UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON REACTOR OPERATIONS

- - -

Nuclear Regulatory Commission

Room 1046
1717 H Street, N.W.
Washington, D.C.

Tuesday, March 10, 1981

The Subcommitte met, William Mathis (Chairman of the Subcommittee) presiding, at 8:45 a.m.,

BEFORE:

W. MATHIS (Chairman of the Subcommittee

D. WARD

W. KERR

J. BUCK

W. LIPINSKI

I. CATTON

J. RAY

M. BENDER

MR. MAJOR, Designated Federal Employee

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Present for the NRC Staff:

P. Check
V. Panciera
W. Mills
S. Rubin
C. Michaelson
E. Jordan
C. Graves
M. Goodman
G. Schwenk
J. Pittman

PROCEEDINGS

(8:45 a.m.)

MR. MATHIS: The meeting will now come to order.

This is a continuation of the Subcommittee meeting on Reactor Operations. Today the Subcommittee will meet with NRC staff to begin its review of Representative Udall's inquiries on ATWS, which were prompted by the June 28th, 1980, Browns Ferry 3 partial failure to scram.

Mr. Richard Major is the Designated Federal Employee for this meeting. A transcript of the meeting is being kept, and it is requested that each speaker first identify himself or herself, and speak with sufficiently clarity or volume so that he or she can be readily heard.

We will now resume the meeting.

I thought possibly, just to refresh the memory of some of you as to why we are here and what we hope to accomplish today, that I might go over just a brief chronology of mainly the Udall letters.

Mr. Udall's first letter to the Commission was dated July 16th, 1980, and he noted there the appropriateness of the persistence of the NRC staff and the ACRS in pressing industry to adopt measures to mitigate consequences of ATWS events. He went on to request the Commission to present its assessment both of the causes of the problem of the Browns Ferry 3 incident and the consequences had control rod failure occurred during full power operation following a design basis event.

The second letter is dated December 17th, 1980, and here he noted concerns about the inability to calculate the consequences of control rod failure that might occur following transients at full power.

His third letter, on October the 3rd, Mr. Udall's letter to Mr. Ahearne, he questioned the extent to which emergency procedures at operating reactors contained instructions for operator action in the event of a partial or full scram failure following an anticipated transient.

There's a fourth bit of information I think important, and that is that the NRC staff has also completed a generic safety evaluation report regarding the BWR scram discharge system. This report is dated December 1st, 1980. In it there are recommendations for some short-term actions in excess of those that are required by I&E bulletins that were issued right after the incident. And it also has some criteria for design changes on all operating B&W plants. Now, that's paraphrasing some of the letter, but I think it highlights some of the things.

Then on December 12th Chairman Ahearne sent a letter to Dr. Plesset requesting the ACRS to do the review requested by Congressman Udall.

In summary, I think we can say Mr. Udall has five basic concerns:

One, the level of confidence placed in the staff's ability to calculate the consequences of an ATWS. And that one I think has a lot of problems that we need to give a lot of consideration to. That includes the ability to calculate the consequences of control rod failures following transients at full power and the ability of the staff to calculate ATWS consequences under the assumptions of a range of design basis transients, and the Commission's assessment of the consequences of Browns Ferry 3 had control rod failure occurred at full power following a design basis event.

Two, the level of confidence in adequacy of actions taken subsequent to the Browns Ferry control rod failure. And there's another part here, and that's what additional ATWS-related concerns does the Commission and ACRS deem appropriate to consider.

Three, that extant emergency procedures at operating plants contain instructions for the operators, given an ATWS.

Four, assessment of causes of Browns Ferry 3 partial failure to scram.

Five, ACRS review of previous Commission responses to Udall's inquiries.

Now, since these events, in looking at what is required by Udall's letter, the EOD has done an analysis of the event and the staff has issued the generic SER.

Hopefully, today I would like to be in a position where we could at least start formulation of a response to Congressman Udall on part of the summary items in two, three, and four mentioned above. I have some real concerns about where we go from there, and I want everybody to think about it, because I can envision in the areas of ability to calculate the consequences of control rod failures that that presents a spectrum of things that I think we need to zero in on and say how much is enough.

I think, with that summary, I will quit. Do any other members of the Subcommittee have any comments? Dave? Jerry?

(No response.)

MR. MATHIS: If not, then I will call on Paul Check of the staff to take off from there.

MR. CHECK: Good morning. I am Paul Check, the Office of Nuclear Reactor Regulation. We are here from several offices this morning to describe as coherently and understandably as possible how the NRC has dealt with the partial failure to scram event that occurred at Browns Ferry Unit 3 last summer.

No single element of the staff has had exclusive responsibility for this issue. Several offices have been heavily involved.

Initially, as you know, when trouble occurs at an operating reactor, the Office of Inspection and Enforcement responds and has the agency lead, with ad hoc assistance being provided by other offices, in this case notably NRR and AEOD.

I&E's purpose was to determine and implement measures required for continued safe operation of Browns Ferry 3 and other BWR's. And of course, among the alternatives would have been to discontinue operation.

Soon NRR mounted an effort to establish requiremnts for final resolution of safety concerns raised by the event. The rest is pretty much history, and that's what our next speaker will be giving us.

(Slide.)

I want to indicate there is a congruence between the Committee's impression of what is important and needs to be discussed and ours, strangely enough. Mr. Mathis has already run down that list and I won't belabor it. You will find us, I hope, trying to convey a sense of the process by which we have handled an operating event. That is, I think, first and foremost what we want to leave you with.

It is not always easy because, as I said, there are a number of parties involved, and it becomes increasingly difficult as the NRC evolves for any one group to speak for the entire staff.

Vince Panciera is the next speaker, and I introduce him and commend him to you as your master of ceremonies for today. He will be, I think, a reasonable guide for you to the activities of the staff. Vince is a section leader in the Reactors Systems Branch in NRR and has functioned since almost the beginning as a focus for one or another task force or study group effort on this problem.

Vince.

MR. PANCIERA: I thought it would be helpful to the Subcommittee for me to present at this time an overall chronology of staff actions. Hopefully this will give you a perspective of how the staff responded and give you a feel for the time sequence in which this response occurred.

MR. RAY: Question. I notice the second item on your chronology is the event itself. But you acted before that. What triggered this?

MR. PANCIERA: I will tell you.

(Slide.)

If you will notice the first item is the issuance of the I&E Bulletin 80-14, and that was on 6-12-80. That was before the Browns Ferry event, by the order of something of 16 days.

This bulletin was issued really because of I&E looking over the LER's and deciding that there may be a problem with the scram instrumentation, the float levels. So this was prior to the Browns Ferry event.

I&E looked at events at Brunswick. At Brunswick there were indications of crushed floats, at the Brunswick plant. There was also indications at Hatch 1 of bent stems on these floats. So the bulletin was issued in response to those concerns.

And the reason I put this on this chronology of staff actions is that during the development of the generic safety evaluation report we did consider those events and we were concerned with it to the extent that the SER deals quite heavily in that area. So I just wanted to present that as a --

MR. RAY: If I'm anticipating you, stop me. But when you got into the Browns Ferry 3 event did you find any such maladjustments as the Brunswick and Hatch incidents?

MR. PANCIERA: No, there were none. But of course, the Browns Ferry 3 event occurred on June 28th. A preliminary notification of the event was issued on 6-30. In response to that event the NRC put together a team that worked with the local region, Region II, and went down to Browns Ferry on 7-12 -- I mean 7-2 and 7-3.

It was composed of representatives from NRR, I&E, and AEOD. Then we got into a series of I&E issuing a series of bulletins. This was done in conjunction with NRR.

The first bulletin was issued on 7-3. That was 80-17. 80-17 required tests and procedural verification at each plant, and we will go into that in a little more detail later. But it basically set the stage, the event occurred, what do you do about it. And there was both manual and automatic scram tests required.

A great deal of data was taken, and this helped us later on in developing -- trying to put together what had happened, and also helped us in the development of the SER, which I will get into later.

Supplement 1 to the 80-17 was issued on 7-18. This came about because of concerns with the as-built condition of the plant. We found a number of instances where we thought the plant was built to a certain specification or design and then we found out there were discrepancies in what we perceived the design to be.

So Supplement 1 required basically testing and verification of the as-built condition of the plant.

On 7-21 -- this was almost three weeks after the event occurred -- NRR established a multi-discipline team to look at the event and develop long-range solutions to the problem. This team was composed of members of the Division of Licensing, the Division of System Integration. We pulled in people who had particular expertise, like in human factors.

I&E participated very heavily in this team. The team -- in order to get a better handle on the conditions that existed at all the plants, the team went out and held regional meetings at three regions. During these meetings, we sat down with each licensee and discussed his as-built condition of the plant, discussed the results of the tests that were done in compliance with 80-17.

This was another cornerstone at the regional meetings that helped us form the basis for the generic SER. That's why I bring this up here.

