing here, I've broken this out between the effect of having only one failure that causes an in direction signal to be present when it's not supposed to be and this middle column is when only the out direction signal is present, and then, finally, as it happened at Salem, if both failures are present.

For an in failure only, when a demand is placed on the rod control system, the following things occur. If the demand is for in motion with an in direction failure, the system works normally. The rods insert.

If the demand is placed on this failure for out motion, the rods in the group that is selected and receiving these current orders will either not move or they all move out.

There's a flipflop of this situation for an out failure. If the failure in the slave circuitry is an out direction signal, when out motion is requested, the demanded signals that are sent out by the slave cyclers present normal out motion. If in motion is requested, then the slave cycler current orders are demanding either no motion or out motion, again.

At Salem, when both signals were present at the same time, two separate failures, two slave cycler failures, whether you requested in motion or out motion, the current orders that were produced, the distorted wave forms will produce either no motion or out motion.

The conclusion with that is that the slave cycler current orders, these are some points to note on this, they are sent to all the CRDMs in the rod group. Again, they are not sent individually to different CRDMs.

The CRDMs may respond with outward motion. They cannot respond with inward motion. The rods cannot move in both directions simultaneously. They can only move out.

MR. THADANI: Can you clarify that for me a little bit? You said that there's overlap amongst the banks earlier. So let's take banks C and D. Is it possible that failures such as the one that occurred at Salem could lead to one of the banks continuing to insert and the other one leading to potentially rods going outward?

MR. FOWLER: No.

MR. THADANI: Okay. Can you tell me why you say that's the case?

MR. FOWLER: Yes, sir. The signals at Salem, the failures -- when I say it's on the in and the out signals, those signals or direction signals are applied to all of th slave cyclers, the in and the out. So if you were in bank overlap and requesting inward motion from control banks B and C at the same time, the slave cyclers within B and C would produce the same corrupted signals. They're being effected in the same way.

So now you'd get to the point where, for control banks B and C, the rods are either not going to move or the signals being sent would cause outward motion of all the rods in the banks. I think that's maybe -- just on the bullet here is that -- I don't want to miss the third from the bottom bullet.

There is not a demand signal created by these failures. There's a signal that changes the direction, but it does not create the signal to say move rods. That is a separate signal. It does not effect that circuitry. It has no effect on bank overlap. Again, if B and C are supposed to move, they will. You can't have A and C move, for example.

MR. CHAFFIE: You said that either all the rods move out in the bank or none of them move at all.

MR. FOWLER: Yes, sir.

MR. CHAFFIE: Whereas in Salem, one rod moved out.

MR. FOWLER: Right. But what I'm stating here is as far as the failures in the logic cabinet, the signals that are created should either -- since they're sent the same to all the CRDMs, should either produce no motion or out motion, never inward motion.

The fact that one rod moved, we'll discuss that later in this discussion, is not as a result of the signals coming out of the slave cyclers. Those are identical signals to all of the CRDMs that are selected at that point.

The final point, just to refer back to what I think was stated in Mr. Thadani's opening remarks, the failure cannot prevent a reactor trip. Whether the corrupted or distorted signals are not being sent out, the reactor trip can override.

MR. JONES: May I ask a couple of questions?

MR. FOWLER: Yes, sir.

MR. JONES: The analysis here is only for the failures of the Salem event, correct?

MR. FOWLER: Yes, sir.

MR. JONES: This kind of motion was not picked up by the original FMEA on the system.

MR. FOWLER: Actually, there is a statement as far as the original FMEA for this type of failure. It describes the effect of the -- as far as the signals that are being produced and it states that the response will be -- at power, anyway, will be a reactor trip.

I think we can get you that exact statement from the FMEA. Roger, the next speaker.

MR. LIPARULO: The next portion of the discussion is going to provide our technical evaluation of the situation of the event. Glen Lang, our first speaker, will cover the regulatory basis.

[Slide.]

MR. LANG: We have been asked to provide an overview of the assumptions we make on the operating modes of the control systems when we perform our accident analysis and also the regulatory basis. So I will be covering the first part. Then we'll talk about the different classifications of the various rod withdrawal accidents and, finally, we'll talk about the event-specific analysis that has been performed.

[Slide.]

MR. LANG: The discussion you are about to hear will provide the basis for reaching these conclusions. The first conclusion we reach is that random failures in control systems are not assumed nor are they required to be assumed concurrent with an AOO or a DBA.

The second conclusion we will reach is that the consequences of postulated failures in the rod control system do not exceed radiological release acceptance criteria established for a Condition III event. And, finally, that all plants should continue to operate and if they are not operating right now, there should be no restrictions on them returning to power.

MR. THADANI: Are you going to address at any time if credit is taken for control systems or if control systems can aggravate an abnormal operational occurrence?

MR. LANG: Yes, sir.

MR. THADANI: You're going to talk about it.

[Slide.]

MR. LANG: The three regulatory standards to industry and one regulatory industry standard that we'd like to briefly concentrate on today would be -- probably the first one is the most well-known, the IEEE-279 concerning single failure, IEEE-379 which was written to expound upon the single failure criteria in IEEE-279, and, finally, the standard review plan concerning operation of control systems.

during the accidents.

[Slide.]

MR. LANG: Section 4.2 of 279 deals with single failure. I think everyone is probably familiar with it. Any single failure within the protection system shall not prevent proper protective action at the system level when required.

[Slide.]

MR. LANG: IEEE-379 was then published to provide clarification to the industry concerning what Section 4.2 of IEEE-279 stated. Basically, this is a quote of the paragraph in 379 that talks about the general single failure criterion. The point that is most applicable here is "The protection system shall be capable of performing protective actions required to accomplish a protective function in the presence of a single detectable failure within the system, concurrent with all identifiable, but non-detectable failures, all failures occurring as a result of the single failure and all failures which would be caused by a design basis event."

It goes on further in the standard to talk about non-detectable failures. I just excerpt the part that was most important. It says "A failure which cannot be detected by a specific system test," as Mr. Fowler talked about earlier, "is considered to be non-detectable."

And, finally, it goes on and states that "In the analysis of the effect of each single failure, all identified non-detectable failures shall be assumed to occur as part of the original single failure."

Now, remember that this standard was written specifically for Class 1E systems, not necessarily control systems, and I'll touch upon that in a little while.

MR. JONES: Does IEEE-279 apply to a non-1E system?

MR. LANG: No, it doesn't. IEEE-279 was specifically written for automatically actuated protection systems.

[Slide.]

MR. LANG: I believe there were some statements out of the standard review plan that were very applicable in the analysis of the Salem event. I specifically picked one out of Section 15.2.7, which is the loss of normal feedwater, but it really doesn't make any difference what incident it's chosen from.

But the sequence of events from initiation until a stabilized -- these are the statements that the reviewer is giving guidance on what they should look at when reviewing a specific accident.

The extent to which normally operating plant instrumentation and controls are assumed to function; the extent to which plant and reactor protection systems are required to function; and, the credit taken for the functioning of normally operating plant systems.

So number one and number three are really the ones that are in question here, and, finally, also, for ESF, which isn't applicable in this particular transient.

[Slide.]

MR. LANG: So based upon those standards which apply specifically for Class 1E, we then generated our assumptions that Westinghouse makes in the analysis of their transient analysis or accident analysis in the FSAR.

As required by the standards I just went over, we must assume a random single failure in the reactor protection system, concurrent with an initiating event. Random failure in the control system can be assumed as an initiating event. Most Condition II events, AMS Condition II events are initiated due to a random failure in a control system.

The control system operating assumptions during the --

MR. THADANI: Can I hold you on that one for a moment?

MR. LANG: Certainly.

MR. THADANI: I have an event. Let me assume it's loss of load or partial loss of load or something that demands rod insertion.

MR. LANG: Yes.

MR. THADANI: The intent of the Chapter 15 analyses has always been that we have found a bounding event in that class of initiators that can take place.

MR. LANG: Yes.

MR. THADANI: Because you don't want to analyze hundreds and hundreds of events. Now, you have an event that calls for rod insertion. You take no credit for rod insertion, because then you say you might -- you'll get the next signal. If things get worse, you'll scram the reactor and the consequences will be okay, whatever class of events we're talking about, II, III, IV, whatever it is. Right?

MR. LANG: Yes.

MR. THADANI: Now, what is your view that -- what if, during this process, you knew that the control system can aggravate the situation? How would you treat that?

MR. LANG: Third bullet. What do we assume for the control system operating assumptions? Number one, it's either assumed to be in a manual mode or it's assumed to be operating in automatic mode. The criteria we use for determining which of those should be applied when we do the accident analysis is dependent upon which assumption results in the most severe consequences of the initiating event.

MR. THADANI: But this says assumed to operate normally.

MR. LANG: Normally meaning as designed, assuming no failures exist in the system.

MR. THADANI: That's what is confusing me.

MR. LANG: We do not assume that there are failures existing in the control system as -- that's the last bullet. No random failures assumed, other than the initiating event, in the control systems, concurrent with the AOO or the DBA.

MR. THADANI: But if you go back to the philosophy of how these classes were developed and how they were analyzed.

MR. LANG: Yes.

MR. THADANI: And a lesson that I thought people learned after the Three Mile Island accident, the effects of PORV opening and so on. Is it your view that the requirement called for not taking credit for control systems or if you took -- or if the control system were operational, its failure might degrade the consequences?

MR. LANG: We assume that if the operation of the control system exacerbates the consequences, we will assume it works normally. The next slide will go into why we will not take a random failure in a control system concurrent with the event.

MR. NEWTON: Ashok, one of the issues here, too, is detectability, and we'll be talking a little bit more about that, as to whether this is detectable or not and whether you need to make the assumption. So it ties together. But we need to talk about detectability.

[Slide.]

MR. LANG: So the justification for the position I just stated that we will take a failure in a control system as an initiating event, but we won't take it as a random failure concurrent with the event, is number one. As Mr. Fowler stated, there are several surveillance tests that we perform on the control systems during operation.

Number two, Mr. Fowler pointed out several things the operator looked at to determine whether the rod control system is, indeed, operating as demanded. So there are multiple, numerous indications in the control room for the operator to know whether his control rods are going where they're being demanded.

MR. THADANI: I will come back and I think this has been stated before. You have to put it in the perspective of what is that information available to the operator, what is the expected response of the operator, and the timing of that response and how that relates to your analyses.

MR. NEWTON: I think one of the key issues, too, is what is normally happening in the control room and if this failure is detected or not. One of the key items is that for the transient you postulated where you have a power reduction and the control system should respond to that, the control system is responding every shift -- I don't want to say every hour, every minute, but it is in operation every shift, every hour, and there's usually rod stepping going on.

If the failure would occur and the rods -- the next time they're demanded to move and they move in the wrong direction, that would create an unstable situation that would become detected immediately during the normal stepping of rods, because it would go out instead of in and the operator -- that would make the condition worse because temperatures would be off, there would be more demand for it, and it would be detected almost on the spot during the normal fluctuation of rod movement.

So one of the keys you'll see and we'll keep bringing up is whether this fault is detectable or not. I think our position is very strongly that it is detectable. That makes the difference as to what assumptions you have to make in analysis space.

MR. THADANI: Roger, I think I understand what you just said and I'll wait and I'm anxious to make sure we walk away with a clear understanding that it is detectable. But also important is the element of timing. When is it detected, what actions are taken, what would be the consequences given that process that you've gone through. That's important.

MR. WALSH: I agree it's important, but I think it's important with the idea is does the -- is the operator the only mechanism that protects -- offers protection. And if it is, then it's very important that he observes it closely and rapidly. But we have precedent that operators have seen failures in feedwater systems that would have caused reactor trips due to low steam generator levels and they've tripped out the reactor early enough, but it's dependent on the mode failure; do they have enough time to see it and what is their response.

And like Roger said, if there was an incident, we'll say, with load rejection and he realized that the temperature was not being regulated by the reactor control system, his choice would be to trip the reactor because of safety purposes. We can't assume that we can understand every one of the actions. All we can assume is he's properly trained and he's well aware of what's going on in a reactor plant.

MR. NEWTON: Also, that failure would have had to occur simultaneous with that event, and we don't have to assume those failures. That's a failure in the control system.

MR. THADANI: I want to make sure you don't walk away with a misunderstanding of what I'm saying. I think we are pretty well convinced that the protection system will do what it's supposed to do when the conditions to those set points.

But what I'm trying to focus attention on instead is what credit is given to operator actions and how that might influence Condition II or Condition III events and what are the acceptance criteria that are applied to these events. I agree with you on the point you made on the protection system aspects.

MR. WALSH: I think maybe we want to hold those questions until maybe at the end of our presentation when we evaluate what we think the analysis shows.

MR. LANG: To summarize what Roger said concerning the periodic surveillance and the detectability from indications available to the operator in the control room, the conclusion is that the result in low probability in random control system failures does not have to be taken with an AOO or a DBA. One point I want to also make --

MR. THADANI: Look. I hope somebody is going to be able to provide supporting information to these statements you're making.

MR. LANG: There will be probabilities presented. If, indeed, we identify a situation where there's a postulated failure that is not detectable through surveillance or control room indication, we would assume that detectable failure or non-detectable failure concurrent with the AOO or DBA. That is an extrapolation of the condition that I went over in IEEE-379 which applied to protection systems, but we would extrapolate that to the control systems

MR. JONES: If I could just follow up and I think it relates a little bit to my understanding of the failure mechanisms in the Salem event and the failure of the slave controllers.

As I understand it, you actually could have a failure which will not -- some sort of voltage fluctuation, as I understand it, the root cause or the postulated root cause of the Salem event and it's the continued exercising of the chip that will degrade the chip and ultimately it will fail.

So that is not a sudden chip failure, but, rather, something that slowly degrades and then appears. How does that fit within your definition of detectable failure when the detectable failure is really voltage fluctuations as opposed to the chip failure?

MR. LANG: We would argue that regardless of the mechanism of how that failure occurred, if we were operating at full power during normal rod motion to maintain your reactor temperature, that that failure would have been detectable, because if a demand would have been generated for rod out motion or rod in motion and it went the wrong way, it would have been detectable through process variables or eventually through alarms available to the operator.

MR. LIPARULO: Plus the surveillance testing.

MR. JONES: Well, the surveillance testing -- again, as I understand the root cause, the surveillance testing will not pick up the voltage spokes that were causing -- or degrading the chip. Again, this is how I understand it. Am I correct on the failure mode as we understand it today?

MR. RULAND: Today, yes.

MR. JONES: Thank you.

MR. NEWTON: But we're playing a little semantics here on what is the failure and what is detected. We're saying that the result of the failure, which can be any number of things that can cause the rod control system not to operate properly. Whatever all those are, those are detected by the operator when the system does not work properly.

That can be very obvious things, such as alarms telling him the system is not working to simply silent on the alarms, but the rods don't move or they move the wrong direction. We're treating all of those as ways of detecting that the system is not working. We don't detect what caused it not to work, but we detect that it's not working. We consider that detectable.

MR. WALSH: Let me restate something, too. I think your description and what I've heard are different. What you described to me sounded like the distorted signal caused the chip failure.

MR. JONES: No. Not the signal that came out of the relay card. I'm way over my head in the I&C matters. So as I say, it's my understanding. But it was something to do with the counters that were put in giving some sort of a signal that a high voltage fluctuation is input to the chip, which could continually degrade the chip with time.

MR. WALSH: We don't have that as information, so I guess I'll pass.

MR. RULAND: At some point, you're going to discuss the probability of failures of the semiconductor devices. Is that going to be discussed to classify this as either a Condition II or Condition III event?

MR. LIPARULO: Yes. We have a discussion on equipment failures and probability.

MR. RULAND: And how long is -- how many steps are you talking about before the operator or the system actually detects the failure?

MR. NEWTON: We've had detection at our plant of

MR. CHAFFIE: Okay.

[Slide.]

MR. LANG: My final slide is something I want to go over on what we assumed. Our control systems, if we have a Condition I event, the one we arbitrarily chose was a load rejection. The three control systems that are most predominant in a load rejection event would be the steam dump to dump a load, pressurize PORVs, the main thing, pressure control on the primary, and,finally, the rod control system to go in to decrease the reactor load.

MR. JONES: If I could go back to just that Condition I, is it not assumed for the load rejection that that bounds normal plant load maneuvering from a -- that that -- that, as a design basis event, is expected to bound scenarios caused by partial load follow events.

MR. LANG: You will not find a design transient load rejection in the SAR analysis. This is what Westinghouse calls design transients, where they demonstrate that with control systems operating normally, the reactor is able to ride through that transient without generating a reactor trip.

But depending upon what load rejection capability a plant would have, it may be 50 percent, it may be 100 percent. But this would be what we call a design transient to demonstrate that the control systems can ride through it.

What we would do in the accident analysis would be to analyze an event we call loss of load or turbine trip, inadvertant turbine trip, to demonstrate that the protection system set points are adequate to protect the core.

MR. JONES: Okay. Let me go back to that event, then. Is it not fair to say that you would anticipate that a normal plant maneuver with a single failure in the control system would be bounded by your design basis load rejection for, say, a partial load event?

MR. LANG: Exactly, and that's what I have down here. If the control systems operate properly, the steam dump system would open and when the load was sufficiently reduced, it would close. If we assume it fails open, we would say this transient was bounded by our steam line break analysis, either Condition II or Condition III.

If the pressurizer PORV opened, normally it would close when the pressure in the primary is below the set point. If it fails open, we would claim that that transient is bounded by RCSD pressurization, which is the DNB part of it, and the small LOCA, which is the stuck-open PORV.

Similarly, for rod control, if we had a malfunction of the rod control system during the design transient, we would say it's bounded by the rod withdrawal incidents.

MR. JONES: And the rod withdrawal incidents are considered to be a Condition II or a Condition III event?

MR. LANG: We will get into that in the next presentation, but they are various. We'll get into the probabilities in the next presentation.

MR. CHAFFIE: And do these rod withdrawal events include just a bank of rods moving out or individual rods?

MR. LANG: We'll talk about the whole spectrum.

MR. JONES: Let me go back to my question and let me ask it slightly differently. If I have a partial load rejection or just a normal maneuvering transient with a single failure in the control system, should that event, in your opinion, be a Condition II or a Condition III event? Or let's put it this way. Should such an event be within the design basis as to not cause fuel failure?

MR. LANG: We would state that if a failure in a control system occurred during a design transient, that it is bounded by a Condition II or III event.

MR. JONES: I'm not asking for a load rejection. I want to be very clear about that. I am talking normal plant operation, the load follow maneuver. Should such load following and maneuvering given a single failure in your rod control system, should such an event -- should the protection system given that event act in a timely manner such that no fuel rod failures would be postulated to occur from a failure of, like, the DNB limit?