Supplement 2 was issued on 7-22, and then shortly after Supplement 2 was issued -- and we will discuss each one of these supplements later in much more detail -- the AEOD report was issued, which was another document that helped form the basis for the generic SER. And Stu Rubin will discuss that in quite a bit of detail.

On 8-6 we met with General Electric and General Electric presented an analysis and recommendations of what they thought ought to be done to correct the problems noted at Browns Ferry. During that meeting a plan of action was conceived where we would basically work with an owners subgroup a BWR owners subgroup, to develop criteria for the long fix.

And that subgroup then was formed very shortly after the GE meeting. And as a result, on 9-19 we had our first staff-owners subgroup meeting, and at that time they had developed at least tentative draft criteria which we reviewed. We had a number of comments that we made on those criteria, and as a result the owners group went back and did extensive reviewing of their own information, of the AEOD report, of some of the guidance we had given them, and then came back with a set of criteria which met our requirements better.

MR. WARD: Vince, one question. Did the GE analysis on August 6th discuss the degraded air supply problem?

MR. PANCIERA: No, it did not. The GE analysis basically recommended -- and forgive me for getting ahead of myself, but recommended certain hardware changes to the system as it exists today for many of the plants. And we will get into the details, but basically they recommended additional instrumentation to assure single failure-proof design.

They recommended better hydraulic coupling between the scram discharge volume and the volume that contains the instruments. It was that kind of a thing, mostly directed at hardware changes.

But the degraded air problem really had surfaced -- let's see -- had surfaced on 8-18. This was a memo from Carl Michaelson to Harold Denton. So the GE analysis did not really cover that.

On 10-1 NRC issued a generic letter to BWR

Licensees. This basically said, we understand that the subcommittee has been formed to develop criteria. We are asking you to commit to adherence to that criteria, and we want a response by the 15th of December.

The reason 15 December was chosen is that we anticipated about the first of December we would have the generic SER out. So it would give the Licensees a chance to look at it and then commit to the long-term solution to the problem.

On 10-8 there was a meeting with the Executive Director for Operations and the head of the Offices of NRR and AEOD, in which a decision was made at that time that the generic SER to be developed would also include plant-specific evaluations, in other words plant-by-plant an evaluation of how that plant responded to the bulleti. requirements and was it satisfactory or not. And an appendix to the SER covers each one of the plants and covers the bulletin requirements, the Licensees' response to the bulletin requirements, and also covers our evaluation of their responses.

Any questions on this first slide before I go on?

MR. LIPINSKI: In the plants in that appendix, Dresden 1 is not in the list. Is there a reason?

MR. PANCIERA: Yes, because Dresden 1 is not in operation.

MR. LIPINSKI: It's being cleaned up, but there is no plan for it to return to operation?

VOICE: The plan is they will -- since it is an extended outage, they weren't implemented in the same time frame.

MR. PANCIERA: We did not include Dresden 1 and Humboldt Bay, basically.

MR. LIPINSKI: Okay, thank you.

(Slide.)

MR. PANCIERA: On 10-15, as I mentioned, the second staff-owners group meeting was held, in which we basically had reached agreement with the owners on the criteria, with the exception of two general areas.

One area was the question of diverse instrumentation whether to provide diversity for scram instrumentation. The second area there was some disagreement on was the dependence of proper venting on scram discharge volume drainage.

Basically, the owners went back, looked at that, held their ground on diverse instrumentation, but did agree with the staff on incorporating in the criteria requirements that the drainage of the scram discharge volume should be independent of its venting. In other words, you should have the hydraulic coupling between the scram discharge volume and the instrumented volume such that you did not depend on venting of the headers. We will get into that a little later.

On 10-17 we asked the Probabilistic Assessment Staff to perform an additional fault tree analysis on the BWR scram discharge system. This was basically to get someone to look in the long range at what additional design improvements ought to be made to future plants. And Jim Pittman this afternoon will discuss the results of that study.

On 10-19 the full owners group met and reviewed the criteria. And on 11-24 we received a letter from the owners group basically endorsing the criteria.

On 12-1 the generic SER was issued. This was followed by a Division of Safety Technology evaluation.

Let me stop here for a minute and explain, I guess, how we are organized to handle this problem within NRR. The SER was issued on 12-1. Harold Denton then took the SER, asked the Division of Safety Technology to perform a peer review of that document.

The Division of Safety Technology chose, because of the time constraints, to break that up into two parts. The SER deals with short-term recommendations as well as long-term recommendations.

So the Division of Safety Technology completed its evaluation of short-term recommendations in the SER on

12-12. That provided the basis for orders that were issued on 1-9 which required the Licensees to implement the short-term modifications. This was basically modifications to address the degraded air problem, because we felt we could not wait for the long-term modifications to address the degraded air problem. We felt in our minds it was a serious problem and ought to be addressed earlier than waiting before the long-term modifications were completed.

Supplement 4 was issued on 12-17. Let me say something about this supplement.

(Slide.)

Let me go back to this slide.

On 8-13, as I mentioned, the AEOD memo was issued on degraded air. Shortly after that, on 8-18, an information bulletin was issued which addressed the degraded air problem. Then Supplement 3 was issued, which further addressed this degraded air problem.

As part of these supplements, one of the -- the I&E Bulletin required that the Licensee install a continuous monitoring system on the scram discharge volume headers that would give an indication to the operator in the control room of any accumulation of water in the scram discharge volume.

As a result, on 10-2 -- and I don't have that on here -- confirmatory orders were issued to all Licensees, with the exception of Monticello, who had already installed this system, that required by 1 December that this continuous monitoring system be installed at all plants. There was some relaxation given to Browns Ferry because of material problems. Browns Ferry had to install this system on 22 December. But this equipment was installed on 12-1.

(Slide.)

And shortly after it was installed, we started to find quite a few problems associated with this equipment. So on 12-1 each Licensee had in place a continuous monitoring system, installed on the scram discharge volume to monitor continuously the level of water in the scram discharge volume.

However, there were problems associated with this. I will classify them as design and installation problems. So as a result, Supplement 4 was issued on 12-17 to address the problems noted with the continuous monitoring system.

In early January we made -- I and some of the human factors men made a visit to Browns Ferry to review human factors, and also to get a better handle on how much time we should allow for the installation of the short-term mods. It was a trip planned basically to find out how Browns Ferry had implemented bulletin requirements to address degraded air.

We talked to some of the operators and basically found that the operators did not have a very good handle on how to cope with the degraded air problem. So this really basically added more urgency to our desire to get the short-term mods installed quickly.

On 1-28 and 2-20, there were two submittals. DST evaluated the long-term recommendations that were in the SER and basically agreed with the long-term recommendations. And I will get into some of the -- some of their thoughts later.

Right now we are waiting to issue orders on the long-term modifications. There is a legal question right now whether to go the orders route, to require the Licensees to install long-term modifications, or to go the rulemaking route and issue a rule to require the installation of long-term modifications. So that's why I don't have a date down here.

We anticipate that the long-term modifications will take a period of one to two years to implement. Some of the Licensees have already started to prepare to implement the long-term modifications, and some of the Licensees who are going down for a refueling period are getting ready now to put the long-term mods in.

Let me point one more thing out: that the generic SER is also applicable to the operating licenses, and some of the near-term OL's have committed to implement the long-term policy. And later on in the presentation we will get into what these long-term mods are.

But I want to just present to you a perspective of how the staff handled it. There was a lot of coordination among the staff. We worked very closely with I&E in the early stages of the solution to the problem. When we were in the bulletin stage, we provided support to I&E for technical requirements that went into the bulletins. In the later stages, I&E supported us through its regional offices to set up the regional meetings, to go back to the residents, to gain specific knowledge or answers to specific questions where we tried to evaluate the plant-specific items. I think that worked quite well.

I will say in summary that I think the staff coordinated quite well on this item. The AEOD report came out. NRR used that report extensively to try to develop the long-term solutions.

Are there any questions?

MR. MATHIS: Vince, you mentioned earlier that this continuous monitoring system was in place on 12-1. And then you had some problems with it and those were addressed on 12-17. Will we hear more of that later?

MR. PANCIERA: Yes, you will hear more about that later. The bulletin that was issued or the supplement to I&E Bulletin 80-17 addressed the concerns the staff had.

When we were developing the SER, we knew that this system was going to be installed on 12-1.

We basically really did not have a good handle on what the system design looked at at that point, and we so stated in the SER. We said we would have to defer really making a judgment on this system until we got it installed and in operation.

At that time or after it was installed, a number of plants had trouble basically with the system detecting water right after scram. In other words, a scram would occur and the system would not detect the water accumulation in the SDV. We found out there were transducer problems, there were problems on how the Licensee ran the electric wiring to the unit.

I think most of these have been cleaned up. And I think, Bill, you will address this further, won't you?

MR. MILLS: Yes.

MR. MATHIS: Let me state a concern as I go through this chronology. This is basically six months after the incident, and we have apparently put in place some temporary measures that we think will take care of this. And two weeks after we put the temporary measures in place we find out we haven't done a very good job. And that bothers me.