MR. NEWTON: Let me see if I can answer the question. I think what we're saying is that for a rod control system failure, we would expect that a bank or group of rods would move together and that's been analyzed as a Condition II event, for what we'll be talking about later.

We'll talk about Condition III as part of the discussion that will deal with that probability. But to answer your question, I think it's a Condition II event that we would expect the failure mechanism to result in bank movement.

MR. JONES: Fine.

MR. NEWTON: Bob, the reason I say that is that it's a detectable situation in that the failure would occur at that time from rod motion, the lack of it. If it had been operating perfectly up to that point in time, rods moving together as a bank in and out, and then you have a failure, a single failure per our analysis that results in signals going to banks or groups of rods.

MR. JONES: I guess what I'm trying to be careful of and separate is -- I know you're putting a lot of stock on this detectable, but going along with the detectable argument, I think there's some sort of an assumption as to the challenge rate. So that there are periods of time when you could be detecting or have to assume other additional single failures.

When you talk about events like load rejection, turbine trips, these are not daily things. If a plant is in a load following mode, that plant can be maneuvering multiple times during that day, making multiple demands, and a 30-day surveillance may not be adequate as a detectable -- as detection. It may just pop up.

So what I'm looking to make sure is the design basis event, in our minds, at least certainly in my mind, has been chosen to bound a lot of what I would call normal everyday operations with single failures in these various control systems.

Whether the situation is detectable or not, if these kind of normal everyday manuevers with the failure within the control system should be bounded by some other design basis transient.

MR. NEWTON: I think one of the keys we're going to show you, and that's why we keep going to detectability, is that it's the basis for our failure rate argument later on and what occurred in the different categories.

MR. WALSH: Going back to your discussion of load follow where plants could be moving their load daily, that's a daily exercise of the rods. So their 30-day surveillance test is happening daily. So the operator observes every day that the rods are functioning properly.

MR. JONES: But the difference, though, Larry, is

I'm not taking you to the next step, which is give me a turbine trip with the control system moving with the single failure. I'm just taking what happens for normal plant maneuvers with this single failure, where do you end up.

Do you consider that bounded or within your analysis envelope as a Condition II event? I believe it is.

MR. THADANI: I think maybe if we can go on, I suppose we talk about detectable or detectable and undetected failures, the concept of standby is important. But for plants where you have rods moving continuously, I'm not sure how significant an issue that is, except when you get into the issue of frequency and what defense you're going to be looking at. I'm very anxious to hear the next part.

MR. NEWTON: I think the point we're trying to make is that with the plants with rods moving all the time, if this failure would then suddenly occur, it would become detectable right away because they're moving right away and they would detect it before the transient that you're talking about occurred.

MR. JONES: Let me ask it simply. Will the presentation -- this is a yes or no question. Will the presentation show me or give me the results of analysis of a partial load -- well, a load following maneuver with this single failure assumed in it?

MS. VERTES: It will tell you that the analysis that we've performed bounds that situation.

MR. JONES: As a Condition II event.

MS. VERTES: We will conclude that it's appropriate to consider it a Condition III, given what occurred at Salem.

MR. JONES: But you do not have the specific analysis I asked about.

MR. NEWTON: We have it treated as a Condition III event, that failure.

MR. JONES: Okay.

MR. COLLINS: It looks like from the slides we're going to get into a key portion of this meeting. Would this be a good point to take maybe a ten-minute break?

MR. NEWTON: We're at a natural break point here.

MR. COLLINS: Why don't we take a ten-minute break, come back at quarter to three.

[Recess.]

MR. COLLINS: Let's get started again. Ms. Vertes.

[Slide.]

MS. VERTES: This is what we were going to describe before we took the break, and that is that the basic design philosophy behind safety analysis classification is that the Condition II, Condition III, Condition IV event classification is based upon probability of occurrence.

We have analyzed a number of rod withdrawal scenarios, all of which could have been postulated to occur as a result of the Salem event, some of which are already analyzed within the FSAR to be postulated to occur as a result of other initiating scenarios.

Of those rod withdrawal events, all of them are bounded by the conditions at which we -- well, below -- initiation from a load follow scenario is bounded by the analysis that we have done, either from full power or part power.

In general, we've seen that initiation from a steady-state condition at full power bounds initiation at some part-power condition at which you would be during a load follow event. The basis for that is a methodology we use in analyzing rod withdrawal at power events, and that has to do with the fact that we assume that these events trip on over-temperature delta-T and that we conservatively assume that conditions in the core will be at the most limiting spot, if you will, on the core limit line, such that we've actually taken a very conservative bounding approach.

If you want to get into the details of why that approach would support any initiation condition from part power to full power, we can get into that later. But I think the basic premise is that the analyses that we've done would bound initiation from a load follow.

Whether it should be classified as a Condition II or a Condition II event is dependent upon what initiates that event following a load follow.

With respect to the basic design philosophy, I'd like to discuss this with respect to how we classify the Salem events. I'd like to just first start off by saying that the basic philosophy is that those that are most likely to occur should have the least risk to the public health and safety.

Those that have the potential for the greatest risk should be the least likely to occur. That basic premise is used in determining the Condition II, Condition III and Condition IV frequency. And because of those frequencies, the acceptable consequences are gradually increasing based on those classifications.

[Slide.]

MS. VERTES: In addition to the ANS classification events design philosophy that's used in plant FSARs for categorization of safety analysis events, the general design criteria is also used to determine the acceptance criteria for control and components within the reactor coolant system.

The GDCs themselves specify the acceptable criteria for operation of control and components. GDC-25 relates specifically to reactivity control system malfunctions. GDC-25, which was alluded to earlier, specifically states that the protection system shall be designed to assure that the specified acceptable fuel design limits are not exceeded for any single malfunction of the reactivity control system, such as accidental withdrawal of control rods.

MR. JONES: Could you give me your definition of what the specified acceptable fuel design limits are with respect to GDC-25?

MS. VERTES: The specified acceptable fuel design limits, as referred to in the standard review plan, refer you back to the minimum DNBR. We would say that although specified acceptable fuel design limits, as referred to in the SRP, are minimum DNBR, but we feel that the intent of GDC-25 is to show that the probability of an event should be commensurate with the consequences or the consequences should be commensurate with the probability.

Hence, it's acceptable, if you have a sufficiently low probability of having a control system malfunction that would result in some challenge to the reactor protection system, that the consequences should be based on the probability of occurrence.

MR. THADANI: I guess I understood the first part of your previous viewgraph. Have you researched this issue so completely as to conclude what you just did? That the intent of this GDC was to look at what the probabilities might be and to assign appropriate safety limits given those probabilities.

I think this GDC has defined consequences. It is not into your previous chart, because the fuel design limits. That's the consequence you want to make sure is not exceeded.

But you concluded that that's driven by probabilities, I think quite correctly. However, this goes on to say for any single malfunction, there's no explicit statement on what that probability is. There's implicit consideration of probability by saying any single malfunction.

If you had said implicit in this is some probability consideration, I would agree with that. But I think you took the next step. That's the part that I don't understand.

MR. NEWTON: I think the next step is required in many of the things we do when we exercise our judgment and how we interpret the regulation. Some part is very explicit. Some part is -- we have to establish how to interpret it.

MR. THADANI: I understand that, but have you done that -- now, what I'm saying is do you agree, first, that the consequence is clearly defined here? Is there any question about the consequence part?

MR. NEWTON: Let me put it this way. We're giving you our logic for making the call under Part 25. If you disagree with that, we're asking you to explain why that is. We think the logic ties together and meets the understanding of the regulation. So we have a sub-logic here and it is tied to probability of occurrences.

MR. THADANI: Let me make sure. Let's take this slowly because this is an important issue. Did you read in the GDC the very explicit definition of what the acceptance criteria are?

MR. NEWTON: It identifies specified acceptable fuel design limits.

MR. THADANI: Have you gone through years and years of analyses as to what this actually means?

MR. NEWTON: We're here to meet to determine what that is. We feel that ---

MR. THADANI: What is specified acceptable fuel design limits?

MR. NEWTON: Right. We feel that there is a definition for Condition II and Condition III that are used.

MR. THADANI: I think let's start -- I want to be very -- let's be very explicit. Do you know what those terms mean?

MR. NEWTON: We are giving your our interpretation.

MR. THADANI: Have you seen safety analyses reports, your safety analyses reports which define what these terms mean?

MR. WALSH: Chris, could you help us on our interpretation?

MS. VERTES: There are some specific plant FSARs which do talk about probability of occurrence and meeting specified acceptable fuel design limits within the Condition III classification of events, which would lead one to believe that you could interpret specified acceptable fuel design limit to be the criteria for the classification of events.

MR. THADANI: We may have to come back to this issue. Now, in terms of the single failure, can you define better what you think the intent was by way of people who crafted this GDC? What do you think they were looking for?

MS. VERTES: I think the intent, and I'm not sure whether my thoughts on this have any real meaning with respect to the outcome of this, was very similar to the classification of events in terms of probability, that it was thought that a single malfunction had a fairly high probability of occurrence and that, therefore, one should limit the consequences to that of the specified acceptable fuel design limit, which I believe at the time the intent would have been minimum DNBR.

MR. THADANI: Yes. Now, I did not ask you on your previous viewgraph for a very specific reason. Now, let me ask you what is the role of confidence limits in these discussions? When you assign probabilities, do you think there is some confidence level at least considered?

MS. VERTES: I think that's appropriate.

MR. THADANI: Are these estimates at 95 percent confidence?

MS. VERTES: At this time, I would --

MR. LIPARULO: Ashok, I think we have a probability assessment that we'll discuss later that puts us, based upon the data we have, within the range of a Condition III event. We have not had the time given the schedule we've been under to assign confidence levels at this point.

MR. THADANI: Nick, I understand that. What I'm trying to make sure is I understand the thought process and what -- as a minimum, I'd like to understand what are those boundary conditions that we're trying to make sure that we are working to. There are two very important pieces in this. One is consequences. In that statement, we all need to understand what those are.

We also need to understand the first part, which is the issue of probabilities. While I understand you haven't had a lot of time, I would like to understand if you think the -- since we're talking about the intent and the thought process, if you think people were looking for some high level of confidence when they considered these values.

MR. WALSH: Ashok, I think we're going to show analysis later and then we're going to show the probability effects, and then come back on a slide that summarizes, and that might be a better point to discuss the same issue.

MR. THADANI: Okay.

MR. JONES: Can I ask just one simple question?

MS. VERTES: Certainly.

MR. JONES: To the best of your knowledge, in demonstrating compliance to GDC-25 prior to the Salem event, did you interpret the SAFDLs in a probability sense or was it the minimum DNBR that you used in demonstrating compliance?

MS. VERTES: I believe that prior to the Salem event, there was no single malfunction that fell outside of Condition II criteria and the Westinghouse method demonstrates acceptable consequences by meeting the minimum DNBR limits. So there was no intent not to consider confidence. It was logical to just look at minimum DNBR.

MR. LIPARULO: I think, Bob, when our next speaker comes up, Baard Johansen, he can at least discuss in his analysis that I believe we did have a probability and a confidence associated with that, his transient analysis.

MR. WALSH: We're at a little bit of a disadvantage in that answer because I think most of the FSARs that look at some of these events, like single rod withdrawal and bank rod withdrawal, just have a common statement. There are Condition II and Condition III events here and I don't know if we narrowed it down to which is which. So we've got a little bit of both.

[Slide.]

MS. VERTES: With respect to the appropriate classification of this event, I think there's four very important points to make with respect to detectability. We believe that the occurrence at Salem is detectable based on two things; one, the every day frequency of rod motion and the monthly surveillance.

We also believe that this is a low probability event based on the operating history of the Westinghouse PWRs. From the reported data that we have looked at or we have been able to obtain, there are only two events which were reported which indicated that a card failure resulted in an RCCA misalignment. In both of those cases, the misalignment was a group or a bank of rods.

Both of those are symmetric rod withdrawal events which are bounded by current FSAR analyses classified as Condition II events. So at this point, there is no event that's been reported which results in a single rod withdrawal at a power or subcritical condition.

The initial assessment of the probability of this event based on the reported data that we looked at would be commensurate with the Condition III probability.

In addition, that probability was based upon looking at the card failures which resulted in misalignment, not necessarily extrapolating that to the limiting condition which would be a multiple asymmetric withdrawal and it would be a very specific scenario defined in a very -- given, say, nine D bank rods, you would have to look at the two rods from the two groups within D bank that are adjacent to each other.

There's only, I think, one four-loop rod control system configuration with the nine rod D bank. So it's a very limited scenario which results in the most significant consequences. And the probability of that occurring is much, much lower than the probability of the card failure resulting in misalignment that we've assessed based on the data that's available.

MR. THADANI: Yes. I think that's an important point you make. I assume in the analysis you have concluded that is the only case where you're going into --

MS. VERTES: That's correct.

MR. THADANI: Okay. The second part -- and I agree with you. That clearly has to be of lower likelihood than any failure. But the second part is have you ruled out aging effects? If you're estimating probability, then you have to look at some random phenomenon.

MR. LIPARULO: We have a specific discussion of aging coming up in the PRA discussion. In summary, we do not see a correlation with respect to age.

MR. RULAND: One question about detectability.

MS. VERTES: Yes.

MR. RULAND: In this case, the operator moved -- at Salem -- moved the rods 20 steps and albeit shut down. Is that within your bounds at power or detectability that they're given 20 steps to detect it or more? I mean, at what point does it have to become --

MS. VERTES: With the analyses that we've done at part power and full power conditions, we've taken no credit for operator action. So we've assumed that the rods would just move -- a single rod or a multiple rod, whichever would be the limiting scenario, would move out of the core and you would get a trip on an over-temperature delta-T, and we've analyzed the consequences as a result of that.

For the rod withdrawal for subcritical analyses that we have looked at, if we were to assume that the operator were to act within 48 steps, I believe, and Baard will get into this, that we would show that the minimum DNBR, when it would be met -- three individual rods from subcritical.

If we have to -- if we do not credit operator action and we assume that the rods would continue to withdraw from the core, then we would expect to see a small percentage of rods fail, but that's based on using our current methods. If we were to use more sophisticated tools, we would expect to be able to demonstrate that there would not be any significant fuel failure.

MR. NEWTON: I don't know if that was the answer. That's the accident analysis answer. Now, if you're asking the operator question, how soon does he detect it, if the operator is getting feedback, meaning he's critical or he's at power, 20 steps is a lot of rod motion without any response from a reactor.

So he's detecting it probably before that, unless he's totally got his back to it. Then you go to the accident analysis to see what the consequence is. The only time an operator does not get significant feedback to rod motion is when he is substantially subcritical, which was the case at Salem, where he was lifting the first shutdown bank out and he had his position indication then as his only indicator of rods out of position.

But the other time, you always expect the in or out feedback from in or out motion and the reactor behaves -- within a few steps, you've seen reactivity increase power, decrease temperature, whatever you're doing. It's there.

MR. WALSH: In addition, he's going to have to ignore alarms because there's a 12-step deviation alarm away from bank. So there's an actual alert point that he's got to ignore to continue to --

MR. NEWTON: Right. If you set all of that aside, what Chris is talking about -- what she's going to talk about on the accident analysis results.

MR. THADANI: I guess I would still go back to how much time are you estimating is available before a certain number rods go into DNBR or at least DNB condition, perhaps. Certainly below 1.3, I guess.

MS. VERTES: Can you address that? Yes. Baard will address that during his presentation.

MR. THADANI: And I would like to understand that in the context of what Roger just said. Where are the operators and how long does it take for certain actions to be taken and how long does it take for rods to go into DNB?

MR. NEWTON: For the at power case.

MR. THADANI: For the at power case.

MR. RULAND: One more question about the operating history. How confident are you of your database? Meaning that you've identified all the instances where this happened. The operator did move 20 steps before he noticed it and it took some additional rod motion before he finally figured it out.

MS. VERTES: I don't know that I'm the best person to answer that. I know that we intend to do a survey. We do realize that not all these card failures would be reported, but we also feel that it's not appropriate to consider every card that is replaced during a maintenance as a failure.

Steve or --

MR. NEWTON: Let me just see if I can answer that from a history perspective. We have a limited database that we have used and it's the best we have now without going and asking the utilities to more specifically go back into their records and look at what's there and bring it forward.

So we ourselves feel that we think it's indicative of what's happening. We're also basing this on our own experience from operating the reactors for 20-25 years and not having these things happen. This is an unusual event that if it happened, operators would be remembering it. We don't have many of these there.

So we know we've operated reactors for hundreds of years without having this happen. We need to go back in the database and look more closely at that, because every once in a while when you look real closely, you get surprised, and we want to do that.

That's one of the things that we'll be talking about later. That's one of the commitments the Owner's Group is making to further quantify the probability.

MR. WALSH: We already stated that we didn't think we had a real high confidence because of the time scale we've been working in and trying to get back to you at this meeting to let you know the general overall picture of what we have determined.

Our intention is to not let go of this and continue to investigate to get some confidence levels.

[Slide.]

MS. VERTES: I'd like to address this with respect to the Salem event, which I think sheds some additional light on the significance of the situation. Given the failure in the logic cabinet that we saw at Salem, all the rods in shutdown bank A should have either moved out or remained stationary.

We believe that there must have been some other condition which resulted in a single rod being withdrawn from the bank. We have a technical investigation that's still ongoing and it's important to understand that if another mechanism had not been present, the resulting event would have been a bank or a group withdrawal, which is currently bounded by the safety analyses presented in the FSAR.

So it's only in addition to this condition that we need to continue to further investigate that you would have a situation where you could have this limiting condition with an asymmetric rod withdrawal occurring.

Again, the initial probability assessment that we feel is appropriate is to assess this as a Condition III event, and, therefore, that it would be appropriate to demonstrate compliance with the Condition III event criteria, which would allow for a small fraction of the fuel to be predicted to fail.

Westinghouse conservatively assumes that it -- we predict that the rods are below the design DNBR limit, that they are assumed to go into DNB and that there's a small amount of fuel failure that would result.

But in reality, what we have seen based on the results is that the small prediction of the fraction of failed fuel that we would get based on using this assumption would easily allow you to conclude that there would be absolutely no gross fuel damage at all.

MR. THADANI: This is, again, with the assumption that you take experience and make a point estimate.

MS. VERTES: Sure, certainly. We have to be able to do that.

MR. THADANI: And you're equating the point estimate to your earlier ranges.

MS. VERTES: Yes. Based on this, we feel that the intent of GDC-25 has been met with these analyses.

MR. CHAFFIE: So what you're saying, then, is that there should be no single failure that should cause a single rod withdrawal to occur and there must have been something else at Salem in addition to this one shift failure that's causing a single rod to move.

MS. VERTES: I don't know that we know that at this time, but there certainly appears to be something else besides a single failure which would result in the incorrect current signal. The incorrect current signal would be sent to all the rods in the bank and you would expect that all those rods in the bank would either move out or stay stationary.

And to postulate that the single rod randomly moved out is something that we're not ready to conclude yet.

MR. RULAND: Let me ask you to postulate something. Let's suppose the single rod moved out because of a design tolerance or corrosion of the mechanism or something along those lines. Would this change the conclusion you've drawn here?

MS. VERTES: I would say not. Based on the probability of occurrence of the event, we still would feel that it's appropriate to consider the consequences commensurate with Condition III.

MR. CALVO: Jose Calvo, NRR. Will you duplicate this particular thing at Salem? Have you tried to do it again to see what happens and you only tried one rod or all the rods in the bank happen to be moving in the wrong direction?

MS. VERTES: I believe they did a test and when they did the test, all the rods that received a signal moved out. The incorrect signal moved out. So we were not able to reproduce one out of a bank or group receiving the same demand.

MR. WALSH: I think we ought to let Salem answer that since they're closer to the issue.

MR. LaBRUNA: We did not duplicate the in situ performance that duplicated or didn't duplicate. We just did not run a test, an active test of actually movement of rods. We did do some testing at our training center where we have a mockup, but it's obviously not the exact environment for loads on the drive mechanism.

MR. CHAFFIE: But in spite of the fact that you don't think any single failure could cause a single rod withdrawal or, the worst case, I guess, two rods adjacent to each other, you still took into account an analysis that showed the impact of a single rod or two rods.

MS. VERTES: Yes.

MR. CHAFFIE: As it pertains to a Class III event against the Class III criteria.

MS. VERTES: Yes.

[Slide.]

MS. VERTES: These are the events that one could postulate as a result of the Salem event. The single RCCA withdrawal at power, which is what you just referred to, is currently analyzed in many plant FSARs as a Condition III event. The classification was based on -- was thought to take multiple failures or multiple operator errors to result in a single rod withdrawing from a bank or group.

The other events --

MR. COLLINS: Excuse me. Does that event result in exceeding the DNBR?

MS. VERTES: Yes.

MR. COLLINS: The FSAR.

MS. VERTES: Yes.

MR. COLLINS: It does.

MS. VERTES: Yes. The criteria used is a small fraction of the fuel could fail. The Westinghouse criteria has typically been five percent. Most of our analyses demonstrate that you're well below that. In addition to the single rod withdrawal at power, you could postulate a single rod withdrawal from subcritical. Also, you can postulate bank withdrawals from power or subcritical, and, finally, asymmetric rod withdrawals at power or asymmetric rod withdrawals from subcritical.

Of these six postulated events, it's the single rod withdrawal from subcritical and the asymmetric rod withdrawals from either at power or subcritical conditions that have not yet been analyzed and presented in plant FSARs.

Westinghouse has done analyses and evaluations to look at these scenarios, has determined that the asymmetric rod withdrawals are the most limiting conditions. We have looked at that from both at power and subcritical conditions, and Baard will present the analyses for that.

The one point I wanted to make earlier and I just want to reiterate on -- Bob, you had asked the question with respect to load follow. Of all these events that you can postulate, for the at power events, if we were to analyze them from some part power condition given a load follow when you had a demand on the rods and you were to postulate that this failure would result in a single or an asymmetric rod withdrawal, the consequences initiated from a load follow versus full power steady-state conditions would be no different based on the way we do the analyses.

They would be bounded by what we have done.

MR. CHAFFIE: I have a question. Of the different examples that are on here, I take it all of these would meet the criteria for Class III type event.

MS. VERTES: Yes.

MR. CHAFFIE: Not exceed that. How many of these would not meet Class II criteria?

MS. VERTES: Right now, from what we have done, which is a bounding case to try to make an initial assessment, given the timeframe, the asymmetric rod withdrawals and the single rod withdrawal subcritical would not meet Condition II criteria given our current methods and the bounding assessment we have done.

The bank rod withdrawals are analyzed in the FSAR to meet Condition II criteria. The single rod withdrawal at power is currently presented in most plant FSARs as a Condition III event and is not required to meet Condition II criteria.

[Slide.]

MS. VERTES: Based on the analyses and evaluations that we have done, we've assessed the following. The events that can be postulated -- the limiting event that could be postulated has a low probability of occurrence which is commensurate with Condition III and infrequent fault. Therefore, we feel that the allowance of a small amount of fuel damage is consistent with the design philosophy used in the classification of events and determining acceptable consequences.

The conservative analysis that Westinghouse has done to assess the significance of this issue at this time would allow us to demonstrate that the rods would experience a calculated DNBR below the limit value, but that it would only be a small percentage of the rods and that little or no actual fuel failure would be predicted to occur.

Based on that, we feel that this presents no undue risk to the public health and safety.

MR. THADANI: Let me ask you your opinion. Condition II events are ones, I guess, you analyze or -- quite a large number of them. For those Condition II events, the way they are analyzed, you have to meet design limits, and that includes fuel design limits.

MS. VERTES: Correct.

MR. THADANI: The initiating events that you considered there have frequencies less than ten-to-the-minus-two per reactor year implicitly and we will not yet define at what confidence level.

MS. VERTES: Right.

MR. THADANI: Would you agree with me that I have now identified a class of events that the way these are analyzed is conservative fashion; that is, you assume conservative initial conditions?

MS. VERTES: Yes.

MR. THADANI: You have, in general, a conservative evaluation model.

MS. VERTES: Yes.

MR. THADANI: You don't take credit for certain situations.

MS. VERTES: That is correct.

MR. THADANI: Give me your own view of what you think the possibilities might be when you take all those conservative factors together and still meet fuel design limits. What do you think the probability might be?

MS. VERTES: The probability of occurrence or the -- I'm not sure --

MR. THADANI: Of the event for which the whole scenario, the event itself, plus the way you analyze with a lot of conservative assumptions, for which you say you must still meet fuel design limits.

MS. VERTES: I'd say it can't occur.

MR. THADANI: That's probably true. I'm trying to get you to take the next step. That is, there is a concept of confidence. When you have this approach of frequency safety limits -- and I think you're exactly right. The more likely the event, the tighter the limits.

But it's not a point.

MS. VERTES: Okay. I agree.

MR. THADANI: It's a band. And I'm trying to get you to think about this not in the point estimate world, but more in the confidence world, so to speak. Ninety-five percent is traditionally what a lot of people do. It doesn't have to be that.

From your own studies and looking at these, what do you think people are looking for? Do you think they are looking for some level of confidence?

MS. VERTES: Yes. I think they are looking for some level of confidence. It's something that we feel, given the way the events are categorized or classified and not recognizing all the conservatisms that one puts into an evaluation model.

You clearly have a hundred percent confidence that you've met acceptable criteria. I can put it in the reverse maybe and say that if I were to use -- if I were to eliminate the gross conservatisms and some of the incredible assumptions that I assume coincident in my methodology and I were to use a three-dimensional spacial kinetics model and look at this event, rod withdrawal from subcritical, rod withdrawal from power, asymmetrically or otherwise, that I would be able to demonstrate that I would not violate my minimum design DNBR limit.

MR. THADANI: Good. Now, that's where I'm headed also. Have you done such analyses?

MS. VERTES: We've done one representative case. We've spoken to a licensee, NNC in Britain, who's currently licensed to model or is in the process of licensing a three-dimensional model for Sizewell B in the United Kingdom.

Based on those results, we would expect to be able to demonstrate the same. However, Westinghouse currently is undergoing V&V on that particular analysis methodology and it's not yet approved by the staff. So we've done some work with SP Nova-K, which is the code that we would be using, and demonstrated significant DNBR margins exist, but we haven't been able to do that in licensing space.

MR. THADANI: Okay.

MS. VERTES: With that, I'd like to introduce Baard Johansen, who performed the safety analyses to assess the significance of these events.

MR. LIPARULO: Baard, could you characterize the probabilities and confidence levels of your analyses? It was mentioned that you were going to do that.

MR. JOHANSEN: Yes. I think that's something we can go through as I talk about the analysis, talk about what sort of conservatisms were actually included in terms of the DNBR criteria that we're comparing to, what sort of confidence is applied to that.

My name is Baard Johansen. I'm Acting Manager of the Core Design Section in the Nuclear Manufacturing

Division at Westinghouse.

My responsibility was to evaluate the core response and the accident analysis impact of the asymmetric rod withdrawal events, both at power and occurring from subcritical condition.

[Slide.]

MR. JOHANSEN: Let me just quickly give you an event description of the asymmetric rod withdrawal at power. The assumption based on the postulated failure mechanism, how this event could occur. RCCA banks would be operating within the rod insertion limits in normal overlap. So you're going to be at some power level with the rods anywhere from their lower rod insertion level to the top of the core.

At some point, operator demand or automatic rod control demand for an RCCA insertion coupled with the postulated failure or control system malfunction results in a single or multiple RCCA withdrawal.

Obviously, if you have an entire bank withdrawing, you're covered by or analyzed as part of our RCCA bank withdrawal at power accident. Also, for most current plants FSARs, we consider the event of single RCCA withdrawal at power and demonstrate that only a small fraction of the fuel would be below the DNBR limit. Typically, that limit would be five percent.

Our concern with this event is that you would have multiple rods, not a full bank, but not a single rod, but some combination of multiple rods withdrawing from the core, which potentially could create higher F delta Hs for peaking factors and also lead to more rods being below the DNBR limit.

[Slide.]

MR. JOHANSEN: We performed the dimensional full core calculation using our approved code system, Phoenix And and C, and devaluated different combinations of single, double, triple and quadruple rod withdrawal, either partially or fully, from the core at different power levels and from banks at the insertion limit and partial insertions.

We determined and we looked at two-loop, three-loop, and four-loop cores as part of our evaluation. We also considered the effect of different control rods. As part of our evaluation, we also considered the effect of different control rod patterns. What we determined was that the limiting results in terms of the greatest number of rods going into DNBR compared to the results of a single rod withdrawal event would occur from those control rod patterns of the nine-rod D bank where you would have the asymmetry, where you have D bank rods in relatively close proximity.

For plants where you would have a five-rod D bank, the D bank rods are not close enough that if you withdrew two, you actually get some power flattening compared to the single rod withdrawal case.

So just to summarize, the limiting cases relative to single rod withdrawal at power event occurred with two or three adjacent D bank rods withdrawing from the core. We only found this to be more limiting for the three and the four-loop core that have the nine-rod D bank.

What we determined for the limiting case, comparing to the limiting single RCCA withdrawal, that we would have fewer than one percent additional rods below the DNBR limit value. The DNBR limit value is based on a 95-95 criteria, the 1.3 or whatever DNBR correlation that plant is using.

So we took no credit for the conservatisms inherent in the DNBR correlation. In addition, we apply an eight percent uncertainty on top of our calculated peaking factors, consistent with our approved methodology.

Now, to put that increase, that one percent increase into perspective, we surveyed all our current core designs that we have the design responsibility for. The maximum percent of rods calculated to be below the DNBR limit value for the single rod withdrawal event was 1.5 percent.

So I think with a high degree of confidence, we could extrapolate and say that for the bounding type of value percent of rods below the DNBR limit for our current reload designs would be about 2.5 percent; again, significantly below our criteria of typically five percent. The conclusion is that little or no fuel damage would result because of the asymmetric rod withdrawal.

MR. THADANI: Are you going to talk about those cases and the time when you calculate the --

MR. JOHANSEN: Yes, I can talk about it. What we did was look at the core power distributions for the different cores analyzed and we selected the most limiting time in life in terms of the time when the power distribution for all rods or rod conditions was closest to the peaking factor limit.

Then we went through and selected the combinations of rods that would be in close proximity to give you the worst power distribution tilting. So we were -- let me show a figure.

[Slide.]

MR. JOHANSEN: This is a typical four-loop control rod pattern. In this case, we have nine D bank rods located here, here, here, center. Obviously, to get the worst peaking factors, we would want to withdraw rods that are in this vicinity of the D bank rods, and that's exactly what we did. We pulled combinations of D bank rods in combination with C bank rods at the lower power levels. At full power, obviously it's just a D bank rod.

So we pulled combinations of this D bank rod with this one in combination with the center rod, in combination with this one, so on. What we found was that after you -- once you begin pulling four or more rods, you got actually reduced peaking factors because you were flattening the core power distribution.

For this particular four-loop core, the limiting single rod withdrawal occurred when we pulled this one out, keeping the remaining D bank rods at their insertion limit. The worst multiple case occurred when we pulled these two adjacent D bank rods.

When we looked at another four-loop core that had the same control rod pattern, again, this was the most limiting single rod. The most limiting multiple occurred pulling this bank and this D bank.

[Slide.]

MR. JOHANSEN: Also, for a three-loop core -- I'm sorry. Here's a typical three-loop control rod pattern. Again, we pulled different combinations of rods, trying to come up with a configuration that gave the worst peaking factors and the largest percent of rods in DNB. The single RCCA withdrawal was this D bank pulling.

We found that three D bank rods pulling gave the worst multiple asymmetry F delta H, and that consisted of these banks here.

[Slide.]

MR. JOHANSEN: Again, for the two-loop core, because of the way -- basically, because of the spacial separation of the D bank rods, you can see we don't have any D bank rods that are in close proximity. Once we pulled a second D bank rod, the core F delta H actually decreased and the percent of rods below the DNBR value was improved.

MR. THADANI: Can you tell me the timing issue?

MR. JOHANSEN: Yes. We looked at -- for the two and the three-loop cores, we picked the time in the cycle depletion where we had the minimum margin to the safety analysis peaking factor limit and picked that depletion step and began the multiple rod withdrawals.

For the four-loop cores, we looked at several times in life, both beginning of live and depending on the type of burnable absorber in the core, perhaps 4,000 megawatt day might be the most limiting, because our burnable absorber, if it depends to deplete out at that point, and you get some power peaking.

We also looked at end of cycle. So end of cycle, you may have a flatter power distribution. It's not quite as peaked, but because you have a flatter power distribution, you may actually generate more rods in DNB, even though your maximum power peak is a little bit lower.

So that effect was evaluated.

MR. THADANI: And for these cases, how long before you were calculating a certain number of rods going into DNB? Twenty seconds?

MR. JOHANSEN: The core response -- these represent static calculations. What we assume is that eventually we will get a trip on OT delta T. And the assumption is any rod above the safety analysis limit will go into DNBR, will be in DNBR. So depending on what the peaking factor of the F delta H limit is for the plant, 155 or 165, any rod above that would be assumed to be in DNBR, conservatively assumed to be in DNBR.

MR. THADANI: What do you think in those cases the operator could do to prevent a rod from getting into DNBR?

MR. JOHANSEN: Well, I think the first indication would be that if he noticed the rods were moving at some point. At some point, he'd see that the rods were misaligned from the rest of the bank. So he will have that alarm.

MR. THADANI: Can I ask you again? How much -- can you quantify --

MR. JOHANSEN: In terms of core response time to the point of DNBR.

MR. THADANI: Yes.

MR. JOHANSEN: That number I don't have, but that's a number that we could provide to you for these cores.

MR. THADANI: Yes. I would be interested.

MR. CHAFFIE: Do you know how far the rods have to be out of position before you have a problem?

MR. JOHANSEN: We assume very deep insertion limits. There are 170 steps. We actually did sensitivity on one plant; does this correlation between the percent of rods below the DNBR limit, how does that vary if you were to have a deeper insertion limit. What we found was the delta in percent of rods in DNBR for multiple versus single RCCA withdrawal, that held up as we went to deeper and deeper insertion limits.

So we looked at a 188-step insertion limit at full power and a 170-step insertion limit at full power. What I don't know is if you were parked at 170 steps, how much of a misalignment could you tolerate before you were in DNBR. But I think the other point is for the plants we surveyed, the maximum of all those plants in terms of percent of rods in DNBR for single rod withdrawal was only 1.5 percent.

For a large fraction of the core, the cores that we looked at, we predict no rods to be in DNBR and that's really a function of the fact that we have different thermal hydraulic analysis being performed for different plants.

Some plants are licensed and have used improved thermal hydraulic methods to predict -- to translate DNBR margins into higher peaking factors. If the plants aren't actually designed to those peaking factors, that's margin that you would have. So you could tolerate a higher withdrawal or misalignment before you would actually have rods in DNBR.

So that's very plant-specific. Some plants, we can go in and use a DNBR margin to demonstrate that no rods would be in DNBR. It really depends on what power level the plant's at and what type of peaking factors they're designed to.

MR. NEWTON: Ashok, what I think we're saying is that we didn't do a transient analysis of stepping the rod out and then seeing which catches you first. The over-temperature delta T trips you out before you get a power distribution, that puts rods in --

MR. RULAND: So that means that any effect on the set point you didn't factor in. Is that true? The OT delta T set point was not -- any effect that the rod misalignment would have on the OT delta T set point was factored in or not factored in?

MR. NEWTON: It's two different static cases, one with the rod in, all rods in at insertion limit, and then you take one or two rods out. You're simply looking at power distribution for rods in DNB. You're not looking at the set point because you're not looking at that calculation.

MR. HEBERLE: Glenn Heberle, Westinghouse Transient Analysis. I think the question related to the effect on the over-temperature delta T set point of the rod misalignment.

The over-temperature delta T set point is taken from the process parameters of temperature and pressure, so forth, and there is one term in there that is affected by the power shape in the core. That's the F delta I penalty function. That would only act to reduce the set point and, therefore, make you reach it sooner.

So if anything, the rod misalignment would cause you to reach the set point faster than without the misalignment.

MR. RULAND: And that's regardless of the position of the rods.

MR. HEBERLE: Yes.

MR. JOHANSEN: Let me add to that. From the neutronics standpoint, the assumption is the plant is operating either through a load follow or at steady-state. But in normal operating mode, the plant would establish a target axial offset which they would maintain during the base load operation or during the load follow operation.

We conservatively assumed that they're operating outside that axial offset target band. So we conservatively skew the power distribution towards the top of the core, pushing the axial offset of power distribution outside the allowable axial offset band; therefore, actually contributing to the impact of the RCCA misalignment. So that's just a further conservatism that's supplied in the analysis.

MR. JONES: Just a clarification. When you said you went into DNB was when you exceeded the F delta H limit.