I would hope we will hear something about that as we go along.

MR. PANCIERA: The temporary measures that we put in place were much more extensive than the continuous monitoring system. The temporary measures we put in place were:

Number one, we, through the bulletin requirements, got assurance there was no water accumulation in the scram discharge volume. There were tests run on a daily basis that would make this determination. We tested the equipment. We made sure there were no vents -- that the vents that came up the scram discharge volume, that may have contributed to the Browns Ferry -- we made sure those were not plugged.

We went even further and had the Licensees provide a positive vent that would go directly from the outlet side of the vent valve on the scram discharge volume to the reactor building atmosphere, so we didn't have to depend on a lot of piping downstream.

We also required after every scram a functional test of the level instrumentation. We required a relook and verification of the procedures to make sure that the procedures -- that in the event of an ATWS situation or partial failure to scram, the Licensee had readily available the ability to initiate standby liquid level control.

So I want to present to you the overall scope, and

I hope we will do that by the end of the day. This continuous monitoring system was one small thing. The continuous monitoring system basically substituted for the daily checks that were being done to assure there was no water in the scram discharge volume.

So I hope I don't leave you the impression that everything we did proved to be wrong. It was one small thing that we did, that we required -- that required some of the bugs to be taken out of it.

MR. MATHIS: Well, that's the point that hit me, Vince. After we look at something for six months, we haven't got all the bugs out. That's the point I want to hear some more about.

MR. PANCIERA: Okay.

MR. JORDAN: This is Ed Jordan.

While this is fresh on your mind, I think it would be well to indicate a little more staff response there. We had pressed the Licensees pretty hard to install this equipment to detect the presence and collection of water in that scram discharge volume.

We had looked at prototype installation by one vendor and had satisfied ourselves that the principle was good. The installations were against the time deadline that we had set. And so the testing by the Licensees was not complete. They installed it while the units were operating, so that it was during subsequent scrams that we found the inability of the system to detect scram water.

So that is what inspired the further testing. So I think we had a couple of weeks where perhaps we had more confidence in the system than was warranted. But the additional testing and modifications that the Licensees made to the units I think has made them a reasonably reliable system.

MR. RAY: Were these inadequacies widespread, prevalent in the systems, or were they isolated?

MR. PANCIERA: I think they were basically isolated incidents.

Any other questions?

(No response.)

MR. CHECK: I would like to make one comment. I think this is an important point, and I think Ed and Vince have characterized different aspects of the overall staff response and industry response which puts it in perspective.

Let me add a homely, if imperfect, analogy. You learn that you have an overheating problem in your fleet of trucks, engine overheating. And you take what steps you think are necessary to prevent that and to mitigate it if it should occur. And those mitigating steps might include backing up your temperature indication with another indication of overheating, an idiot light.

I think what we are talking about here is having difficulty with the idiot light.

MR. PANCIERA: Okay. Now Bill Mills will give a discussion on the principles of operation in the scram discharge system.

MR. LIPINSKI: I'm not sure if this should be addressed to Paul Check. There is one thing that's bothering me and I don't know if it's going to appear in the agenda as we work through the day.

But 12 years ago, when the ATWS issue was first raised, General Electric was the first vendor to be interviewed. At that time they came in and they had a calculated reliability, I think it was 10^{-15}. Probably Bill figured they would not scram. And that was based on the analysis of the front end, the rods getting in. They had not even considered that scram discharge volume.

And when the question was raised, what happens when the volume is full, they said the rods will not move. How do you guarantee it's not filled? At that time it was only a single volume, a single float switch. And they said, by administrative controls we guarantee it will not fill.

They became conscious of it and tried to make some improvements in the system. And I think about in '78, when ATWS was again taken as a rather serious issue and the staff issued the NUREG-0462 reports, I think GE came back in again with a series of reliability calculations.

Somewhere within the licensing process the staff reviews the systems again to see whether they meet the requirements. Now, somewhere General Electric had some requirements in terms of how that system was to be designed and installed.

Will we hear whether they were responsible for the design and installation, or to provide requirements to an architect-engineer that interprets, designs and installs?

MR. PANCIERA: I intend to cover that. If you like, I could do it right now.

MR. LIPINSKI: It's up to the Chairman. Because there is something more fundamental. Here we have a case of where something has gone wrong. It's been analyzed. But more fundamentally, why did it happen in the first place?

MR. MATHIS: Well, that's a question that certainly needs to be addressed, Walt. And I will leave it up to Vince to see whether or not it will come later in a more orderly fashion, or do you want to address it now?

MR. PANCIERA: Let me address it when I talk about the regional meetings that we held. I have a slide that shows what we covered.

I am prepared to talk about the large degree of variability we found in system design and the large degree of variability in the way these systems were tied to other systems. I also intend to discuss how GE handled their specification requirements, basically, and the other parties who were part of this design team.

There was a subcontractor who subcontracted both to GE on the turnkey contracts, as well as to the architect-engineers or the Licensees themselves on the non-turnkey. And I will try to bring out what I found. And basically, I don't think it is a very pretty picture.

MR. LIPINSKI: I think we could defer it until that time. Thank you.

MR. MATHIS: Okay. Thank you, Vince.

MR. MILLS: I'm Bill Mills and I'm in the Events Evaluation Section in IE headquarters.

(Slide.)

I will discuss the control rod drive system, the design and basic principles of operation, the sequence of events that occurred at Browns Ferry during the partial scram, and the immediate investigations that were done to determine the cause of that partial scram.

(Slide.)

This slide shows the main components of the scram hydraulic system to the normal valve lineup. During power operation, the control rods, of course, are withdrawn from the bottom, so they are latched in the area below the core region.

The control rod is coupled to the control rod drive mechanism. Control rod motion is accomplished by putting a differential pressure across the drive piston. And during normal operation, the scram system is maintained in a state of readiness to rapidly insert the control rods if an automatic shutdown is needed.

This is done by basically doing two things: One is by providing a high-pressure source of water to the area under the piston; and then also venting the area above the drive piston. That differential pressure then rapidly forces the rod into the core. They are designed to scram within approximately three seconds.

During normal operation, the scram inlet and the scram outlet valves are closed, so the scram system is not having an impact on the drive. And during normal operation there is basically a zero differential pressure across the drive.

You have reactor pressure above and below the drive. There is actually an internal port which makes available reactor pressure to the area under the piston.

MR. LIPINSKI: What's the full stroke?

MR. MAJOR: 12 feet.

The scram inlet and outlet valves are closed, as I said. If you look at this on a principle of operation, if you open the scram outlet valve that would vent the area above the drive piston. Water would flow out to the scram discharge volume. And during normal operation, scram discharge volume is maintained empty, so that it can receive water displaced from the control rod drive mechanism during the scram.

MR. WARD: Bill, going back to the little check valve symbol in the piston, is that just one check valve in the system, or is there an individual one?

MR. MAJOR: There is one for each control rod drive. Actually it's internal to that. There's a ball check valve and, whichever pressure is higher, the reactor pressure or the pressure coming from the scram accumulator, will be applied to the bottom of the piston. So I have the ball check represented by these two valves.

During normal operation, you keep the scram discharge volume empty. And we will go into more detail later. But you leave the vent valves and the drain valve open, so that any water that leaks into the system will drain through.

You also have level instrumentation which is designed to detect the accumulation of water in the instrument valve.

On the supply side, you have a scram accumulator which is maintained charged during normal operation by the control rod pump, which has a discharge pressure of around 1500 pounds. And of course, reactor pressure is approximately 1,000 pounds.

So to get to scram all you really have to do to get the rod to move in rapidly is open the outlet valve and have a free discharge volume, so you vent the upper area of the piston.

(Slide.)

This is the same drawing. It just shows the valves in a scrammed lineup. The scram inlet and scram outlet valves are open. The scram discharge volume vent is closed.

So when a scram signal is received, the scram outlet valve opens slightly before the scram inlet valve, vents the area off above the piston, applies the high pressure water to the bottom side of the drive piston. The control rod is forced up into the core, water is displaced from the area above the drive piston, then flows into scram discharge volume.

Since it's bottled up, it will accumulate there. Normal scram, about three-quarters of a gallon is displaced from the above-piston area, and the scram discharge volume to receive about 3.3 gallons per drive. So you have basically three times -- more than three times the volume you would need for one scram.

However, once you get to scram there is seal leakage that occurs from the seals in the control rod drive mechanism. So reactor water then can come from the vessel through the seals and flow into the system as well, and it does that after the scram is complete, as long as the scram outlet valve is open.

So this leakage will flow into the scram discharge volume, fill that, and it will pressurize to reactor pressure. So if the scram is not reset within the first couple of minutes, the scram discharge volume will fill and pressurize.

Then when the operator resets the scram, which is a manual action, that will close the scram inlet and outlet valves again and open the vent and drain valves so the system can drain and be ready for the next reactor scram.

MR. LIPINSKI: How long does it take to get to reactor pressure?

MR. MILLS: It's approximately two minutes. The time was determined during testing that was required in the bulletins.

MR. LIPINSKI: There are certain scram conditions that are not resettable, as I recall. So consequently the system does go to reactor pressure in two minutes in some conditions.

MR. MILLS: I think it's quite typical to have that. Many of them will be, but not all of them. So the thing will pressurize on a number of scrams.

MR. LIPINSKI: The entire scram discharge volume, the instrumented drain tank, they all become part of th primary system boundary, then?

MR. MILLS: That's correct.

MR. LIPINSKI: They don't apply the same criteria on those valves because they're in single mode right now, correct?

MR. MILLS: In the past, the reactor coolant pressure boundary was really only considered up to the valves, and you don't really have isolation valves here.

That will be discussed more later, and that's one of the changes in the design criteria that's been put together since the Browns Ferry 3 event.

MR. LIPINSKI: Thank you.

MR. WARD: What's the capacity of the scram accumulator in terms of number of scrams?

MR. MILLS: The scram accumulator will only be good for one scram without recharging. The drive pump has a discharge pressure of around 1500. It keeps the accumulator charged.

There is actually a stop piston in here. The accumulator gets to around 1100 pounds and the piston stops. Then when you get a reactor scram and open the scram inlet valve, that forces the water in even before the scram stroke is completed.

The pressure in this accumulator may be below reactor pressure if you are at full reactor pressure. So then the stroke of the scram can be completed by the reactor water. In fact, when you are at full power and full pressure, the accumulator is not needed to provide the required scram time. The reactor water alone on the bottom side of the piston will provide enough high-pressure water to get the control rod in within the required time. So this does one scram without recharging.

MR. WARD: Does the nitrogen have to be

recharged?

MR. MILLS: No, that's dead. And the pressure increases and decreases depending on the location of the drive piston in there.

MR. MATHIS: Bill, one other question. What happens on a power outage to this whole system? Are they all alike to where -- that is an electrically driven pump. What about the valves and the scram accumulator and so forth?

MR. MILLS: The scram valves are powered from the reactor protection system, and they are energized during normal operation. So loss of power to the scram valves will result in them failing open and that would cause a scram. You have separate power supplies to the scram valves and to the drive water pumps here.

MR. MATHIS: What about your discharge volume vent valve, for example?

MR. MILLS: These also come from the reactor protection system. They are the same as the scram valves.

(Slide.)

MR. WARD: Wait. Could you go back to that again?

(Slide.)

MR. WARD: In the normal scram lineup, the vent valve and the drain valve from the scram volume are closed?

MR. MILLS: Right.

MR. WARD: And you're saying with an electric power instrument failure, those would open?

MR. MILLS: These happen to be the opposite, because during normal operation these are closed and these are open. They operate just the opposite of a scram valve.

MR. WARD: Okay. In a power failure they close.

MR. MILLS: They all go to the safe position on loss of power.

(Slide.)

That will be discussed a little bit more later, when we get into the air system and how those valves are controlled.

As I said, one of the things you need to get a successful scram -- this slide here shows a little bit more of the detail on how the scram discharge volume is set up at Browns Ferry. The rods on the east side of the core go into the west scram discharge volume volume. The rods on the west side of the core go into the west scram discharge volume. So they actually have it divided into these two sections, with a common instrument volume and then level switches to detect a buildup of water, the rod block, and then the scram switches.

And during normal operation these are open and the drain is open, so any leakage in there can flow through. The power is used to hold these valves open and they would close on a loss of level.

MR. LIPINSKI: With that drain open, there is a possibility of liquid coming in the reverse direction to fill up the instrument volume?

MR. MILLS: Yes, there is that possibility. However, if it does back up, you should have these switches.

(Slide.)

At Browns Ferry, on June 28th they were in the process of shutting the reactor down for routine maintenance. They had decreased power to approximately 35 percent, and this is the control rod pattern that they had. 48 represents full up. Zero represents control rods full in.

As you can see, they had a lot of rods out. They had primarily reduced power by reducing the recirculation flow. They had inserted just a few of the control rods all the way. So approximately 35 percent power.

The operator was going to do a manual scram to shut the plant down to do maintenance on the feedwater system. He depressed both manual scram buttons and moved it into manual shutdown. What he expected to see was the entire core -- and this entire display is up in front of him.

But he expected to see a change to all zeroes, showing all control rods going full in.

(Slide.)

MR. MATHIS: Bill, before you go any further, refresh my memory. How are these rods held in position when they are partially in?

MR. MILLS: I can discuss that. It gets a little bit detailed. I think Sty may be planning to go into more detail into that later.

MR. MATHIS: Okay.

MR. MILLS: They have a latching mechanism which prevents them from coming up. It really doesn't interfere with the scram on the way in. As long as Stu is getting into that, I will leave it to him.

MR. MATHIS: All right. Thank you.

(Slide.)

MR. MILLS: So when the operator hit the manual scram buttons, rather than seeing all the rods go in, this is what he actually saw. The rods on the west side of the core went full in. The rods on the east side did not. Power level went down to about two percent, so from an operational standpoint the power level was insignificant. He did not have any problem there.

He knew he had to get the control rods back in. So he then started resetting the scram, and he subsequently induced three more scrams and the control rods moved a little bit further in on each of the three subsequent scrams. So they were fully in after the third subsequent scram.

(Slide.)

Here's the sequence of events listed here.

MR. LIPINSKI: What is that "W"?

MR. MILLS: That's for the row right in the middle, and the ones with the "W" go to the west scram discharge volume. Those are west, and these go to the east volume.

(Slide.)

Here is a very brief list of the sequence of events.

MR. WARD: I'm sorry. Could we go back? I noticed I guess one of the west rods isn't all the way in.

(Slide.)

MR. MILLS: Right.

MR. WARD: What's the explanation for that?

MR. MILLS: That can happen if the control rod drive basically has some leaky seals in it, that the rod comes all the way in and, rather than being buffered properly, it will go all the way in and then bump and come back out and settle out one notch, rather than staying at position zero, which is full in.

So there is no indication that there was any problem with the west side of the core as a whole. That's a specific problem that can happen to one drive, depending on the state of the seals and how much leakage they have. I don't know, maybe Stu was going to discuss it.

MR. RUBIN: I just wanted to mention that that particular phenomenon is not particularly an uncommon occurrence in a BWR scram. There is a fair amount of experience at reactor scrams where you will see a couple or three rods settled out at the 02 position. And I think NRR is looking into that question of the significance of stopping at the 02 position. But it is not an uncommon occurrence.

MR. WARD: Is there a specification on that, a limit on the number of rods?

MR. RUBIN: I'm not sure exactly of the scope that NRR has envisioned. But I would suspect there would be no problem with shutdown with several rods still being in that position. In other words, effectively you have got virtually all of your shutdown reactivity at that point.

MR. WARD: Well, that's another question.

(Slide.)

MR. MILLS: Okay, back on the sequence. You can see it was around 14 minutes from the time the operator first depressed the scram button to the time he had them all in. And during that 14 minutes the operator had to reset the reactor scram manually. That's a manual function.

And then when he did that the scram inlet and outlet valves closed. That we saw in the earlier drawing. And the scram discharge volume vents remained open. So then a certain amount drained between those resets.

So then when he did the subsequent scrams there was room again in the scram discharge volume to receive more water, and the rods moved in further on each scram.

(Slide.)

Then support people were immediately called in to the site to investigate and determine the cause of the partial scram. And they checked quite a few items early that day and later on in the day to find out why the partial scram occurred.

They went down and checked the valve alignment on the control rod drive system and the hydraulic modules, looking for any valves being misaligned that might have caused the problem, and found nothing.

They suspected they had water in the east scram discharge volume because the rods were out on that side. That side fed the east volume. So they looked at the vent valve on the east scram discharge volume and basically found no problems with its operability.

They surveyed the drain lines that connect the east scram discharge volume to the instrument volume, thinking there might be some blockage in that line and that would show up in a radiation survey, and they found nothing there.

They also surveyed the drain sumps, where the drain from the scram discharge instrument volume goes, looking for any foreign objects or debris that might have been an indication of blockage. They didn't find anything there.

Like I said, there was no problem with the reactor power and the reactor coolant samples showed okay.

They did a callibration check of the level switches on the instrument volume. They did find two problems there. The 3-gallon and the 25-gallon switch did not actuate when they did this callibration check. They did actuate, however, during the event itself when the water flowed in there. And these switches were found to be stuck, and they were flushed out and they have got a certain amount of what was described as "fine silt-type" of material that came out, that caused the switches to be stuck.

That's different from the problem that was talked about earlier in the Hatch and Brunswick events, because in those events they actually had damage to the float or the float stem. This wasn't that kind of problem.

Also, these switches are not used to provide the scram function. One is alarm and the other is a rod block.

They also did visual mechanical inspections of the vent valves and they did some evaluations electrically, which I will discuss in just a minute, to see if there were any electrical malfunctions.

(Slide.)