MR. JOHANSEN: The assumption -- the core --

MR. JONES: Or your minimum DNBR limit.

MR. JOHANSEN: The assumption on the set points is that any rod that is at the safety analysis F delta H limit will be at the point of DNBR or will have a DNBR of 1.3. So we say that any rod that has an F delta H greater than the safety analysis limit would be below the DNBR limit.

MR. JONES: That appears to be conservative.

MR. JOHANSEN: Right.

MR. JONES: On the other hand, you're obviously then not starting these analyses at conditions that your tech specs allow you to be at, correct?

MR. JOHANSEN: Correct.

MR. JONES: F delta H and other things.

MR. JOHANSEN: We start the assumption, the initiating condition is that -- well, these really represent just a static calculation. This is where you're going to wind up after you have the misalignment. This is the peaking factor that you will find up with.

MR. NEWTON: But does the worst power distribution have the core limit peaking factor. It might be somewhere else in the core. Or are you looking at peaking factors that aggravates this portion of the core as your starting point? I think that's what you're saying.

You could be at your limit, but it might be somewhere else in the core and it would actually help you for this rod withdrawal.

MR. JOHANSEN: That's right. We're taking the worst set point combined with the worst power distribution, which could -- and the worst power level, which actually could come from different times.

MR. JONES: I thank you.

[Slide.]

MR. JOHANSEN: We have also examined asymmetric RCCA withdrawal from subcritical. The conclusion is that it's a multiple withdrawal, so it would bound the single RCCA withdrawal both from the standpoint of peaking factor based on the conclusions we determined from the full power event that two rods or three rods would lead to higher peaking factors than a single rod.

Also, the reactivity insertion associated with two or more rods going out would be greater than the single rod withdrawing.

For this event, the reactor is conservatively assumed to be at hot zero power with a core value of 1.0. So you're just critical with the shutdown bank's withdrawal from the core. The banks are assumed to be operating at normal overlap and can be in any position from fully inserted to up to their rod insertion limit.

Again, the failure mechanism is that you're in manual rod control. The operator gives a demand for a rod RCCA insertion, coupled with the postulated control system malfunction, RCCAs actually withdraw. Two or more RCCAs withdraw from any inserted bank.

And that could be -- if you're fully inserted, all banks fully inserted, that could be any rods coming from A bank. It could be from A plus B if A is partially inserted into the core, so forth, B plus C, C plus D.

Again, the concern with this event relative to what we currently analyze for most plant FSARs, the rod withdrawal from -- rod bank withdrawal from subcritical is that you may have higher peaking factors associated with an asymmetric withdrawal.

That, of course, would be offset by the fact that when you're only withdrawing two or three or four rods, the reactivity insertion that you're adding to the core is going to be significantly less than what you obtained from bank withdrawal.

[Slide.]

MR. JOHANSEN: Let me first talk about some of the conservatisms that are in our current bank withdrawal analysis. The way we currently analyze it, we assume that the banks are withdrawing with one hundred percent overlap. That means A plus B bank are both pulling out the core at the same height.

What we're trying to do here is maximize a reactivity insertion rate, do a very conservative bounding type of analysis. We also assume that the rods are moving at a high rate of speed, typically 72 steps per second. We also in our evaluation of DNBR assume a very conservative bottom skewed power shape, a type of power shape that you would only see perhaps in a no xenon core for a first cycle.

You would not see that type of power shape in a reload core. So the implication of that is that it's a significant DNBR penalty when we actually go to do the DNB calculation.

We also use conservative radial power distributions. The concern here is that for the postulated asymmetric withdrawal, the F delta H could be higher than our typical generic radial F delta H assumed for the bank withdrawal. So somehow we need to address that.

The first thing I think we can assume is that for the manual operation, the typical rod speed would be about 48 steps per minute. If, for a worst case scenario, we postulate the operator, despite the training that he's received, despite the fact that he's getting a rod deviation alarm, allows the RCCA withdrawal to continue for a full minute with no action.

At that time, you would have the maximum misalignment of the 48 steps. This would provide -- would limit the amount of the F delta H perturbation compared to the symmetric bank withdrawal case. Also, because we're looking at a relatively low number of rods withdrawing and the fact that they withdraw and overlap, the reactivity insertion rate of this transient is very low.

We have calculated for a number of cores not to have greater than 15 pcm per second reactivity insertion rate. That compares to the 75 pcm per second we obtain for a generic RCCA bank withdrawal analysis.

And just to describe the core response for the bank withdrawal event, when you insert a high reactivity, core power increases very quickly. We eventually trip, but the trip doesn't occur fast enough that you get an overshoot in power level. And it's that maximum power level which could be significantly above the trip set point that we analyze for DNBR.

Core response is calculated for the type of reactivity insertions that we're postulating for this event are showing much lower power levels. Basically, when you hit the trip set point, you will trip and you won't get the power overshoot.

Right off the bat, that provides a significant DNBR margin. Other areas of conservatism in our bank withdrawal analysis, we assume that in mode two, when you're critical, you will have only two of four pumps running for a four-loop core or one of two pumps running for a two-loop core, two or three pumps running for a three-loop core.

Point of fact. When you're in mode two, I think all tech specs require that you have all pumps running. Again, when you make that assumption and more better estimate type calculation, take credit for the fact that pumps actually will be running in mode two, you get a tremendous DNBR benefit.

Calculations for four-loop core indicate that that DNBR benefit is worth on the order of about 40 percent, not taking credit for the fact of using more realistic power shapes.

So I think we have several areas of conservatism in the analysis, the assumptions on the number of pumps running, the conservative bottom skewed power distribution, the lower reactivity insertion rates associated with this event, that all lead us to the conclusion that the results of this analysis should be bounded. When we are able to go through a detailed analysis for two, three, and four-loop core, we'll be bounded by the results for the bank withdrawal.

At this point, we are comfortable in drawing the conclusion that we would have little or no fuel rods below the DNBR limit value. When our analysis is completed, we feel that we can demonstrate that there would be no rods in DNBR.

I think something else that needs to be mentioned, we've talked about it, is we are still working with methods that are 15 years old or 20 years old. We have new methods that are being developed, the 3-D space kinetics programs.

In fact, we did a benchmark calculation last year of the rod withdrawal from subcritical event -- this was bank withdrawal from subcritical event -- where we compared the core response for using -- for this event, using the current methods and their conservative assumptions compared to what you would obtain from a 3-D solution.

Using the current methods, we predicted about an eight percent DNBR margin for this four-loop core. When we went to the 3-D kinetics methods, the percent of DNBR margin increased from eight percent to 77 percent, which you could translate directly into increased F delta H, which you could use to accommodate asymmetric RCCA withdrawal.

So I think looking down the road, with new analysis tools, you could probably say even if I permitted full withdrawal from the RCCA from subcritical, any subsequent peaking factor associated with that would be -- we would be able to accommodate that using these types of methods.

Again, I think the bottom line conclusion is based on either current methods and revisiting the assumptions in those methods or going to more detailed methods, we can safely conclude that there is little or no fuel damage as a result of this event.

MR. THADANI: Are you planning to do that analysis?

MR. JOHANSEN: That is not really in our plans. What is in our plans in a short time period is to conclude our analyses using the current methods, improving our assumptions, and looking at the two, three and four loop cards.

MR. THADANI: I will come back to it when we talk about what the individual licensees are going to do. I think this would be an issue we would want to discuss.

MR. JOHANSEN: I think at this point Nancy Closky will give a discussion about the probabilistic assessment that was performed.

[Slide.]

MS. CLOSKY: My name is Nancy Closky. I work in one of the probabilistic risk assessment groups at Westinghouse.

In the short period of time since the identification of this event, we have conducted initial review of the component failure located in the logic cabinets of the rod control system, using the available data sources that were available at the time, within the past few days, the nuclear plant reliability data system, the licensee event reports and nuclear power experience.

[Slide.]

MS. CLOSKY: Based on that initial review, we identified 34 logic cabinet component failures. When we broke those component failures down, we broke them down into what they -- what impact they had on the rod control system. Twenty-four of those events resulted in no rod movement, or no rod movement with an urgent alarm. Two of the events were step counter driver failures. One failure was a card failure that was identified subsequent to reactor trip, and was not identified and related to that with an MSSV trip.

MR. THADANI: Could I ask you a question? It's a general question. How much confidence do you have in this database, particularly, if you believe this represents the total population of Westinghouse-designed plants?

MS. CLOSKY: Our initial review of these indicates that this is not a consistently reported type of failure. And that's why we have agreed to do the Westinghouse owners group survey to collect additional data.

MR. CALVO: Jose Calvo, NRR. If this event would have occurred at power, would the licensee of the utility have reported that to Westinghouse or to the NPRDS data? Is this event you have in the NPRDS -- this is an event that happened during maintenance or happened during power operations?

MS. CLOSKY: Most of the ones we have identified have been during power operation.

MR. CALVO: Power operation?

MS. CLOSKY: Yes. Some are due -- the LER ones are actually due to the failures during the tests, the monthly surveillance tests. Those are the ones that are reportable by the LER events.

MR. CHAFFEE: But, are these failures required to be reported in the NPRDS system?

MS. CLOSKY: No.

MR. JONES: Of the 24 no rod movement events, were you able to find anything dealing with the root cause to those failures? Were there chip failures that showed up on those, similar to what was seen in the Salem event, or were they just 24 failures and you don't know the condition of the card?

MS. CLOSKY: We have identified just to the component level whether it was a slave cycler or a buffer memory or supervisory memory card. That's as far as we have been able to determine. A lot of the data that's available currently does not go into the level of detail to say whether it's chip failures or not.

MR. JONES: Of the 24, how many would be slave cyclers?

MS. CLOSKY: I don't have that readily available; but, I have those identified.

MR. CHAFFEE: If some of the NPRDS data did identify chips, were you able to figure out if those were the chips that we were interested in?

MS. CLOSKY: In the time frame that we have been able to conduct this experiment, we have not been able to go into that level of detail. The nuclear power experience does give the best descriptions of most of the events which what exactly failed. Some of them are just faulty cards. That's why we are pursuing the additional data.

MR. JONES: I guess my reaction is it seems a little bit low, although I don't have a magic database. But, it seems to me that lately, in the last two to three years, there has been a large number of events that have come to my attention dealing with problems with the rod control systems at various plants, generally PWRs, and a lot of the issues related to changing the technical specifications and the definition of operability, or interpretation of operability is related to only the trip function and not the movement within the normal rod control system -- that is, checking whether you can move the rod plus or minus a few steps was not necessarily considered to have an effect on the operability of the control rods so that you could still trip and, therefore, fulfill its safety function and ending up giving either additional time to repair or modifying the steps to give more time for repair of the cards so you could replace the cards in those circumstances. So, it appears to me there has been -- there has been some interaction on this over the last two or three years that seems to be high. I don't know how that may correlate. I will just point it out to you that you may want to look into that kind of experience. I don't have any numbers or even who. It has died down lately, but it may be because we changed several tech specs, and plants just stopped asking for them, since we have taken care of a bunch of them which were having problems, I don't know.

MR. RULAND: How do the numbers that you've found compared to the numbers and data found in the Brookhaven study that was performed?

MS. CLOSKY: Most of the data that we have included in the 34 covers those events. We have done a correlation between those. There are a few that, in their assessment, would fall into the power cabinet versus the logic cabinet. We are saying the logic cabinet is the one that could cause the rods to move.

We identified five failures that caused rod drop events and we identified two rod group misalignment events that had occurred previously to the Salem event. Let me reiterate that this was groups or banks that moved in those two events. Okay? It was not a single rod moving.

[Slide.]

MS. CLOSKY: Based on our initial review, we have not found a reported failure that has resulted in a single rod becoming misaligned, as with the Salem event. And, based on our preliminary calculations of the frequency of occurrence of this misalignment with the two events, plus the Salem event, we feel that it is a condition -- it falls into the Condition III frequency.

MR. THADANI: Let me ask you your opinion. Given that you said that you yourself have some questions whether you have good quality database, that you are still looking, would you question the words that says confirms that the event is a Condition III?

MS. CLOSKY: Well, based on the distribution that we saw of the rod movements, okay, the number of rod jobs -- the number that actually caused no rod movement, okay, we are getting to a smaller subset each time. Okay? Based on our knowledge from the operating history side from the plants, we don't think that that's going to increase significantly.

MR. THADANI: I can understand that statement. But, you don't think it's going to go up significantly? But, to me, that's not the same thing as confirming that it's low.

MR. NEWTON: I think we will give you the numbers we have and we can make a judgment on that a little bit better. That's one of the items that we feel we do need to look at more carefully.

[Slide.]

MS. CLOSKY: Just to share the various types of events -- this didn't come out too well on the slide. We tried to correlate it with what we know at this point. So, we took the failures and distributed them over the time frames, the five-year time frames. The first block on each shows the number of failures within the given time periods. The other one is just to show how many plants -- Westinghouse plants we had in commercial operation at those times. So, by the time you get up to 50 or 48 we have had a relatively minor amount of component logic failures from the data that we have seen this far.

MR. CALVO: Excuse me. Have any of those failures that you have noted -- have those resulted in the reactor scram? Were those just failures that occurred at power, and fail -- it didn't -- these did not participate a reactor scram?

MS. CLOSKY: Most of the rod jobs would precipitate a reactor --

MR. CALVO: It precipitated it?

MS. CLOSKY: Most of them would. We don't have the data parceled out to say which would cause a trip.

MR. CALVO: I was wondering if you had a problem at power that it precipitated a reactor scram. Then when the trouble-shooting was done in the shutdown conditions, were there any failure that it would find out that the cause was a particular reactor scram? What I am saying is suppose you have got a control rod withdrawal that you don't want to see it at power, then the reactor -- the protection system -- the over delta T will catch it, will trip the reactor. Then you go down to zero to shutdown condition, you trouble-shoot the reactor control system. Would you then report that event -- that malfunction?

MR. NEWTON: Every reactor trip is reported. And certainly if a trip down and over -- you know, temperature delta T, that would significantly be reported. I think --

I'm not sure I heard what you said, but, for those cases where rods drop, they usually result in a reactor scram. For cases where the system just locks up, no, it does not usually result in a reactor trip.

MR. CALVO: Okay.

MR. NEWTON: Most of these cases are -- I am making a judgment on system lock-up versus dropped rods.

MR. CALVO: Okay.

MR. NEWTON: So, I think most of these cases did not result in reactor trip.

MR. WALSH: In Westinghouse plants there's such a thing as a negative insertion trip, and most plants that tripped on dropped rods got that negative insertion trip.

MR. CALVO: I guess I was just wondering -- those control rods that fail at power, any one of them show what kind of the problem was in the control rod system indicative of some of the problems that we are looking at on Salem? That was what I was getting at.

MR. NEWTON: Those are the things that we are going to have to look at more carefully to characterize it correctly. Was it a logic card -- and then look at their resultant repair on that to determine, indeed was it chips or was it something else that caused it to lock-up.

MR. CALVO: I am sorry to tell you, this data, it doesn't give me the kind of warm feeling that I can see that you support your conclusions. That is all right.

[Slide.]

MS. CLOSKY: We also looked at the card failures -- the reported card failures by time of commercial operation. As you can see, most of those failures occurred within the first three years of commercial operation of plants and has remained relatively constant in the years after that.

[Slide.]

MS. CLOSKY: So, based on our initial reviews, we don't -- we do not feel that there is a correlation to the aging effect. But, we are giving consideration to collecting the additional data and revisiting this at that time.

MR. COLLINS: Your last bullet here says consideration is being given to the collection of additional data. I thought I had heard that that was something that you had decided to do already.

MS. CLOSKY: Yes, we have, but we haven't exactly figured out what type of data and what kind of form we want that data in.

MR. COLLINS: Okay.

MS. CLOSKY: Okay.

[Slide.]

MS. VERTES: I see a lot of smiling faces. Oh, we reversed the order. I wanted to go through the safety assessment, based on the evaluations and analyses that you have heard about so far. I want to stress some of the things that Mr. Thadani had pointed out -- that the approach that we have taken has been conservative and consistent with the approved methods that we are currently using for design basis analyses. Given the time frame and the need to make a very quick assessment on the safety significance, that we felt was the most prudent approach to take, given that it would be the most easily defendable, and most easily understood or recognized, based on what the staff has already seen, in terms of Westinghouse methods for performing safety analyses.

Given those analyses, and our initial assessment on the probability of occurrence of this event, which is based on not only the probability data, but the detectability of the failure itself, and the operating history which indicates that this has never occurred, we feel that this is, when we are all said and done, going to be in the realm of probability of a Condition III event -- that, if we were to use the conservative methods that we are currently using, that we would predict minimal or no actual fuel damage as a result. If we went to best estimate or 3-D spacial kinetics models, we would be within the Condition II acceptance criteria, and that, in addition, no challenge to the integrity of the reactor coolant system or containment has been demonstrated as a result of the conservative methods that we have already used. And, as a result, there is no undue risk to the public health and safety. And, based on those conclusions, we feel that it's appropriate to have plants continue to operate or resume operation as currently scheduled.

MR. JONES: Let me ask a couple of questions, since this is kind of your wrap-up slide. I don't know where to ask these questions as they build up.

MS. VERTES: Okay.

MR. JONES: I am not sure you are the right person to ask them to, but I will ask them to you, and I am sure you will get your cohorts --

MS. VERTES: I will defer them.

MR. JONES: -- to pitch in.

MS. VERTES: Yes.

MR. JONES: Where I am coming from is one, is GDC-25 and the control systems in general, the rod control system. Now, it's my understanding the FMEA was done on the control system, is that correct?

MS. VERTES: Yes.

MR. JONES: What were you trying to accomplish, or what was the purpose of that FMEA, if not to show compliance with GDC-25?

MS. VERTES: I am not the appropriate person to answer that. I don't know whether that's Steve or Horum.

MR. JONES: Someone could answer me about it earlier.

MS. VERTES: Yes. Okay.

MR. FOWLER: I have a copy of it here. I will just read you the abstract as far as what it says the purpose was.

"By the use of a failure modes and effects analysis, it is shown that the full length rod control system will perform its reactivity control functions considering the loss of single active components."

MR. JONES: Okay. Very much like what is in the GDC. Does the Salem event raise any questions in your mind about the completeness of the FMEA done in the control system?

MS. VERTES: Steve?

MR. THADANI: Go ahead, Nick.

MR. LIPARULO: I think that's a very difficult question for us to answer at this time, Bob. I think, as we perform the evaluation of the event, as it continues, we will be able to give you a better answer to that question.

MR. JONES: Okay. Let me just continue it then. I know you can't answer it, but let me go through the rest of my line of thinking. It's my understand of the FMEA that when you look at the FMEA, it was done in the very high level of the block level, and never considered the type of failures I think we are seeing in -- from the Salem event. At least, that is the preliminary understanding I have from the team and their feedback to us. I think that, in turn, raises some questions about the completeness of the FMEA done on this system and how that demonstrates or doesn't demonstrate compliance to GDC-25.

I think it also may raise some questions about some of your assumptions related to your safety assessment. If part of your assumptions are, while you are focused, and rightly so, I think on the specific failures that showed up from this event, if FMEA is incomplete, there may be other events and failure modes where things such as not having bank overlap may occur. I don't know whether that's true. I am not an I&C person, as I stated earlier. But, it appears to me the issue of completeness of the FMEA and those kinds of things come into play, whether all of your assumptions in these analyses are correct or not.

I will also wish to state, for the record, my opinion that when we developed GDC-25, way back in the late '60s, early '70s, that it was the staff's to not have any single failures in a rod control system for maneuvering allow fuel failures. And while you may be looking at changing that definition here, I would say that that is a change in the licensing criteria and the GDC. That's my opinion.

MR. THADANI: Let's go ahead.

MS. VERTES: I would like to introduce -- well, bring back Roger Newton.

[Slide.]

MR. NEWTON: Chris had the task of summarizing the safety aspects of it, and then we have to kind of extrapolate that to system operability. And since system operability is utility call, they felt it was more appropriate that the owners group do that call versus Westinghouse. And, since we are used to doing that, I felt an obligation that we need to look at the system operability from what we have seen.

So, we are looking at the operability of the rod control system. We are saying that, through the tech specs requirements that we do, and we have the requirement for periodic testing to determine that the rods, you know, do move, which is a demonstration of operability of that, and that normal plant operation that we talked about, you know, being able to detect, you know, the failure faster than every 31 days or 30 days, that the system is detectable and maintained -- that those requirements result in the assessment or conclusion that their control system is operable. There's nothing there that we feel violates a significant design aspect of the control system.

The protection system. We have talked about maintaining that. We all agree that that is not interfered with. So, it's just a question of now what do we say the control system state is? This is based upon the ability to detect and also the infrequent nature of what happened at Salem. It was the first of its kind after a lot of years of operation. We are going to go back and look at that more carefully determine -- sometimes things happen and we don't see all of what's happening there. So I think, if we go back and look at it more carefully, we will characterize whether this was the first of if there are a few more.

And it wouldn't surprise me if we found that there might have been a couple more. From the numbers we ran with the operability numbers, you know, Salem was one, to stay within the Condition III-type event, I think the numbers came out to be that you could have up to eight of a similar event where you felt that one rod was moving in the multiple direction, one or multiple rods was. So, from that standpoint we felt quite comfortable with the conclusion that we are making here.

MR. CHAFFEE: Is your review, in terms of looking for other examples, is that going to include Westinghouse plants outside of the U.S?

MR. NEWTON: It will not, no. Okay? On one of these slides we put domestic up there to -- okay?

MR. THADANI: Let me make sure I understand what you just said. Each licensee is expected to make an operability determination. I assume they have done that. Guidance is given in Generic Letter 91-18. Certain statements are made are made in the FSAR, as well as in the safety evaluation reports. Can you tell me those licensees who have -- let me make an assumption. It's fairly clear in the record that a single failure in the control system should not lead to exceeding fuel design limits. How would you expect that licensee to make an operability determination?

MR. NEWTON: There are two aspects of that. We are summarizing what we have talked about here before. The failure at Salem, we are characterizing as a failure of the logic cards, which resulted in similar signals going to the rods that -- when they look at that, that same failure will result in a bank or sub-group moving. They will make the judgment that there is another mechanism or something there that did cause the Salem event to occur. Also, from the operating experience of the utility, from a frequency standpoint, with the data that we have tried to provide to add more information to them, we are taking it -- even if this does occur, how do you treat that? We tried to give them the bigger, broader picture in what information we provided to them. So, I think, if they go back and look at the design of their system, they will be back to where we were -- that the bank or group of rods will move together, and they have been analyzed for that. At the Salem event something else happened, and it is very infrequent. And, when we look at that combination with infrequency, you know, it's beyond the operability call, or you look at how you analyze that from a risk standpoint.

MR. THADANI: I didn't completely follow that. I guess can you address the following? You don't have a quality database. You don't have a detailed failure modes and effects analysis. There may be other faults that could be of concern, not that there are. Until you have some high level of confidence that your database is fairly solid, and that you really do understand specific single faults or failures that might lead to these conditions, I don't know how you or I, with the conclusion you just did --

MR. NEWTON: I guess because, you know, as an operating utility, we have to make these calls all of the time with soft information. And, as of this time, there's not enough specific, firm information to say the system is not operable. Therefore, the call is not based on not having specific information that says the system will not perform as it is supposed to.

So, we are left with the operability call of the information of the owner's group that we have been able to work with the industry. We have not found anything accounted to accept as conclusion at this time is what we are saying. So, asking us to make the call today -- we are still saying the systems are operable. But, it is a call the utilities have to make all the time.

MR. CALVO: I wonder if you were confronted with the event at Salem getting at the root of that particular event, in order to duplicate what happened with the event? It is an event that happened, but it seems like you were having difficulty trying to duplicate that event.

MR. NEWTON: That is correct.

MR. CALVO: You also indicated today that you had technical specifications that required some surveillance to be done at power. And that's one way that you would be confident that the rod moved as required, based on the surveillance theory. But, maybe those technical specifications -- the surveillance was prepared as a function of a failure mode and an externality that showed the weakness or what is important to the technical system. It can be may be in a more sophisticated technical specifications that will look for consideration of how fast you plan to insert, how fast you are going to withdraw the rods that may give you an indication there that maybe something was wrong with the system. Will that -- will the failure mode and effects analysis show that sort -- an additional surveillance would be required or not or is that something that you will have to determine?

MR. NEWTON: That is obviously one of the things that, as our evaluation continues, we will look at more completely. As of right now though, the logics that we went through on what happens when you have these failures, confirms that the banks or groups of rods are getting the motion. What happened at Salem -- something else caused that set of rods to behave differently. I can postulate all sorts of things, and other people do too, but those are just postulations of things that could happen. I think the better test is the online demonstration that the rods are moving all of the time. And we test them at least every 30 days. Some do it more frequently than that. It does demonstrate the system is operating. So, that's the basis of the operability call.

MR. JONES: Let me ask you a different question. Let me just follow it up a little bit. Your 30-day test on your surveillance is you move the rod a few steps in and out, which was to look for binding of the rods. What happens if you are unable to move a rod -- you go to run a test and the rod doesn't move? What is your call on operability at that point?

MR. WALSH: the call on operability is you -- if it's not affecting the plant conditions right then and there, you put the control bank in a manual condition and call the instrument and control technician to try to describe what the problem really is.

MR. NEWTON: I think our call on operability would be, if we caught this before we caused the rod to be outside of the tech spec limit for rods out of position, we would halt that and probably still say the system is operability. I am just saying what I think our utility would do. Now, maybe other utilities can speak up, because I think we have had this happen before. We correct the problem. We realign the rods if indeed they were out. And, through this whole time, the system has been operable. The control system may not be able to do exactly what it is asking for, but the protection system and the rods in alignment, from a power distribution standpoint, have been maintained within their operability limits.

MR. JONES: If you do that, what data will you collect, assuming it is some sort of card failure? What follow-up would you do on that card failure to try to understand the specific failure mode of that card failure, to relate it as to whether or not that was a Salem-like condition in that card?

MR. NEWTON: This is one of the items that we are going to have to talk amongst the utility people as to how they record it. In our plant, you know, we have a maintenance work request. Before they do anything, a maintenance work request is written. You know, it gets tagged that it is a rod control system. Then it goes down and they write exactly what they did in that, and we have a chance to go back in on the database and dig that out. Does everybody do it that way? I don't know. But, a piece of paper should be written for even the maintenance of that sort of thing. Those are the things that we will be able to go back in and look for because this would not have been a reportable event. Okay. So, I think we can significantly enhance the database by going back into those records. That is what we are thinking of doing and talking about how we do that.

MR. WALSH: What we want to do is create a survey, sending it to the industry, that is going to give us some benefit instead of a whole lot of data coming into us that doesn't really mean a lot.

MR. NEWTON: One thing we have talked amongst ourselves is that we are not interested in everything that happens when the unit is shut down during maintenance. For example, Salem had a lot of things happen that they did maintenance on and had failures. Well, those we are not likely to take forward into the operating environment. We are looking at things that occurred during the operating environment, meaning, not maintenance, the system is going critical or at-power, or whatever. We will be looking at those events. Because we just don't want to be overwhelmed by normal maintenance that is done on the system and have to plough our way through that. So, we are going to be somewhat selective. But, we think the selection will be right. We haven't developed the criteria for that yet. That is something we will be working on.

MR. WALSH: I think that brings up a little bit of a point too. In the maintenance area, when you say failure, you have got to watch your terminology because, while testing and reaching and failure doesn't mean inoperable, it may mean that the card no longer meets the specifications for which it was originally designed, but it will still work, it just works with less tolerances than Westinghouse designed it for, and they want to refurbish it before it does go to full failure.

MR. NEWTON: Like instrument drift. Okay.

MR. VIRGILIO: Have you had an opportunity to go back and look at the Westinghouse Plants and bound the range of surveillance requirements that might be out there? I think we have been throwing around every 31 days, but, can you say with confidence all plants have that as a tech spec requirement?

MR. NEWTON: I am pretty sure I can say that with

confidence. I asked our people. We tested every two weeks.
MR. VIRGILIO: And what about operability requirements?
MR. NEWTON: Operability of this system is a judgment call, like I described to you.
MR. VIRGILIO: I realize that making the operability call involves some judgment. But, once you make a call and determine it is inoperable, then the first phrase of the first bullet there -- what are the requirements? What are the range of requirements that are out there?
MR. NEWTON: For the rod control system?
MR. VIRGILIO: Yes.
MR. WALSH: You have to go to your individual tech specs for your action statement.
MR. VIRGILIO: I realize that. Have you gone back and looked to see what the range of requirements might be?
MR. WALSH: Not in a great deal of detail. This is just a week old.
MR. NEWTON: We look at two parts of operability on this thing. Is the protection part of it operable or inoperable, which is a significant difference versus the control part. We have more flexibility with the control part being inoperable in time to repair it, versus the protection part. So, there's a couple of different calls on this system, because it does combine both control and

safety, you know, kind of in the same system. Although they are somewhat separate, they certainly are interrelated.

MR. VIRGILIO: Will your efforts result in a recommendation to the owners with regard to control system inoperability, as far as what actions are appropriate? I recognize this is just a week old. I am trying to see where you are going with this.

MR. NEWTON: I think it's premature to do anything beyond what they already do.

MR. VIRGILIO: Which varies?

MR. NEWTON: Which varies, yes.

MR. WALSH: I think the idea is we are trying to bolster our opinion as of today. And, if it is not bolstered, and it goes in the other direction, we have to investigate what avenues we need to take then.

MR. NEWTON: Right.

[Slide.]

MR. NEWTON: The other part I said we would get to eventually was to look at the five questions. And then from all of the information that is presented, what are the answers to the five questions -- and that was the applicability question. On this one, we did put domestic in -- how many plants could possibly be affected? The answer is that all domestic Westinghouse plants, except Connecticut Yankee, have a similar rod control system in principle. And

Westinghouse made the comment that the rod control system is one of the systems that have had the least modifications or evolutions over the years. So, we are quite similar on this. Yankee is the only one that has the old mechanical step-type countering system for signaling when each of the coils get its power. All of the rest have its solid state type system.

So, this was the easy one. I am assuming we have no disagreement on this.

[Slide.]

MR. NEWTON: Two and three we put on the same sheet just because they are interrelated. Question two asks are these plants susceptible to the single failure experienced at Salem, which results in uncontrolled rod withdrawal? It's kind of -- you know, do you hate your wife question. You don't know how to answer this with how it is worded. So, we tried to word it in a more positive way in our answer, okay?

MR. THADANI: I wrote that. I wouldn't ask an unfair question like that.

MR. NEWTON: Right. I know. Okay. It sounded like one of your questions by the way. We tried to answer that in a way that we think characterizes what you were looking for there. Since the plants have a similar rod control system --

MR. THADANI: Roger?

MR. NEWTON: Yes.

MR. THADANI: Which part? The uncontrolled part? When you say it sounded like Bob's question, what did you mean?

[Laughter.]

MR. NEWTON: Both parts, to tell you the truth. Okay? Since the first question, as I said, were similar, what happened there? Since we have similar rod control systems, we have the same susceptibility, relative to the control system itself.

The expected response to a single failure though is where we -- you know, the second part of it we have a problem with. We still feel that's the group where the bank withdrawal is the -- when you do your failure analysis, that is still what you come back to.

MR. CHAFFEE: Why do you believe it would be a bank that we would withdraw rather than a single rod? I mean, I know you said earlier that's because they are getting the same signal from the logic --

MR. NEWTON: Right.

MR. CHAFFEE: -- but, in Salem's case, one rod went out?

MR. NEWTON: Well, the other thing is that we have not seen it ever.

MR. CHAFFEE: Except at Salem.

MR. NEWTON: Right. That's one case in 600 years of operation. And, with the rods on the bottom at Salem --

MR. THADANI: I will keep coming back. When you say we have not seen it, I don't think you have looked hard enough.

MR. NEWTON: One of the things we are doing is we are going to look harder too, okay? We recognize that -- so we can answer your question with more assurity that we have looked harder.

MR. CHAFFEE: Part of the reason I ask is because I am wondering if you know something that we don't about how those signals are generated, such that it absolutely is clear that there has to be another failure mechanism. That is why I am asking. I am wondering -- because, what I have read so far, from what the people have said, it's -- there are a couple of things that people come up with to explain why the single failure caused the one rod. And I was curious if you knew something that refutiated that.

MR. NEWTON: I think the case is demonstrated somewhat at Salem, when they took it to their training facility and simulated the card failures -- the rod did move, which was the normal, expected way. So, whenever we go to try to explain what happened there or duplicate it, we get our standard answer back, is what we have been getting so far. So, there was something else that happened there. Whether it was corrosion or -- because they were on the bottom -- it takes more force to pull them out of the dash box, and if rods do stick, they tend to stick when you are pulling those out. At least that's what happens at our plant. So, there are other things that could have been going on, which when the rods are in the normal mode of operation, you know, it just doesn't exist, and we haven't seen it.

MR. CHAFFEE: I think there is a misunderstanding. I thought what they did at the training center was they were able to demonstrate what actually occurred in terms of a single rod motion after a period of time, in the undesired direction.

MR. CALVO: The feedback I got was that you tried four dashes before you started moving the rods. This is what our people tell us. So, actually, after you tried it and nothing happened, you went four times before you started moving. Is that right?

MR. LaBRUNA: It was an extensive series of tests before where we moved rods consistently, where they moved together on-demand. And there was one occasion -- and I might have to yield to one of our engineers that was present when some of the testing was going on -- where we did have, where the rods were fully in -- a couple of instances of a misstep, and then the rods continued to withdraw together. We have two rods in simulation at our training center. And we are comparing the performance of one against the other.

MR. CALVO: Did you all find out the reason for that -- why, at this particular time you had that kind of failure?

MR. LaBRUNA: This is Dave Best from our Engineering Department.

MR. BEST: Good afternoon. Yes, we conducted a test out at the training center where we pulled steps out on these two mechanisms at the training center. In each and every case that we have pulled the rods, either we asked the rods to move out or the rod did step out. And there was only one case, and that rod was located on the bottom, but it's just on the floor here, there was no dashpot, where it missed the first three steps of a five-step request. It missed the first three, then ultimately it stepped the last two.

MR. CALVO: Was this all of the rods in the bank or only one out of all of the banks in the bank?

MR. BEST: Out at the training center we only had one rod in a bank.

MR. CALVO: I see.

MR. LaBRUNA: There are only two rods in simulation, where we have coil stats.

MR. CALVO: I see.

MR. LaBRUNA: There for trouble-shooting and training purposes.

MR. CHAFFEE: So, when you gave an insert command, the rods when in, and when you gave a withdrawal command, the rods went out?

MR. BEST: No. With the failures, when we requested it -- we first request, now we demand the rods when out.

MR. CHAFFEE: I see.

MR. BEST: When we request an inward demand, the rods went out, in every case except this one particular one. And we were not able to repeat that.

MR. RULAND: So, you would say is corrosion another failure? Is that what you are implying?

MR. NEWTON: We are not implying anything at this time, okay? We are saying that the expected behavior is as the group behavior, like we talked about. And something else happened there. And because we haven't seen this occur at plants, we are having a hard time explaining it. But, it isn't very frequent when we come down and look at it.

Now, the database needs to be looked at, and we agree with that -- that we need to do that more thoroughly.

MR. CALVO: Yes. But, Roger, plants like -- we are getting older. As you get older things shows up that normally don't show up when you are young. I was just wondering, without knowing the reason for it, I think I kind of feel uncomfortable about it.

MR. CHAFFEE: One last comment. When they gave the insert demand at the simulator, did the rod immediately move out, or did it take some time before it started to move out?

MR. BEST: In every case it moved out.

MR. NEWTON: The answer to that question was that it immediately moved down in every case, except for the one exception that they ran into.

MR. BEST: We probably move the rod 50-60 steps, in increments. We probably asked for five steps out, and five steps in, and we probably did that 15-20 times. And, in every time, the rod moved out, except this one case.

MR. CHAFFEE: In the one case that it didn't move out, was that early in the test, late in the test?

MR. BEST: About 80 percent into the test.

MR. WALSH: I would just like to make a statement. I think it can be categorized that we looked at Salem event for information towards the generic aspect of this issue, and we did not do any detailed looking at Salem's event. So, I am not too sure that if you are going to continue down the road of asking a lot of things in Salem that the owner's group can give you any answers. That best be answered by the utility.

MR. NEWTON: I think the point being is that Salem -- their investigation should not be contrary to the conclusions we are bringing. This fell into the envelope of what we are trying to say anyway.

The last sentence here deals with the other part. We do not believe that the rod withdrawal is uncontrolled, since the resulting rod motion is detectable. So, it's detectable in many forms. If it is manual, it is obviously not uncontrolled, the operator will stop it. If, for some reason, it was a demand signal on automatic, you would be getting alarms, or an operator would pay attention to it. So, we feel it is detectable. So, we think we answered it in a positive way as best as we could.