Their electrical evaluation considered that the operators in the control room saw blue lights, which are on this matrix that I showed you that had the control rod positions. Those lights indicate that the scram inlet and outlet valves are open. So the operating people saw that at the time of the scram, so they knew the scram valves had worked properly. So the electrical portion had really been completed.

So that really eliminated a lot of questions on the electrical part, so they suspected a hydraulic problem as well from that indication.

MR. WARD: Does that light -- is that from a switch on the valve or does that indicate a signal through the valve?

MR. MILLS: From a limit switch on the valve. There's actually one on the inlet and outlet valve, and they both have to be open in order to have the blue light.

They did some other electrical inspections, looking for jumpers that might have been inadvertently installed to put power in the reactor protection system that might have caused the problem.

They looked at the separation of various groups electrically and did some testing on the de-energizing of the pilot valves to find out if there were any electrical problems, and concluded there were none. And there was no identified electrical malfunction that could have possibly caused the rods to stay out on the east side.

MR. LIPINSKI: On that subject of jumpers, is there a mechanism where a jumper could have been installed and caused it? The reason I'm asking, it very well could be that someone is trying to cover his tracks and may have removed something without the knowledge of people who were doing the followup.

MR. MILLS: The person would have to install jumpers in a fuse cabinet that was out in the reactor building, and I think he would have to install a large number of jumpers. No one jumper would do it.

MR. LIPINSKI: Okay. So it would be for as many rods as failed, it would take that number of jumpers.

(Slide.)

MR. MILLS: If you look here, this is the way the rods are dispersed electrically through the core. There's four different electrical groups. So electrical problems would have given you a problem on this kind of dispersion.

And that was one of the first things that one of the guys called in and went down to check, because he happened to be an electrical type, very familiar with that system. And he ran down quickly and opened the covers on the fuse panels and specifically looked for jumpers or any signs of anybody who had tampered with that system, and found nothing.

MR. LIPINSKI: Even if it had been tampered with electrically, you could not have produced the phenomenon by electrical tampering.

MR. MILLS: That's right.

MR. PITTMAN: Also, Bill, your blue lights would not have come on on your scram panel if there had been jumpers installed.

MR. MILLS: It may be a process of elimination, but there is a lot of things that show the problem was not electrical. But the feasibility of the scram discharge volume being full is pointed out because all the rods on this side do go to the east scram discharge volume.

And the radiation survey they did was of this line, looking for blockage in here and checking the vent and drain valves to try to find some problems.

(Slide.)

So as a result of those investigations, they concluded that the problem was not caused by an electrical malfunction, it was not the misposition of valves in the control rod drive system, and it was retention of water in the east scram discharge volume.

But in all their inspections, they could find no definite cause for that retention of water. They couldn't find any blockage in the drain lines. And what was concluded by the staff immediately following that event was that generic action had to be taken on other plants and what we needed to do was verify that we maintain the scram discharge volume fully operable and that we verify and periodically check to make sure that the scram discharge volume is empty; and that, based on everything we have seen from the Browns Ferry event, the scram system would work properly as long as the scram discharge volume was maintained operable and full empty.

And that was the basic philosophy that led to the issuance of bulletins that came out shortly after the Browns Ferry event.

MR. LIPINSKI: Even though the scram discharge volume was full, there is still a line connected to the instrumented volume. Now when you start pressurizing that volume, you would drive water out of it into the other volume, unless the line were plugged, and then you would not be able to move the liquid.

Now what would be the flow rate through that connecting line as you start pressurizing that volume? I assume it's got to be much less than the rate at which it is coming in in order to cause the problem with the rods not scramming.

(Slide.)

MR. MILLS: This is a two-inch line here.

MR. LIPINSKI: 60 feet long?

MR. MILLS: 150 feet. So the flow rate would be much less than the flow rate coming into the instrument volume, into the scram discharge volume during the scram.

And Stu Rubin is going to talk next, from AEOD office about what they did, and I think he may get into some of those draining rates that are possible through the two-inch line.

MR. RUBIN: One point there is that I think the operators observed that the 50-gallon switches actuated at about -- I'm not sure, 18 or 19 seconds, indicating that the volume had filled to that point. And well before that point the rod motion had ended.

So I think you cannot really talk about water getting across the instrument line to the other discharge volume. But it filled much quicker than normal.

MR. WARD: Bill, what's the drain from the instrument volume? Where does that go?

MR. MILLS: The drain from the instrument volume ends up in the rad waste system. They have a drain tank typically that the instrument volume drains into, as well as a lot of other equipment in the reactor building. It's a common drain system that collects water from various equipment drains throughout the building.

MR. WARD: What is the design philosophy for having these scram volume headers in the first place? I mean, why doesn't the water just blow down to the drain collection systems?

MR. MILLS: You need to minimize the loss of reactor coolant following a reactor scram. So you do need a system that contains -- if it has limited volume, that will contain it and be isolated.

MR. WARD: This is instead of depending on valves that close off or something like this? That's the idea of this?

MR. MILLS: You really use a combination of limited volume plus a valve to do the complete isolation. As long as you have limited volume, you would have in some sense a controlled leakage through the vent and drain valves if the valves did not close.

But if you discharge from the reactor coolant system directly into the rad waste drain system, you would have a large flow of water going directly into a drain. That would be a loss of reactor coolant water, plus it would also result in overheating of the drives, because they have a large flow rate through them and you would be pulling reactor water through.

MR. PITTMAN: I think the answer to the question is, this becomes the primary pressure boundary, this instrument volume. And if we did not have the valves in there and we just dumped it back in, it would be a small LOCA within the containment, or if it went outside, like into the rad waste tank, it would be a small LOCA outside containment.

MR. MATHIS: Well, the rad waste tank comes to -- you've got approximately what, 1,000 pounds pressure drop? You'll have a flash and water hammer.

MR. MILLS: It definitely needs to be contained in a safety-grade volume.

MR. MATHIS: This is a good opportunity, I think, to take a break. Why don't we take ten minutes and we will reconvene at 10:15.

(Recess.)

MR. MATHIS: We will reconvene the meeting.

I'm sorry the coffee is moving a little slow. But I imagine in another few minutes it will be ready. So if you want to individually get up and go out and get a cup, I'm sure no one will mind.

Mr. Rubin, do you want to proceed?

(Slide.)

MR. RUBIN: George Lannick is going to be passing out a copy of the slides I will be showing you.

My name is Stuart Rubin. I'm a reactor systems engineer with the Office of Evaluation for Operational Data.

Today I'd like to talk with you about some of our investigations and case study reviews prompted by the Browns Ferry 3 event. This morning I will be talking about our reviews of the Browns Ferry event and the scram system. That will be followed immediately by a presentation on the potential for adverse air system-scram system interactions. After lunch I hope to talk to you about AEOD's assessment of the interim measures taken at Browns Ferry shortly after the event so as to avoid a similar type scram system failure. And at the end of the day, I will briefly discuss some preliminary results of additional BWR scram system studies being performed by AEOD.

(Slide.)

Within a few days after the Browns Ferry event, AEOD technical representatives went down to the site as part of an NRC team to begin to gather information about the event, the scram system design, and the results of some system tests and inspections that were performed by TVA personnel at the site.

With this initial contact, AEOD initiated its own independent investigation of the Browns Ferry event, its cause and lessons learned, so as to provide recommended corrective actions. This morning I will be providing some of the key results of that work.

I will start by providing once again, in spite of the fact that Bill Mills did such a great job, a review of the BWR scram system design characteristics, so you can better understand the things I will be talking about subsequently.

That will be followed by parts of our analysis of the cause of the event, as well as discussion of the Browns Ferry scram discharge volume, including its hydraulic characteristics. Then I will describe our findings, recommendations and conclusions.

(Slide.)

In order to better understand AEOD's evaluation, let me review with you again some of the key elements of the BWR scram system design, operation and operating characteristics.

(Slide.)

These are sort of cartoons that are somewhat different and I think may be helpful to really pin down how the thing works. I will try to make the system come alive.

The darkened area is the part of the drive that will move upward during scram or any other rod motion, while essentially all other parts of the drive stay where they are shown during periods of no rod motion. These are spring loaded into grooves on the darkened index tube. The index tube and attached control blade is rapidly inserted by applying a net differential pressure across the drive piston at the bottom of the index tube.

Normally during periods of no rod motion, no net differential pressure exists across the drive piston, except for that associated with the small amount of cooling water which passes up across the piston seals. The fluid above the piston, shown dotted, hydraulically communicates and is piped to the so-calleld scram discharge volume through the scram outlet valve. It's normally above the piston area and maintains above reactor pressure.

The below-piston area also communicates with the reactor pressure via an internal to the drive path past the check valve.

Normally we have at least 550 psi required to insert the rod.

(Slide.)

What we see here is the rod moving in. The rod is scram-inserted, and this is accomplished, as shown here, by rapidly reopening the scram outlet valve, which exposes the above-piston area fluid to atmospheric conditions associated with the empty scram discharge volume tank.