Question three is somewhat related to it. What are the consequences of rod withdrawals caused by such failures? Is there a potential or common cause failures which can cause multiple rod withdrawals because of this system?

The RCCA bank withdrawal is a Condition II event and is analyzed in current plant FSARs, with the result being no predicted occurrence of DNB. That's pretty well-established. The single, or asymmetric rod withdrawals are treated as a Condition III event, and only a small fraction of the rods, less than five percent, like we have talked about, are predicted to experience DNB. This, we feel, meets the acceptance criteria for a Condition III event. We are dependent upon the failure frequency. We just haven't seen that. That is important to our overall assessment of safety.

We then get into the common cause failure thing. To date, and this is a generalization, but either at Salem or at other plants, no common cause failures have been identified. This also is part of things that we are continuing to look at. But, we felt we needed to make a call of where we were on these questions right now.

[Slide.]

MR. NEWTON: In question four, what interim actions or operating restrictions are necessary to ensure the plants remain within their design basis, again, this was a cleverly-worded question here. We feel the plants are operating within their design basis now, but we did make recommendations, you know, provided in this Westinghouse Letter 93-007, that emphasized that attention be given to specific routine operating practices, to assure that the practices they have now maintain the reliability and are also aware of this new possibility that they may not have thought of before. So, their sensitivity to it is raised.

And we asked the question amongst ourselves, you know, we always talk about an operator, when he goes critical, he is withdrawing rods. But, if he decided to shut the plant down and drives rods in, is his attention level as acute as when he was going critical? If he drives it in, the rod starts coming out. Is he paying the same level of attention? We felt that he would. His awareness going in might not be as acute, but, from the standpoint of his training of confirming motion and so on, we feel confident that, indeed, the awareness would be there. But, with the knowledge that this could happen, the operator will give just that much more attention to withdrawals and insertions, making sure he always confirms what's going on. I think that is an important fact that, you know, the operators become aware of this possibility, as remote as it is, such that they are not surprised by it, and they are paying attention to it.

So, we feel that the design basis, you know, currently is being operated within and we just are paying attention to those items that assure that he doesn't even approach anything that -- I don't want to say would exceed the design limit, because I don't think we are approaching that, but, that he just operates the plant as safe as possible.

MR. CALVO: Roger, let me just ask you a question. What will happen if I am at a hundred percent power, and I am in low follow, I have got the control rod drive system in automatic, and all of a sudden the automatic system moves the rod 20 steps and nothing happens? What happens to the automatic system? What kinds of information do you provide to the operator that the rods are not behaving as they are supposed to behave?

MR. NEWTON: If the demand was to move it 20 systems --

MR. CALVO: That's right, 20 steps.

MR. NEWTON: -- and it didn't happen --

MR. CALVO: Right.

MR. NEWTON: -- you know -- if it actually did happen when it wasn't supposed to, something is going to happen to the plant. There is going to be a mismatch on actual load. But, say, for some reason, it went 20 steps, but it actually didn't -- is that what you are proposing?

MR. CALVO: Yes. Will the control -- will the -- the automatic system will control -- give it another 20, in view of the fact that he didn't get what he wanted?

MR. NEWTON: I think we are mixing apples. At full power, if the control system actually moves the rods, and there is not a change made on the demand side, the turbine side, he is going to be driving power, mismatched, the temperature is going to start wandering up or wandering down on him. He is soon going to be getting a deviation alarm on temperature that his control system is not controlling it properly.

MR. CALVO: Yes. But, I am going through the mechanics to issue demands to move the rods. The rods are not moving -- use of the demand signal is there. The rods are not responding, right? So, things are going to get out of whack. Then all of a sudden I am going to come down with the signal. So, I am creating the same situation that happened on Salem.

MR. NEWTON: Right.

MR. CALVO: The question is what kind of information do you have in the automatic system to say don't do no more, because you are not going to accomplish what you want, or what information is presented to the operator, in view of alarm or other things, for him to say, take it out of the automatic, let's put it manual?

MR. NEWTON: Right. For example, in automatic mode, the demand position light, up or down, comes on in automatic. So, that, if for the demand, the light says, I need to go in, and he is looking at rods, and they actually go out, you know, right away you know he has a problem with it.

MR. CALVO: But, he is looking at it. Is anything else -- like an alarm or anything else that will come up under those conditions?

MR. NEWTON: Since that is an unstable condition, with respect to the control system, he will soon be driving the rods in the wrong direction from the control system demand, and temperature immediately is going to be out of the controllable band. He will get an alarm that the control system is not controlling temperature within the allowable band. That is the first alarm. If there are any other operators, that is the first one he would probably hear.

MR. CALVO: But, in the mean time, I am still in discrepancies between the demand signal where the control rods are, right? There I have a deviation there that I have not made anybody aware of it.

MR. NEWTON: Well, the demand signal is always on T-average. You don't put a demand on position. So, the control system runs off of T-average. So, if demand said I should decrease T-average, that means put rods in. But, really, if control systems put them in, but they go out, that's going to cause temperature to go higher, and you are going to be farther away from your demand signal, and you are going to get an alarm saying that it's not working right.

MR. WALSH: You have a two-degree difference of T-average, versus T-reference, which is the temperature you should be at. That is your first alarm that would get you in temperature space.

MR. NEWTON: Right. Normally, if the control system is behaving itself, there is a degree and a half difference there, and that the system operates nicely -- that it controls within a degree and a half. If you wander out of that, it is two degrees, and it doesn't take long, you will get this first alarm.

MR. CALVO: It never goes to automatic?

MR. NEWTON: No. The operator would have to change it to manual. It's the only way it could happen.

[Slide.]

MR. NEWTON: The last question dealt with what long-term actions are contemplated to resolve this issue? We have the evaluation that we are working on. We have committed to ourselves to collect data on the operating events and continue to interact with the NRC during this evaluation period. The immediate -- I think -- commitment we have only made is to look at the database and indeed get a better feel for what has happened out there. That will then cause us to react differently, if the results come back different. If it confirms what we think, I think our story will hang together from what we described here, an we will stay with that story.

Our expectation is that -- and we are basing it on our own judgment of 25 years of experience of just not running into this -- that it will indeed confirm what we have already made a claim to.

Now, you made a statement that you feel uncomfortable with the failures that have occurred in the rod system from the data that was presented here. I think we are going to come back with a lot more and I am going to use the word failures, when there are really operating indications of a failure that we get on a rod control system. We get quite a few of those. We get quite a few non-urgent alarms and urgent alarms that, you know, they have to respond to. That is not an unusual occurrence. Many times there is not a real failure there, re-set or whatever it is, takes care of it.

Many times we end up replacing cards just because we find that that is an easier way of trouble-shooting a problem. And, in some cases, we may not identify the root cause. Other times, we may be able to do that. But, this control system is a complex system with, you know, thousand of dials probably in the system. I don't know the number. And it is sensitive to -- I don't want to say failure -- but having system detect things that are not normal and that we have to respond to.

MR. CALVO: Keep in mind on salem, as a result of all this trouble-shooting, to keep in mind that it led to an event that we can't explain today. So, as you take it into account, and you put new cards in, mistakes are made. And, when making the mistakes at power, it can be more damaging than doing it at a condition where you have less reactivity in the core. So, I mean, if you say that it is a lot of challenge, a lot of failures that happen at power, it is a matter of replacing this card, keep in mind what happened at Salem was as a result of doing that kind of a thing. And I just want to be sure that you are all prepared to preclude what happened at Salem at all of these other plants that are operating.

MR. NEWTON: One of the things too, that the rod control system, because it's what the operators are having to live with every minute of every day, when they put the system back in service, they do pretty good post-maintenance testing on running the cards and the systems through the diagnostics. So, that when you are at power and you put this thing back on line, you have demonstrated at least why you took it off as fixed, and you are not left with a residual problem. Okay? You have moved your rods, you have tested your cards, whatever it is. So, the post maintenance testing is pretty good when it is put back in service.

MR. LIPARULO: One conclusion you reached was that the maintenance on Salem caused the event. I don't think we have reached that conclusion. You made a statement that --

MR. CALVO: I know what you are saying. Maybe I am jumping ahead. In view of the fact that we never got to the root cause yet, we cannot duplicate it, you have got to blame somebody. If you don't blame the trouble-shooting, then you blame the aging or degradation. That has more severe consequences than that.

MR. LIPARULO: The only point I am trying to make is that that hasn't been --

MR. CALVO: It's like you say. Until I find out more about it, I am going to blame it.

MR. THADANI: Okay. This is the part we are all waiting for.

[Slide.]

MR. NEWTON: We have featured actions. We are now and we will continue to update the NRC on the status. This week we are having a full owners group meeting. So, from a timing standpoint, we plan to take pretty much the material we had here and update our owners, and all of the rest of the utilities to fill in the gaps that may surround the information we sent them.

I guess I would like to leave this meeting with a feeling of where we stand on answering your questions. I hope we have answered a good fraction of them. I am not sure we answered all of them to your satisfaction.

We are continuing to participate in the evaluation of the root cause determination of the event. That is an ongoing evaluation. So, we are following that. We are not doing it. It is between Salem and Westinghouse. But, from an owners group standpoint, we are hopefully plugged in very close to that, because that is important to us.

The results of this effort. You know, we think somewhere in the August time frame, as well as -- we will have data on the performance history to come back and talk to you about it, but I hope that we have left you with the warm feeling that -- from the operability standpoint, we have just the system -- the operability. From a GDC-25 standpoint, we at least have our logic that we feel we are in compliance with that. So, from all of the aspects that involve the operating and startup of our plants, we think we have addressed them. We are continuing to look at it. And it is our judgment right now that we are hoping to further confirm these judgments. If that is not the case, we will tell you what we do find out too because it is important to all of us.

MR. THADANI: We certainly want to thank you. I know this has been hectic for you. It is clear you have been working very hard on this thing. You have done a lot of very good work actually. Obviously there were some important elements to what you are saying. First and foremost is that all of the automatic safety systems performed their functions properly -- that, if this failure were to occur, although a small number of rods would go into DNB and that, if you were to do a really good realistic analysis, maybe none would. I think that is what I heard you say -- and that not all rod withdrawal events would get you into potential for DNB conditions. I think, in my mind, those stick out as being important factors which probably confirm the view that, at least given the information we have today, it is not an issue that requires huge precipitous type of action from a public health and safety point of view.

On the other hand, I think we are going to have to think about what you said. I don't think you have demonstrated compliance. I also don't think you have made a strong case that this type of Condition III event -- there are so many questions that I am not sure that's necessarily the concern -- so many questions about the database, the quality of the information available.

So, it seems to me -- I think we made the right decision to wait until we heard this story from you, so to speak, your analysis and the results of your analyses. We are going to carefully consider what you have said before we take our next action. We will continue to work with you. We may want to go forward and acquire certain information from licensees, as to their bases for concluding that they are in compliance with GDC-25, B, that they have met the requirements -- and more specifically -- and finally, when they come back with their decision. Some of those we can deal with generically. I suspect many of them you can't, given what we have heard today.

So, our next step is going to be to kind of gather amongst ourselves and make sure we collect our notes and thoughts on what we have heard before we take our action. I will commit to let you know what that action would be as soon as we make that decision.

MR. WALSH: We appreciate the opportunity to be able to come in and have the time to sit down and explain the full breadth of this. It is an interesting and complicated issue that we are dealing with here.

We have a lot of work to do, and I hope we have given you the impression that we are going to try to continue to do it in a straight-forward and factual manner, so that we base our ultimate conclusions on as much information as we can obtain.

I would like to react to your comment on asking individual licensees on when they are going resolve this issue. It will be very difficult for them, since they haven't had the problem. So, they have a hard time resolving something you don't have. I think they are going to come back to the owners group and try to do it on a generic basis. So, I hope the owners group can provide that to the Westinghouse members, because it will be difficult for them to do that individually.

MR. THADANI: Yes. We would clearly ask them for their schedule. But, I guess the part that is -- that needs to be thought through a little bit more carefully is the issue of GDC-25 and, as I think one of your presenters read the statement -- that there are different -- fairly different statements in different safety analysis reports. I imagine that can only be done on a plant-specific basis. That's how I understood the comment that was made earlier.

MR. WALSH: When you see the answer that we gave you was that we feel that everybody but maybe Connecticut Yankee has the same control systems. We feel this is truly a generic question. We would like the opportunity to know the questions you are going to ask the utilities, to maybe give you an answer that WOG would like to have, versus getting an opinion of 50 different reactor sites on what the question really is.

MR. THADANI: Our concern is, and the question, by the way, that you said it was cleverly worded, it was not cleverly worded, that was real. Our concern was and is do the plants comply with GDC-25? You said yes. The letter that went to the individual licensees says potentially they don't comply. I don't know what your real views are on the issue. We really need to debate this amongst ourselves to come to some consensus. But you have not made a compelling case, at least, that I can say.

MR. NEWTON: After you have thought about this, we would like to know what your concerns are, so that we can address them. Because it will be hard for an individual licensee to address them. So, we want to be given that opportunity as a owners group.

MR. THADANI: My concern is why we think that the licensees are not in compliance. The licensees need to know that. The licensees need to be taking some actions, whether there are some actions that you are recommending or something else, I don't know. But, they need to determine what they need to do.

MR. NEWTON: That is correct.

MR. COLLINS: Before we close, I would like to ask if there are any members of the public who wanted to make a statement for the record before we close out the transcript? Is there anybody there? Would you raise your hand if you would like to come up and make a statement?

[No response.]

MR. COLLINS: All right. I see no one wishes to make a statement from the public then.

I believe we can adjourn this meeting.

[Whereupon, at 5:01 p.m., the above-entitled meeting was adjourned.]

REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

NAME OF PROCEEDING: Generic Assessment of Salem Event

DOCKET NUMBER:

PLACE OF PROCEEDING: Bethesda, MD

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.

Marilynn Estep

Official Reporter
Ann Riley & Associates, Ltd.

GENERIC ASSESSMENT OF

THE SALEM EVENT

NRC PRESENTATION

JUNE 14, 1993

INTRODUCTION

PURPOSE

- Meeting at NRC's Request

OBJECTIVE

- To provide an open forum in which to discuss the issues surrounding the Rod Control System Event.
- To update the NRC on the latest status of the W/WOG evaluations of this issue.
- To address NRC questions with respect to plant safety and operability.
- To outline W/WOG future actions.

GENERIC ASSESSMENT OF SALEM EVENT

AGENDA

- **Overview and Status** (WOG/W)
  - Objective Meeting — Newton
  - Agenda Review — Newton
  - Status — Newton
  - WOG RRG Activity — Newton
- **Background** — Liparulo
  - Overview of the Rod Control System — Fowler
  - Description of the Salem Event — Carrier
  - Failure Analysis — Fowler

GENERIC ASSESSMENT OF SALEM EVENT

- Westinghouse Technical Evaluation

- Regulatory Bases	Lang
- Classification of Postulated Events	Vertes
- Analysis of Postulated Events	Johansen
- Equipment Performance History	Closky
- Safety Assessment	Vertes

• Operability Assessment	Newton
• Action Plan	Newton

STATUS

- The Salem plant-specific evaluation is underway.

- Westinghouse and the WOG are continuing to evaluate the generic aspects of the event.

- The Westinghouse Reasonable Assurance of Safe Operation (RASO) adequately addresses concerns regarding plant operability and the health and safety of the public.

- All plants should continue operation and/or start up.

WOG RRG ACTUATION

Mon.	PM	W Notify WOG Chairman of Event at Salem Details Limited
Tues.	AM	A. Thadani Request WOG Chairman that RRG be Activated
		5 Questions Faxed to WOG Chairman (RRG Chairman Unavailable)
Wed.	AM	WOG Chairman RRG Vice President Hold Event Review Meeting
		AM - Telecon with RRG Chairman and Other Members
Thurs.	AM	RRG Officially Activated First Full RRG Briefing and Responses. WOG Chairman and WOG Vice Chairman[1] at W for Review and Evaluation
	PM	Conference Call with NRC, WOG, W and Salem Site Reps Discussion of Rod Control System - Safety Evaluation - Event Probability. Fax NRC W Draft Customer Advisory Letter ~ 1:00 a.m.

[1]OG Chairman is a member of RRG also

GENERIC ASSESSMENT OF SALEM EVENT

WOG RRG ACTUATION

6/11	AM	2nd RRG Conference Call Review and Evaluation W Customer Advisory Letter
	PM	Conference Call with NRC, WOG, W, and Salem Site Reps Discussing Advisory Letter and Monday 6/14 Meeting Agenda

ROD CONTROL SYSTEM OVERVIEW

The Rod Control System positions rods in response to demands for motion from either the Reactor Operator or the Reactor Control System.

The Rod Control System is a Non-Class 1E system.

System Description:

- Control Rod Drive Mechanism (CRDM):
  - Normal withdrawal sequence
  - Normal insert sequence
  - Response to reactor trip
- Control rod arrangement:
  - Rod banks, shutdown and control
  - Rod groups
  - Control bank overlap
- Rod Control System cabinets
- Slave cycler description

FIGURE 1
CONTROL ROD DRIVE MECHANISM

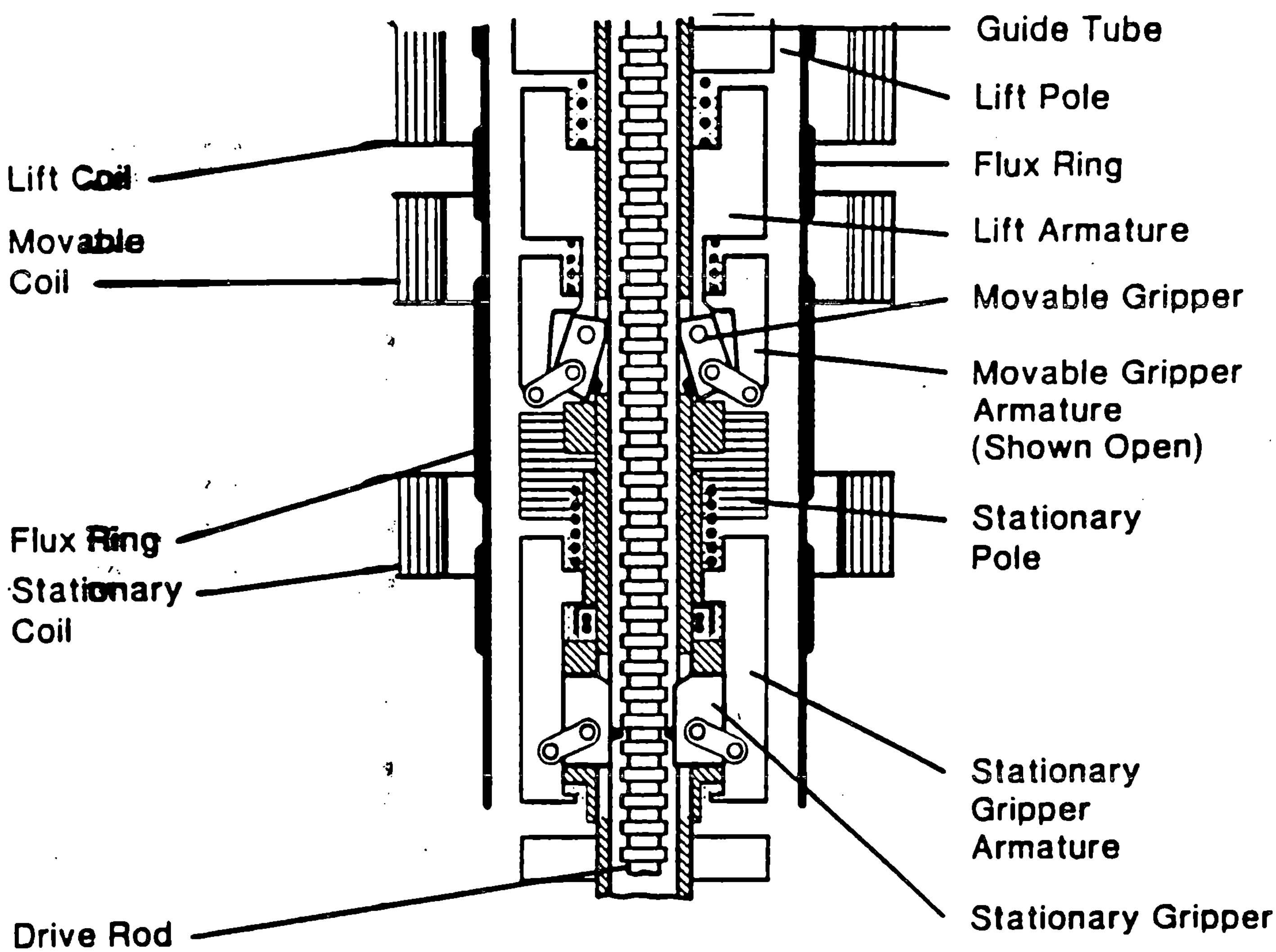
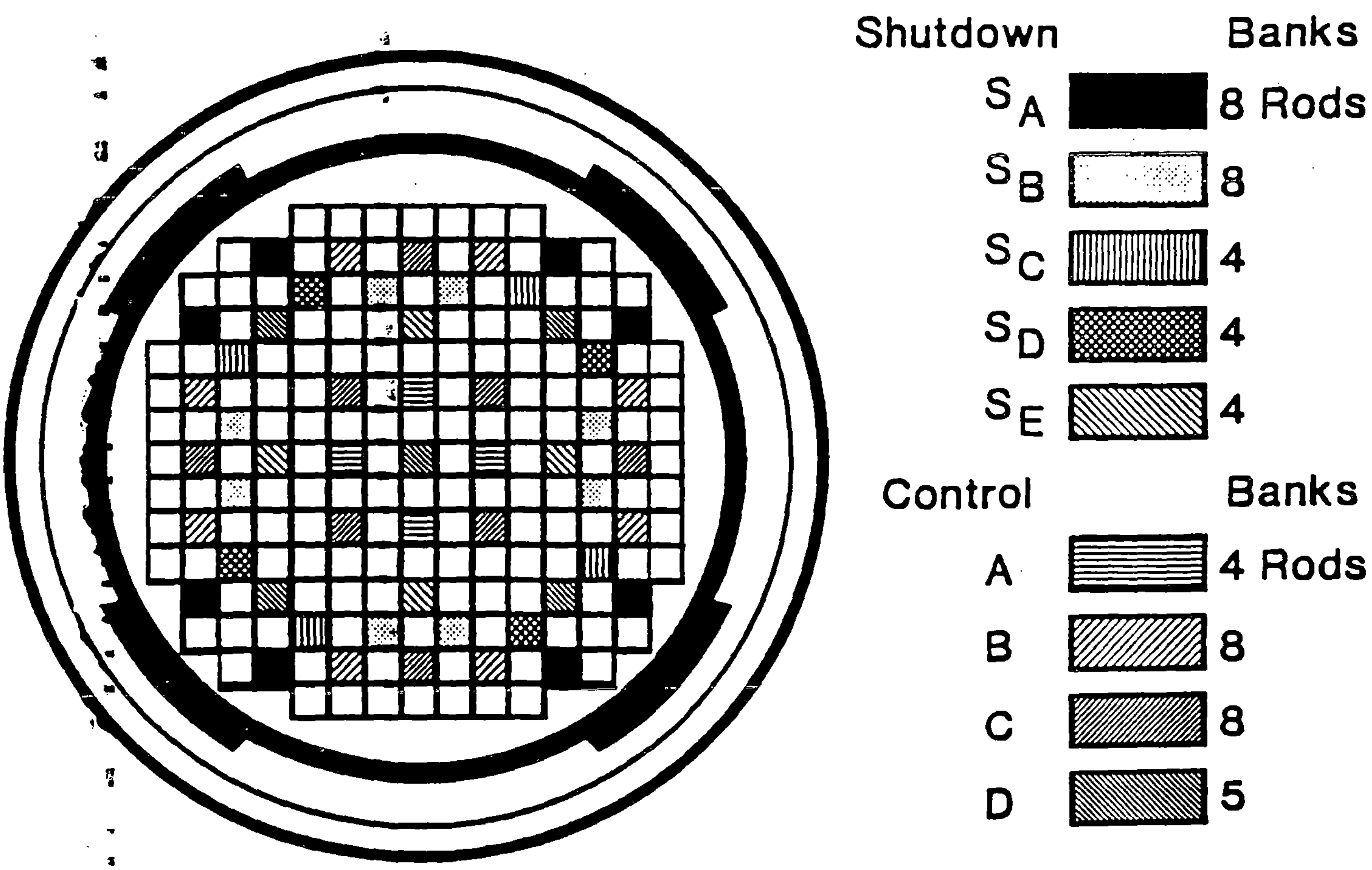


FIGURE 2
CONTROL ROD ARRANGEMENT



GENERIC ASSESSMENT OF SALEM EVENT

FIGURE 3
BANK OVERLAP

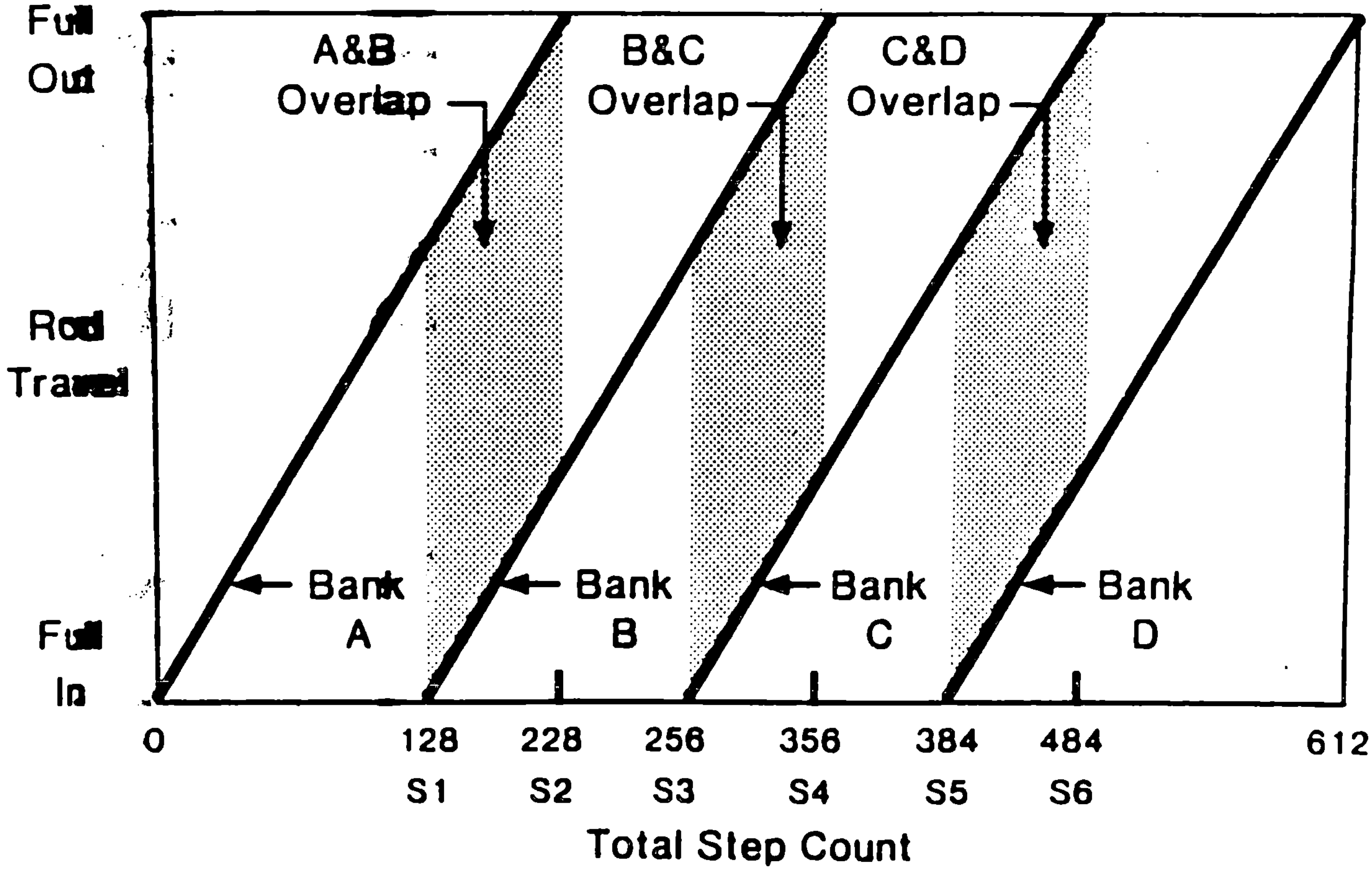
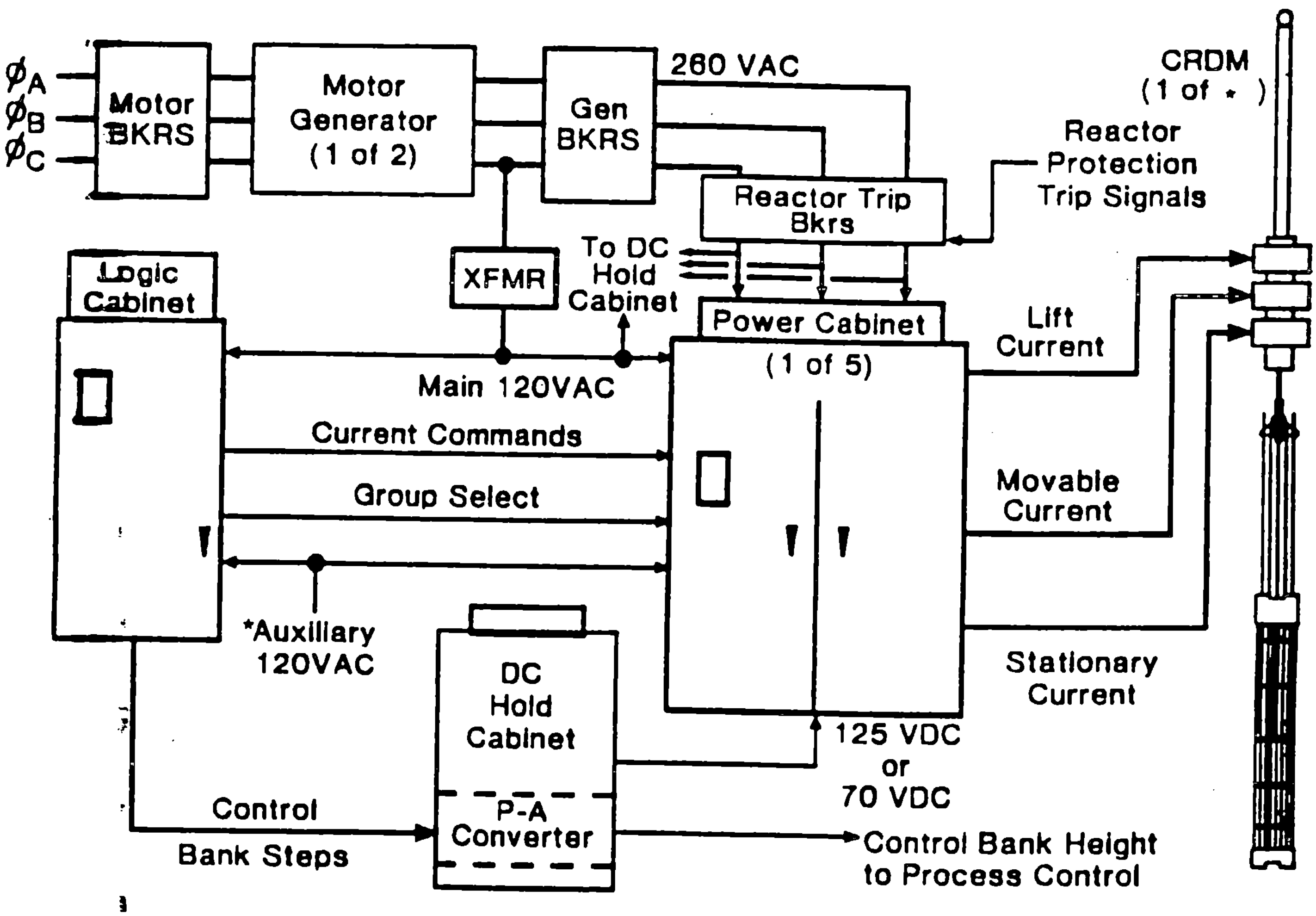


FIGURE 4
ROD CONTROL SYSTEM BLOCK DIAGRAM



ROD CONTROL SYSTEM OVERVIEW

System Operation from Startup to Full Power:

- Startup tests
- Individual bank operation
- Manual operation with bank overlap
- Automatic operation:
  - Response to changing Tavg
  - Response to changing load
- Operator interaction
- Rod Motion Surveillance Tests

Rod Control System response to a reactor trip:

- AC power removed from Power Cabinets
- Current removed from CRDMs
- CRDMs release rods

A reactor trip signal overrides all Rod Control System signals.

ROD CONTROL SYSTEM INDICATIONS AND ALARMS

Rod Position and Movement Indications:

- Individual Rod Position Indication (IRPI)
- Group step counters
- IN/OUT demand lights
- Rod Insertion Limit (RIL) recorder
- Rod Bottom lights

Alarms:

- Rod Control Urgent Alarm
- Rod Control Nonurgent Alarm
- Rod Deviation Alarm
- Rod Insertion Limit Alarms
- Rod Bottom Alarm
- Control Bank D Withdrawal Alarm

DESCRIPTION OF SALEM EVENT

The Reactor Operator demanded outward motion of shutdown bank A:

- SBA step counters read 20 steps
- No rod movement observed on IRPI

The Reactor Operator demanded in motion of shutdown bank A:

- With step counters at 6, 1SA3 indicated 8 steps
- With step counters at 0, 1SA3 indicated 15 steps
- All other rods indicated 0 steps

Rod Position indication was verified by voltage checks.

1SA3 stationary gripper fuse was pulled to insert rod.

Lift coil disconnects were opened to prevent rod movement

Recordings were made of Shutdown Bank A current orders.

Distorted wave forms were identified.

Two circuit board failures were identified.

The technical investigation is continuing.

GENERIC ASSESSMENT OF SALEM EVENT

FAILURE ANALYSIS

Two circuit failures were located in the Logic Cabinet slave cyclers.

The effect on the slave cycler current orders, both singly and in combination, would have the following effects:

FAILURE	IN ONLY		OUT ONLY		BOTH (SALEM)	
DEMAND	IN	OUT	IN	OUT	IN	OUT
MOTION DEMAND	IN (NORMAL)	NONE OR OUT	NONE OR OUT	OUT (NORMAL)	NONE OR OUT	NONE OR OUT

CONCLUSIONS:

- Slave cycler current orders sent to all CRDMs in rod group
- CRDMs may respond with outward motion
- CRDMs cannot respond with inward motion
- Rods cannot move in both directions simultaneously
- The failure cannot create a motion demand
- The failure has no effect on bank overlap
- The failure CANNOT prevent a reactor trip

ACCIDENT ANALYSIS CONSIDERATIONS

- REGULATORY BASES

- CLASSIFICATION OF POSTULATED EVENTS

- ANALYSIS OF POSTULATED EVENTS

  - LIMITING SCENARIOS

  - ASSUMPTIONS

  - RESULTS

CONCLUSIONS

- Random failures in control systems are not assumed nor required to be assumed concurrent with an Anticipated Operational Occurrence (AOO) or Design Basis Accident (DBA)

- Consequences of postulated failure(s) in the rod control system do not exceed radiological release acceptance criteria established for ANS Condition III events (Infrequent Faults)

- All plants should continue operation and/or start up.

GENERIC ASSESSMENT OF SALEM EVENT

CURRENT REGULATORY BASES

- IEEE-279

- IEEE-379

- NUREG-0800 (SRP)

IEEE 279-1971

Section 4.2 Single Failure

"Any single failure within the protection system shall not prevent proper protective action at the system level when required."

IEEE 379-1977

Single Failure Criterion for Nuclear Power Generating Station Class 1E Systems

"The protection system shall be capable of performing the protective actions required to accomplish a protective function in the presence of any single detectable failure within the system concurrent with all identifiable but nondetectable failures, all failures occurring as a result of the single failure, and all failures which would be caused by the design basis event requiring the protective function."

Nondetectable Failures

" ... A failure which cannot be detected by specific system tests is nondetectable."

" ... In the analysis of the effect of each single failure, all identified nondetectable failures shall be assumed to occur."