As shown in the figure, the dotted above-fluid piston area -- above-piston fluid -- now exposed to atmospheric conditions, is exhausted through the scram outlet valve which is opened into the scram discharge volume tank, while the below-piston area, still exposed to reactor pressure, causes the index tube and control blade to be driven upward into the core.

During this motion, the above-piston fluid is displaced and discharged into and collected by the scram discharge volume. During this time, the 184 other drives are doing the same thing, discharging their above-piston fluid into the SDV.

MR. LIPINSKI: There is no break in that drawing, but from the bottom of the vessel all the way to the bottom of the drawing, that's over 12 feet long, is it not?

MR. RUBIN: 12 feet we are talking about, that's correct, from this point basically to this point. And there are approximately 24 little notches, that are hard to see on here, each one of which is approximately six inches long, which gives you the 12-foot length.

That index tube is essentially 12 feet long.

MR. LIPINSKI: If you're below the reactor and saw the bottom of the reactor to where the mechanisms terminate, they are at least 12 feet long?

MR. RUBIN: Oh, yes, this distance is at least 12 feet long.

MR. WARD: How did the water get into that axial path where it's flowing downward there? I guess it's not clear to me.

MR. RUBIN: It's not clearly shown on this drawing, but there are some flow paths. This little section here also represents above-piston fluid area, and there are little flow holes in this inner tube which allow that displaced above-piston fluid to go into this annular area and be pushed down into the SDV system..

Similarly, not shown at all on this figure, are some paths that allow this outer annular fluid to be exhausted out into the scram discharge volume.

MR. BUCK: Are these pretty much just field drawings here?

MR. RUBIN: I wouldn't go that far. The length is considerably compressed.

(Slide.)

This final figure shows the darkened drive piston just having attained its full insertion, which takes about three seconds or so. During this motion, about three-quarters of a gallon of above-piston dotted fluid is displaced and exhausted into the SDV system. For 185 drives, this would be about 135 gallons discharged into the tank.

However, the total volume of the tank is about 600 gallons, or about 3.3 gallons per drive. So the tank does not fill during this period of rod motion.

However with the scram valves left open the tank does subsequently fill within a minute or so due to the leakage past the various seals in the drive to the over-piston area, and subsequently into the SDV tank. The leakage is typically two to three gallons per minute for each drive.

The reason the tank is made so large is that the dotted exhaust fluid pressure won't significantly build up in the tank during scram insertion, which could slow down a rod motion. If you leave the scram valves open after a scram, the tank will eventually fill and you will not have a chance for another scram.

You may have noticed, I did not talk about the scram inlet valve, although it's shown. The reason it's there is for reactor conditions where the reactor is at atmospheric or very low pressure. Again, it's to provide a high-pressure source of water under those circumstances. It really is not necessary at high reactor pressure.

(Slide.)

That gives you a slightly different perspective of what Bill was saying.

How do typical scram valves work? Each scram outlet valve is air-operated and air pressure on the operator keeps the scram valves closed as shown. The pressure must be at least 45 psi air pressure. If it falls below this slightly, it will start to crack open, allowing water to flow past the scram outlet valve into the SDV.

Air pressure to the operator of the scram valves is normally supplied through two normally open scram solenoid pilot valves in series, as shown here. The pilot valves are held open, allowing air to pass through them to the operator, keeping -- the pilot valves are held open, allowing air to pass through them to the operator, to keep the respective solenoid valves energized.

If either one of the solenoids is de-energized and closed, he air flow path is such that the remaining energized solenoid valve will continue to provide air to the operator. Both solenoid valves must be de-energized to prevent air pressure from the scram valve air operator to open the scram valve.

Thus, with the scram outlet valve kept closed by the air pressure provided by the two energized and open solenoid valves, no water gets into the SDV and all the CRD index tubes stay where they are. This is the unscrammed state.

By the way, these two pilot scram solenoid valves also control opening of the scram inlet valve in the same manner. The scram solenoid valves are energized and opened by the reactor protection system. Half an RPS energizes one solenoid valve, while RPS-B energizes the other solenoid valve.

Both solenoid pilot valves are [illegible] and removed. Venting these pilot valves, which in turn is shown on this next figure, opens the scram valve. A reactor scram occurs.

(Slide.)

(Slide.)

A little more about the system design operation and I will get into our analysis.

I hope these cartoons are helpful.

The SDV system at Browns Ferry is sketched in the next figure. During the scram, water exhausted from the drives is collected in either of two headers in the east and the west SDV header. The east CRD exhausts to the east header, while the west side CRD exhaust is routed to the west header.

Each SDV header involves about 300 gallons of available volume. During normal power operation, these headers or tanks are maintained empty of any water which might try to accumulate in them by leaking of the scram outlet valves by a continuous draining process.

Water which might otherwise accumulate is allowed to drain out by venting the high points of each header through a vent line with open vent valves, while draining the low points of each header to a small 50-gallon instrument tank. The tank in turn is continuously drained with a bottom drain line incorporating an open drain valve. The instrumented tank contains float-type level switches at the 3, 25, and 50 gallon elevations to monitor for water accumulation.

The 50-gallon elevation instruments in the tank are tied into the reactor protection system, so that if water were to accumulate to this level in the instrument volume, an automatic scram would be initiated, presumably before water accumulated in the SDV headers. That is, the scram would be initiated before water collected in the SDV headers which might prevent a scram.

The vent valves and drain valves are operated with air pressure applied to the valve operators, keeping them open. These air-operated vent and drain valves are piloted open and closed by solenoid air pilot valves analogous to the scram outlet valves.

The solenoid valves are also energized open by the RPS.

(Slide.)

An RPS trip de-energizes the solenoids, which results in venting of the air operator, which will result in closure of these valves at the same time the scram valves are opened. By closing these vent and drain valves, the SDV system is sealed after a scram, thereby containing and limiting the exhausted water from the reactor out of the CRD's.

Whenever an RPS is reset after a scram --

(Slide.)

-- going back from the SDV system viewpoint, the scram valves are reclosed. The vent and drain valves are reopened and this returns the full configuration to the unscrammed state and allows water which has accumulated during the scram to begin draining out of the system.

(Slide.)

As mentioned by Mr. Mills, there are several possible causes that were investigated by TVA. They could be characterized as electrical, mechanical, hydraulic and purely hydraulic, that is, related to the scram hydraulics. Although all these are discussed in our report, I will only discuss the last, which was concluded to be the cause of the event.

As mentioned earlier, the CRD scram exhausts at Browns Ferry are partitioned into the east and west headers. The east are located on the east side of the core, and those which exhaust on the west are located on the 300-gallon west header.

(Slide.)

Looking at the next slide, we can see the most notable observation of the control rod pattern -- this is probably obvious, but let's try to be analytical. The most noticeable observation was that all the drives connected to the west header inserted full-in, while all the drives exhausting to the east header inserted an average of only 20 positions.

This control rod pattern provides strong evidence that the cause of the failure was hydraulic, that is, something was preventing the CRD's from exhausting properly.

Did all the east scram header valves open? Yes, they had, as discussed by the blue lights coming on in the control room showing open positions for these valves.

There is also a manual isolation valve. So is it possible they were left partially closed? No, each of them was verified to be open by TVA immediately after the event.

What about some kind of blockages in exhaust paths? This was ruled out by individual scram-testing of rods, which eliminated that as a possibility.

The only possible mechanism, we believe, is that either there was inadequate free volume in the east SDV header or excessive exhaust back pressure on the drives caused by excessive under-to-over-piston bypass flow from the multiple control rod drive seal failures. The latter was also ruled out by testing at Browns Ferry and the drive rods were shown to be okay.

Thus we can conclude that the observed rod motion can best be preliminarily explained on the basis of at least a partial full scram discharge volume immediately before the first scram.

(Slide.)

Let's try to quantify this and substantiate it. Let's first try to see if the observed rod motion for the second and third scrams is reasonably consistent with the amount of free volume which we believe was made available by the SDV draining process just before these two scrams. Draining, you may recall, was accomplished when the operator reset the RPS.

By showing these two to be consistent, we can infer back basically how much actual free volume was available in the 300-gallon east SDV header for the first scram. Well, what do we know? Looking at the total notches inserted on the east side of the core after the second and third scrams, we see 956 total positions inserted during the second scram, or about 4.3 positions per drive during the third scram.

What kind of free volumes on the east header would give us this average rod motion?

(Slide.)

To answer that, we can look at a simple sketch which tries to explain some test performance at San Onofre by GE. In these tests, the scram exhaust volume shown in the figure was limited to 3.3 gallons, which would be the share of one of the 93 drives exhausting into an empty 300-gallon east header, down in volume increments to values like 7.5 gallons and zero gallons.

For each of these scram test simulators, the number of rods inserted was noted. From these tests it is possible to construct an almost straight-line relationship between the exhaust volume available and the positions which would be inserted.

These tests were also run for different simulated control rod drive leak rates. The motion observed at Browns Ferry -- from the average motion observed at Browns Ferry, as shown on the previous slide, it can be concluded that about .18 gallons per drive of the normal 3.3 was available for the second scram, while only .07 gallons per drive of the 3.3 was available for the third scram.

For 93 drives, this would work out to be about 17 gallons out of the 300 for the second scram, and only about 7 gallons for the third scram.

If one considers CRD leak rate effects, these numbers would increase by perhaps 20 percent. There's hardly any free volume available in the east SDV headers for the scrams.

How does this compare with the amount of volume that we think was made available from the drains?

(Slide.)

Backing up, from the event printout recorder we can tell that the operator drained the SDV system for 93 seconds prior to the second scram initiation and for 53 seconds prior to the third scram initiation. Also, from drain rates for the east header based on drain tests which I will talk about later at Browns Ferry, we know the east header drains at about 12 gallons per minute.

Thus, what is shown -- with the known drain rate and the shown drain times, we could conclude that about 18 gallons would have been made available for the second scram and about 10 gallons for the third scram.

Comparing the observed rod motion and what would have to be available with what we think was made available, they are reasonably consistent. Thus one can conclude that the east SDV was draining normally between scrams one and two and between scrams two and three, and that the average rod motions for insertions during the second and third scrams was the amount which one would expect for the amount of volume made available by the drain.

MR. WARD: On the fourth scram, did the rods go all the way in?

MR. RUBIN: They went all the way in. And I think if you would calculate how much volume drained out, given the amount of time that the operator was draining, there was more than was necessary to get the amount of positions that were left to be inserted.

MR. WARD: So it is a pretty good correlation, then.

MR. RUBIN: Yes, I think so.

Using the same approach and logic, one could infer from the 20 positions average east side control rod drive insertion that during the first scram only .35 -- and again, one would be looking at this figure --

(Slide.)

Using the same approach and logic, one would infer that, from the 20 positions average east-side control rod drive insertion, that during the first scram only .35 gallons of free volume per drive was available in the east

SDV header on the first scram. Only 33 gallons out of 300 was available for the first scram. The east header was virtually full of water prior to that scram.

There's one final bit of evidence about that, and that is the time it took to initiate the high level switches in the scram instrument volume. It took about 19 seconds to raise the level up to that 50 gallon elevation on Browns Ferry on that day. Normally it took 42 to 54 seconds, based on previous data. So one can conclude from the 19 seconds elapsed time that the east SDV was almost already full of water at the time of the first manual scram.

(Slide.)

And hence, from some analytical viewpoint we could conclude that the cause of the east side rod motion is best explained on the basis of an almost full east SDV header prior to the first scram.

(Slide.)

Well, how is that possible, for water to accumulate in the SDV header and not trip the scram instrument volume level switches? To help answer this question, let's look at a more precise SDV system layout an consider its hydraulic characteristics.

(Slide.)

As shown in this SDV system isometric sketch, the 300-gallon east and 300-gallon west SDV volume headers are actually composed of cross-connected six-inch diameter pipes, and the long pipes are a total of six inches over the length. The high end of each header is vented through a cross-connected one-inch vent line through a normally open one-inch vent valve.

The vent valve line is routed down to and sealed into a four-inch drain line of the clean rad waste drain system. The low end of the east and west headers are drained by two-inch drain lines into a 50-gallon instrument tank which is physically located close to the west header.

These drain lines have a total drop of about one foot, seven inches, over the length between the headers and the point where the line connects with the instrument volume tank. The drain line from the SDV header drops this one foot, seven inches, over a distance of approximately 150 feet, or half the length of a football field. The west header drain line is about 20 feet long, however.

The instrument volume tank into which these drain lines feed has the four float-type level switches to initiate scram. The switches are located at a height of eight feet from the bottom of the tank. Two of the switches, for control room alarm and control rod withdrawal, are located at low levels.

The instrument tank in turn is drained at the bottom by one two-inch drain line through a normally open drain valve, into the same reactor building clean rad waste drain system line.

Now that's what it looks like. We still don't know what caused water to accumulate in the east SDV header with no automatic scram. Suffice it to say that people looked for a lot of causes and nothing conclusive about the specific cause was found.

Rather, I would like to talk about the hydraulic characteristics of this system and its vulnerabilities.

(Slide.)

MR. LIPINSKI: Before you take that up, the height is shown as eight inches. That's eight feet. And what is the diameter of the tank?

MR. RUBIN: Excuse me? The instrument tank is a 12 inch in diameter tank, which is somewhat longer, approximately eight feet-plus long.

MR. LIPINSKI: Okay, thank you.

MR. RUBIN: Two types of drain tests were performed at Browns Ferry immediately after the event, one in which the SDV drain system vent and drain valves were opened, simulating normal free drainage of the system, while the other test involved draining with the header vent valves closed, thereby simulating a blocked path.

For the normal drainage test -- and I have shown a figure looking into the system made of glass -- the entire system was first filled with room temperature water with the vent valves open, as shown in the figure. At time zero the instrument volume was opened and both headers allowed to drain simultaneously.

(Slide.)

Still looking into the glass system, after nine and a half minutes the west header was empty and the 50-gallon auto-scram level cleared. 45 seconds later --

(Slide.)

-- the 25-gallon level switch cleared.

(Slide.)

Then after 11 minutes, 20 seconds, the 3-gallon level switch cleared.

Finally, after 25 minutes had elapsed, the east header finally emptied. I don't have a slide showing that. Based on the times involved -- and the idea is that this tank is dropping down a lot faster than that is emptying -- based on the times and the volumes involved, we can conclude that the drain rate of the west header is about 35 gpm and the other one is only about 11.6 gpm, while the average drain rate of the instrument volume, based on the rate of clearing of the instrument switches, is about 24.5 gpm.

But this drain rate is with the east SDV header still draining into the instrument volume at an average of 11.6 gpm. That is, at Browns Ferry the instrument volume drains 24.5 gpm faster than the east header drains.

Okay. I don't have any more slides on the test. But with regard to the block vent simulation test, the drain rates were in the range of .6 to about 3 gallons per minute out of the headers when one considered no free venting of the system, which is to say if you have blocked vents water will tend to hold up.

(Slide.)

MR. BUCK: What did you say the drain rate was on the west vent?

MR. RUBIN: It's in the neighborhood of 35 gallons per minute.

MR. WARD: What was the time to the first level sensor clearing? You said it, but I don't remember.

MR. RUBIN: After nine and a half minutes from time zero, the west header was empty and the 50-gallon auto-scram switch cleared. So basically all the water had drained out of the west header at nine and a half minutes, and it was at that point, the level was dropping pretty fast in the instrument, and it wasn't doing much in the east header.

(Slide.)

Well, what does this review of the SDV system basically and its characteristics tell us about the problems with the system? Already I have given you one, which is that we believe that the water was the cause of the Browns Ferry event.

The findings with regard to our studies is that one can conclude from the drain tests that the Browns Ferry scram instrument volume high-level scram function did not and still does not provide protection against accumulation of water in the east scram discharge volume header, even for normal venting and draining of that header. And that can be seen from the drain test.

With the relative drain characteristics of the header and the instrument volume, we can see that if we were to leak into the SDV, the east SDV, faster than the 11.6, water would start to accumulate and fail the east header. And at the same time, the water draining out of the east header at 11.6 gpm will never accumulate in the instrument volume, since that has got a big hole in it. It drains at 35 gpm.

This process with time would result in water filling the east header without an automatic scram ever occurring.

MR. WARD: You wouldn't get an automatic scram, but you would get an indication.

MR. RUBIN: That's not clear, either, because of if one looks closely at the hydraulics involved, you can explain it on a hydraulic head turn, okay. The instrument high volume is a high cylindrical tank and the 50-gallon switch is located eight feet above the volume of the tank. Therefore you have to build up a head of eight feet in the tank before you're going to get those level switches to actuate.

Now, if the drain line from the instrument volume to the clean rad wastes is relatively short, which it is at Browns Ferry, the an eight-foot driving head would result in a fairly rapid drain rate, which we saw.

On the other hand, the SDV header is a horizontal pipe, essentially, with a very small slope. And even when filled, the maximum head of water that can be developed above the SDV drain is approximately two and a half feet. Thus, with the relatively short drain line between the SDV and the instrument volume, the flow rate in this line for even the west SDV would be suspect.

In other words, just looking at the heads and the resistance to flow, one could probably conclude that you don't have protection on the west side, either.

MR. BUCK: Is that two and a half feet from --

MR. RUBIN: To answer your question, because of the elevation of the alarms in the rod withdrawal blocks, I'm not sure what the height is. But it wasn't clear to us that you would develop the proper head, based on comparing it with the head of the scram discharge volume to instrument volume height.

MR. BUCK: You said the head was two and a half feet. From where to where, can you show me that, please?

(Slide.)

MR. RUBIN: Basically, the two and a half feet would be the distance from the very top of the inner diameter of the high point of the header to the point in the tank where the drain line from that header intersects this. So you're really talking about at this point two and a half feet of driving head.