NUREG-0800
STANDARD REVIEW PLAN

EXCERPTS FROM SRP SECTION 15.2.7

The sequence of events from initiation until a stabilized condition is reached is reviewed to ascertain:

1. The extent to which normally operating plant instrumentation and controls are assumed to function.

2. The extent to which plant and reactor protection systems are required to function.

3. The credit taken for the functioning of normally operating plant systems.

4. The operation of engineered safety systems that is required.

ACCEPTED ANALYSIS ASSUMPTIONS AND CONTROL SYSTEM OPERATING ASSUMPTIONS

- Random Single Failure in Protection System Assumed Concurrent with Initiating Event
- Random Failure in Control System Assumed as Initiating Event
- Control System Operating Assumptions During Anticipated Operational Occurrence (AOO) or Design Basis Accident (DBA)
  - Assumed to be in Manual Mode

    or

  - Assumed to Operate Normally in Automatic Mode

  Dependent on Which Assumption Results in Most Severe Consequences
- No Random Failures Assumed (Other than Initiating Event) in Control Systems Concurrent with AOO or DBA

GENERIC ASSESSMENT OF SALEM EVENT

CONTROL SYSTEM FAILURE AND OPERATING ASSUMPTIONS

- Periodic Surveillance of Control Systems per the Technical Specifications

- Capability of Operator to Detect Abnormal Control System Operation Based on Control Board Indications and Control Limit Alarms

- Any Postulated Failure that is Not Detectable Via Surveillance or Control Board Indication Assumed Concurrent with AOO or DBA

- Resultant Low Probability of Random Control System Failure Concurrent with an AOO or DBA

GENERIC ASSESSMENT OF SALEM EVENT

POSTULATED PLANT EVENT: LOAD REJECTION (CONDITION II)

CONTROL SYSTEMS ASSUMED TO NORMALLY OPERATE:

STEAM DUMP

PRESSURIZER POWER-OPERATED RELIEF VALVES (PORV)

ROD CONTROL SYSTEM

CONSEQUENCES OF POSTULATED CONTROL SYSTEM FAILURE(S):

- STEAM DUMP FAILS OPEN

  BOUNDED BY STEAM LINE BREAK ANALYSES

- PRESSURIZER PORV FAILS OPEN

  BOUNDED BY RCS DEPRESSURIZATION/LOCA ANALYSES

- ROD CONTROL SYSTEM MALFUNCTION

  BOUNDED BY RCCA WITHDRAWAL ANALYSES

SAFETY ANALYSIS CLASSIFICATION

DESIGN PHILOSOPHY

- Most probable occurrence should yield least radiological risk to the public
- Situations having the potential for the greatest risk to the public should be those least likely to occur

ANS CONDITION II
MODERATE FREQUENCY (> 10^{-2} /YR)

- Minimum Design DNBR Limit

ANS CONDITION III
INFREQUENT FAULT (10^{-4} - 10^{-2} /YR)

- Small Fraction of Failed Fuel

ANS CONDITION IV
LIMITING FAULT (< 10^{-4} /YR)

- 10 CFR 100 Dose Limits
- Maintain Core Coolability

APPLICABLE
GENERAL DESIGN CRITERIA

10 CFR PART 50 APPENDIX A

Necessary design and performance requirements for systems & components to provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public.

GDC 25
PROTECTION SYSTEM REQUIREMENTS FOR REACTIVITY CONTROL MALFUNCTIONS

"The protection system shall be designed to assure that specified acceptable fuel design limits are not exceeded for any single malfunction of the Reactivity Control Systems, such as accidental withdrawal of control rods."

ASYMMETRIC RCCA WITHDRAWAL PROBABILITY OF OCCURRENCE

- DETECTABLE
  - Rod movement during normal operation
  - Monthly surveillance
- OPERATING HISTORY
- INITIAL ASSESSMENT INDICATES LOW PROBABILITY OF CONTROL SYSTEM CARD FAILURES RESULTING IN RCCA MOVEMENT (CONSISTENT WITH ANS CONDITION III FREQUENCY)
- LIMITING ASYMMETRIC RCCA WITHDRAWAL SCENARIO HAS LOWER PROBABILITY OF OCCURRENCE

WITH RESPECT TO THE SALEM EVENT:

- The failures in the Logic Cabinet should have caused all Shutdown Bank A rods to either move out or remain stationary.

- Some other condition may have caused only one CRDM to respond.

- The technical investigation is ongoing.

- The frequency of these combined effects classifies it as a Condition III event.

- It is appropriate to demonstrate compliance with the acceptance criteria for a Condition III event (small fraction of failed fuel).

- This meets the intent of GDC 25 for meeting acceptable fuel design limits.

POSTULATED EVENTS

- Single RCCA Withdrawal at Power
- Single RCCA Withdrawal from Subcritical
- Uncontrolled RCCA Bank Withdrawal at Power
- Uncontrolled RCCA Bank Withdrawal from Subcritical
- Asymmetric RCCA Withdrawal at Power
- Asymmetric RCCA Withdrawal from Subcritical

ASYMMETRIC RCCA WITHDRAWAL

- Assessed to have a low probability of occurrence commensurate with Condition III Infrequent Fault

- Allowance of a small amount of fuel damage is consistent with the design philosophy

- Conservative generic bounding evaluation of limiting scenarios indicates that a small percentage of the rods would be predicted to experience a calculated DNBR below the limit value. Little or no actual fuel failure is predicted.

- No undue risk to the public health and safety

ASYMMETRIC RCCA WITHDRAWAL AT POWER

Event Description:

- RCCA banks operate within rod insertion limits in normal overlap
- Operator or automatic rod control demand for RCCA insertion AND postulated failure lead to RCCA withdrawal
- Any combination of 2 or more RCCAs from inserted control banks (D, D+C, or C+B) withdraw partially or fully from core

GENERIC ASSESSMENT OF SALEM EVENT

ASYMMETRIC RCCA WITHDRAWAL AT POWER

Possible increase in FdH due to asymmetric RCCA withdrawal compared to single RCCA withdrawal

Limiting Scenario

- Full withdrawal of 2 or 3 adjacent D-bank rods (from different groups)
- Remaining D-bank RCCAs at insertion limit
- 100% power

Fewer than 1% additional rods found to be below DNBR limit value compared to limiting single RCCA withdrawal case

Current W reload designs show a maximum of 1.5% of rods below DNBR limit for single RCCA withdrawal at power event

Margin exists to accommodate any additional rods below DNBR limit due to multiple RCCA withdrawal and still satisfy Condition II criteria

Little or no fuel damage will occur due to postulated event

ASYMMETRIC RCCA WITHDRAWAL FROM SUBCRITICAL

Event Description:

- Reactor in STARTUP MODE with K-eff = 1.0
- Shutdown banks are withdrawn from core
- RCCA banks operate in normal overlap
- Operator demand, in manual control mode, for RCCA insertion AND postulated failure lead to RCCA withdrawal
- Any combination of 2 or more RCCAs from inserted control banks (A, A + B, B + C, C + D) withdraw partially or fully from core

ASYMMETRIC RCCA WITHDRAWAL FROM SUBCRITICAL

Typical rod speed in manual mode is 48 steps per minute

Operator action limits maximum misalignment to 48 steps

- Impact on peaking factors is limited
- Reactivity insertion rate is low

Use of currently approved methods expected to demonstrate the number of fuel rods below DNBR limit will be limited to small fraction of core

Use of 3-D kinetics methods expected to demonstrate no fuel rods below DNBR limit

Little or no fuel damage will occur due to postulated event

EQUIPMENT PERFORMANCE REVIEW

INITIAL REVIEW CONDUCTED

- To identify failures of components located in the rod control system logic cabinet

- Using three available data bases

  - Nuclear Plant Reliability Data System (NPRDS)
  - Licensee Event Reports (LERS)
  - Nuclear Power Experience

EQUIPMENT PERFORMANCE REVIEW

RESULTS

- Total of 34 logic cabinet component failures identified
  - 24 no rod movement or no rod movement with urgent alarm
  - 2 step counter driver failures
  - 1 card failure identified subsequent to a reactor trip and unrelated
  - 5 rod drop events
  - 2 rod group misalignment events

EQUIPMENT PERFORMANCE REVIEW

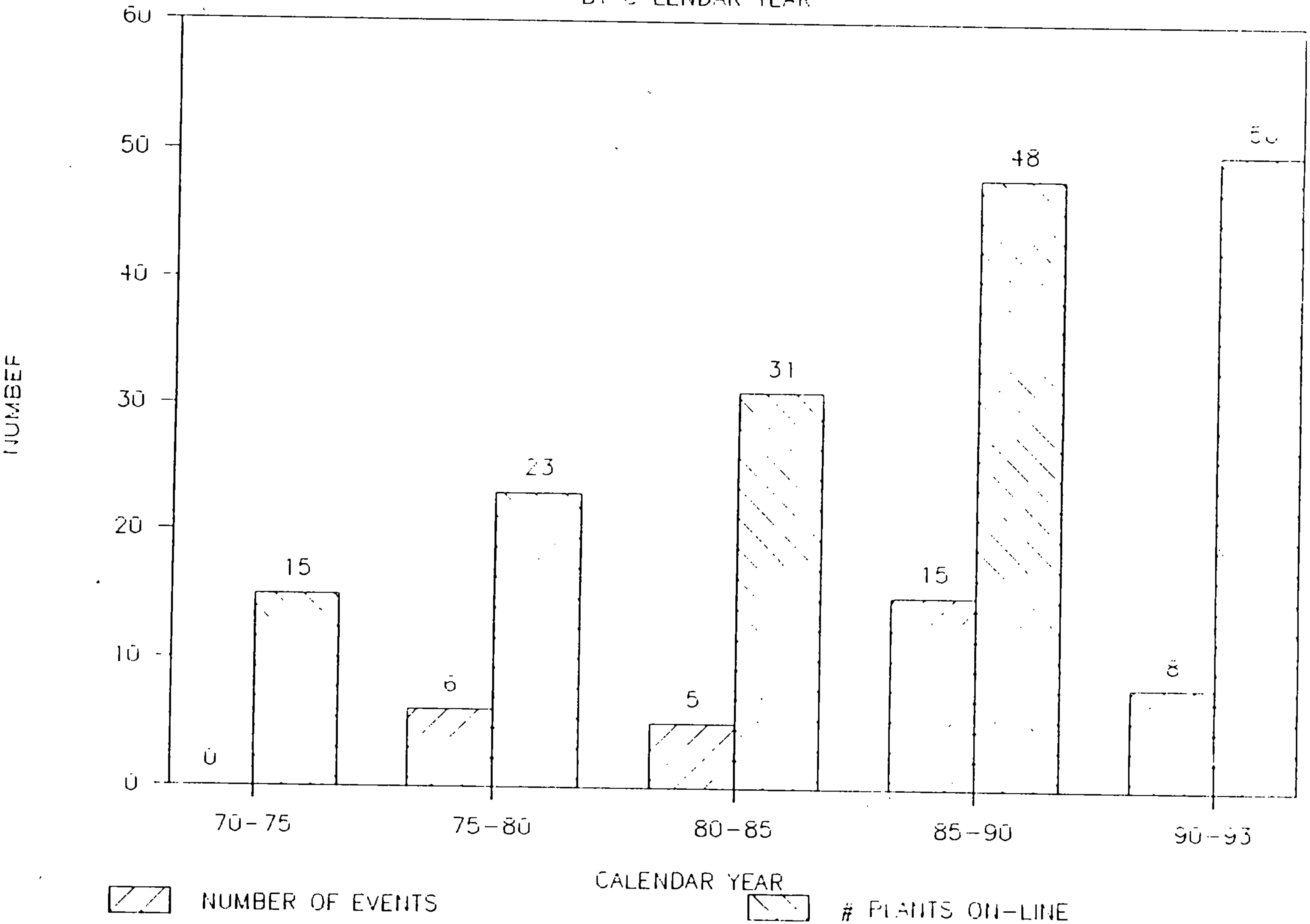
CONCLUSIONS

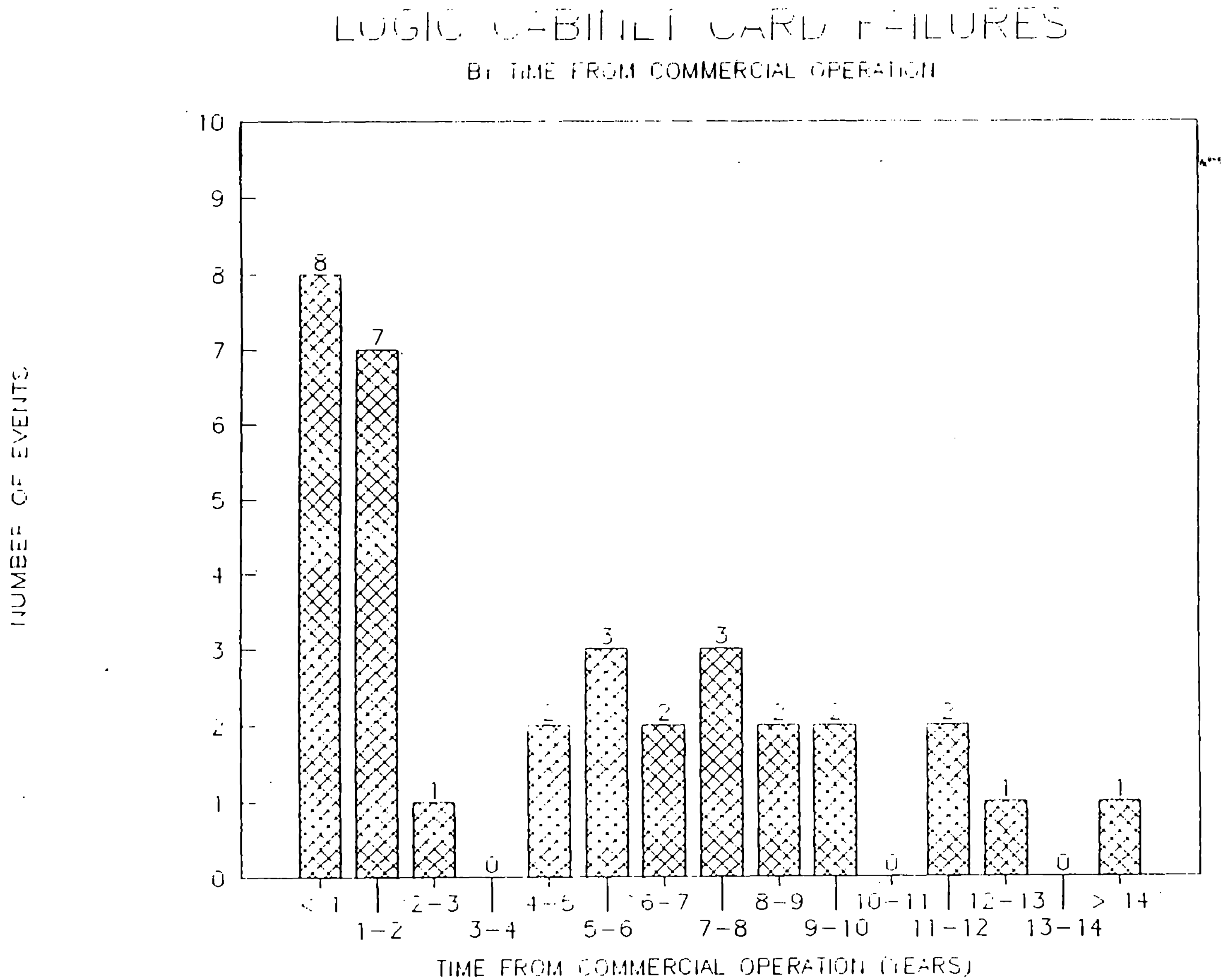
- No reported failure events occurred where a single rod became misaligned (similar to Salem event)

- Estimated frequency of misalignment confirms that event is a Condition III event

LOGIC CABINET CARD FAILURES

BY CALENDAR YEAR




LOGIC CABINET CARD FAILURES
BY TIME FROM COMMERCIAL OPERATION
NUMBER OF EVENTS
10
9
8
7
6
5
4
3
2
1
0
8
7
1
0
2
3
2
3
2
2
0
2
1
0
1
< 1
1-2
2-3
3-4
4-5
5-6
6-7
7-8
8-9
9-10
10-11
11-12
12-13
13-14
> 14
TIME FROM COMMERCIAL OPERATION (YEARS)

AGING CONSIDERATIONS

BASED ON INITIAL REVIEW

- The distribution of reported failures by years of plant operation shows no aging

- The distribution of reported failures by calendar year shows no aging

- Consideration is being given to the collection of additional data

SAFETY ASSESSMENT

- Meet ANS Condition III Acceptance Criteria
- Minimal or No Actual Fuel Damage will Occur as a Result of Postulated Failure Scenarios
- No Challenge to the Integrity of the Reactor Coolant System or Containment
- No Undue Risk to Public Health and Safety
- All plants should continue operation and/or startup.

SYSTEM OPERABILITY

- Operability of the Rod Control System will continue to be determined through Tech Spec requirements and normal plant operations

- Current assessment is that the Rod Control System is operable

NRC QUESTIONS FOR REGULATORY RESPONSE GROUP

1. How many plants and which plants have a rod control system similar to that at Salem?

Answer

All domestic Westinghouse plants except Connecticut Yankee have a similar Rod Control System

NRC QUESTIONS FOR REGULATORY RESPONSE GROUP

2. Are these plants susceptible to the single failure experienced at Salem which results in uncontrolled rod withdrawals?

ANSWER

Since the plants have a similar Rod Control System, similar Rod Control System failures could occur. The expected response to the single failure is a RCCA group or bank withdrawal. We do not believe that the rod withdrawal is uncontrolled since the resulting rod motion is detectable.

3. What are the consequences of rod withdrawals caused by such failures? Is there a potential for common cause failures which can cause multiple rod withdrawals because of this system?

ANSWER

The RCCA bank withdrawal is a Condition II event and is analyzed in current plants' FSARs with the result being no predicted occurrence of DNB.

Single or asymmetric rod withdrawal are treated as Condition III events and only a small fraction of rods (less than 5%) are predicted to experience DNB. This meets the acceptance criteria for a Condition III event.

To date, either at Salem or at other plants, no common cause failures have been identified.

NRC QUESTIONS FOR REGULATORY RESPONSE GROUP

4. What interim actions or operating restrictions are necessary to ensure the plants remain within their design bases?

ANSWER

The plants are operating within their design basis; the recommended actions, provided in NSAL-93-007, emphasize that attention be given to specific routine operating practices.

GENERIC ASSESSMENT OF SALEM EVENT

NRC QUESTIONS FOR REGULATORY RESPONSE GROUP

What longer term actions are contemplated to resolve this issue?

ANSWER

The evaluation already underway of the Salem event should continue. The WOG will collect data on operating events and continue to interact with the NRC during the evaluation period.

WOG FUTURE ACTIONS

- NRC updates on status
- Update full Owners Group (6/16/93)
- Address NRC comments resulting from this meeting
- Continue to participate in the evaluation of the root cause determination of the event.
- Meet with NRC to discuss evaluations (August)
- WOG to continue to investigate Rod Control System performance history (TBD)