At the same time, you have to develop about eight feet of driving head in the instrument volume to get those things. It's just not in the cards that you're going to be able to hydraulically get those instruments to trip, with water coming into the SDV system greater than the drain rate.

The only way the system works is if you were to plug this line right here, and then water will start backing up this way. This system works fine for a plug right here. But under normal, unplugged vents and drains in this system, the basic hydraulics are such that you will never get those switches to actuate.

VOICE: The specification calls for a slope of one eighth of an inch per foot, and we find that most of the plants met that most of the plants met that eighth of an inch and nothing much more than that. That's why there's not very much elevation between the high point and the low point.

MR. BUCK: Is that also true on the west bank as well?

VOICE: Yes.

MR. RUBIN: So this resistance is the same as this resistance, and you've got a two and a half foot driving head here and you've still got to develop an eight foot head there to get the switches to actuate.

So if one makes the assumption these are the same resistances, you won't get protection on this side, either, for water filling the west header.

MR. WARD: But the water has to be coming in from the drives or something.

MR. RUBIN: Well, presumably through scram valves, the scram outlet valves leaking, or any other sources of water in the system, including there are some flush lines in the system.

In other words, when one looks at sources of water going into the SDV tanks, the instruments don't help. If one considers water backing up in some way, the instruments are fine. Those are, I believe, kind of the less likely things to worry about.

There are kind of disappointing hydraulics in that system. Okay.

(Slide.)

The third item as far as our findings, based on the drain rate characteristics of the system, in which for instance, like Browns Ferry, which has one SDV tank which normally drains significantly slower than the instrument volume, it's possible to completely disable the protection provided by the high level scram for both the east and west headers by postulating a blockage in the faster-draining SDV tank.

There is perhaps some hope, is what I'm saying, that if both of them are filling and draining, then the combined drain rates will be faster than the instrument volume is draining, so you will get a buildup of water in the instrument volume.

But if you plug the faster-draining one and get very little contribution from it, then the combined draining rates won't be enough to fill up the instrument volume.

Okay, what other things can we conclude? With the current scram discharge volume design, a blockage in the SDV vent or drain path can cause water to accumulate and at the same time disable the protection function. That's kind of also disappointing.

The only case where that is not true is if one were to again postulate a blockage here, in which that would result in water accumulating up this way, and you wouldn't have disabled these instruments by preventing water from accumulating in the tank before they filled up this tank.

(Slide.)

But if one puts a blockage here, you fill up the tank, then you have also blinded these instruments. So you cause the problem and you disable the equipment that is supposed to protect you against the problem from ever happening in the first place, with these kinds of drains and vent lines.

Okay, the current scram -- excuse me, let me go back to my findings.

(Slide.)

Am I talking fast enough?

The current scram discharge volume, item 5 here, instrument volume results in the automatic high-level scram safety function being dependent on the non-safety-related reactor building clean rad waste drain system. For the scram instrument volume, the high-level scram switches to actuate, you have got to accumulate water in the instrument volume.

For water to accumulate there, if you have any chance of accumulating water, you've got to have a good venting of the system. Venting in turn is controlled by what's downstream of that vent line, which is the clean rad waste drain system.

Improper venting from the SDV can sharply and totally prevent water from draining into the SDV from this test. So one could conclude that the operability, you might say, of the level instruments, the safety instruments, depends on good venting of the clean rad waste drain system, which is a non-safety system.

Okay. What about the sources of water and holdup mechanisms? If one looks at the system, you could probably come up with a dozen ways to hold up water in there and a few ways you can get water in there.

Possibly sources of water are from the previous scram, multiple scram outlet valve leakage, injection from SDV flush lines. I didn't show it on any figures, but there are small lines on these headers which allow them to be flushed to clean them out of high radiation. And that's a potential water source.

The mechanisms to hold the water up there could be a blockage in the vent piping, coupled with a dip in the drain piping; a plugged SDV into SIV drain lines; or a closed vent valve; the vacuuming effects or siphoning effects of the vent line coming down to the floor, and so on.

So the point is, I don't know exactly which one it was that caused Browns Ferry, but there are enough of them there to be of concern.

MR. MATHIS: Stuart, before you go on, when was the previous scram?

MR. RUBIN: It was several weeks prior, I believe. I don't know exactly the date. I don't think it was -- it was also in early June, was it not? Bill, do you know?

MR. MILLS: We have all that information. I think it was about a month.

MR. MATHIS: That long, and you can hypothesize that there is enough leakage somewhere that you assume things were cleaned up from the previous scram and had apparently worked all right, and there's been something drastically changed in that interval of time? That gives me some problems, that we don't know or have any idea of what it may be.

MR. RUBIN: Well, rather than losing sleep over the specific root cause of the event --

MR. MATHIS: The root cause is the thing I get concerned about.

MR. MICHAELSON: If you like, I can give you some speculation. There are a number of ways it could have gotten there.

Perhaps a good speculation is the presence of hot water in the CRD system. It drains hot water from a number of components in the building. That hot water, of course, is flashing a little bit. We'll call it the vapor.

The vapor now enters up into these relatively cooler headers and slowly but surely condenses, and it keeps on condensing. What happens then is that the condensate runs down these very small slope lines, and it is also rusting away the carbon steel in an ideal rust environment.

So it's forming sludge and building up a little dam somewhere. It doesn't take much of a dam, of course, to hold back a couple of feet of water. In this case, if you're forming a vacuum behind the water, and of course you're tending to pull a little vacuum by the condensation process.

So it's very easy, with a small blockage, so that you don't get any backflow of air from the instrument volume to support that column of water.

But there are a lot of other ways. But that's one way in which you could insidiously fill the system over a period of about a month and get what you're looking for. There are a lot of other ways, but this looks good, because we don't find the high leakage rates we would otherwise look for. We don't find any other good sources.

The previous scram clearly would not be the source over this period of time. So indeed, there is a very effective blockage somewhere. But a slight low point is all it takes to make the condensation model work.

MR. MATHIS: But I consider your analysis, when you talk about small amounts of flashing and so forth -- I would think that would take care of any small amount of rust blockage or something of that nature. I mean, I just have trouble with it.

MR. MICHAELSON: It's not coming in very quickly, so it makes it easier to build up dams. Even a low point in the pipe will form a vapor sealage on the discharge side, and as long as you're getting vapor in through the vent line then you can accumulate the water. And if you're pulling even a very slight vacuum, you can support that water column. Two and a half feet of water is not very much vacuum.

MR. MATHIS: It doesn't take much flashing to move things.

MR. MICHAELSON: But keep in mind, it's not occurring in the line; it's occurring in the drain system and the steam is coming up the drain system into the headers and condensing there. And there is no violent or rapid flow of water down the drain line. It's just kind of trickling down there.

MR. LIPINSKI: Were these cut in the middle, though, and examined in both directions?

MR. MICHAELSON: They were after the event. But as soon as you scram, you're going to blow all this up.

Obviously, you can't hold -- well, it wasn't 1,000 pounds, but it must be approaching that, because the tank appeared to be almost full to begin with to make any of these models work. So the pressure across the plug had to be very large.

MR. LIPINSKI: What was found when the lines were cut?

MR. MICHAELSON: They pulled out plenty of sludge and so forth. But you've got to keep in mind, this is connected to an open system. So every time the system backs up, you're going to find a lot of sludge anyhow.

MR. LIPINSKI: The lines were not clean. They were dirty.

MR. MICHAELSON: Oh, yes, very definitely. This is carbon steel and it rusts, and of course that's a very important question here, too.

It's just speculation.

MR. RUBIN: We and AEOD beat our heads for several days trying to convince each other of what each other felt the cause was, and after a while we concluded that that really wasn't the important question. It was simply to build a case that the system has too many vulnerabilities, too many possible things that can go wrong, so we should change the system irrespective of finding the specific one.

Okay. The next one is the Browns Ferry 3 event and some other previous operating experiences led us to believe that the float type water level monitoring instruments had a significant degree of unreliability. For example, following plant shutdown, as Bill mentioned, the three gallon and 25 gallon switches were found to be inoperable at the same time.

After the instruments were flushed of residue, the switches operated okay. Additionally, inspections at Brunswick Unit 1 following a reactor scram on November 14, 1979, revealed in inoperable alarm in rod block level switches due to bent rods.

Also, Bill mentioned other inspections at Hatch 1 on June 13th, 1979, that found two high level scram switches inoperable due to bent float binding against the inside of the float chamber.

These experiences led us to conclude that there was a significant degree of unreliability of float-type level switches resulting from various common causes.

Next we found that, with the current BWR reactor protection system logic, the presence of certain automatic scram conditions precludes SDV draining, that is, the scram reset, to permit reset. So if we had an MSIV closure, that would have initiated the Browns Ferry event. That trip condition is not readily bypassed -- cannot be bypassed and shut down for refueling modes, which is the modes you have to be in to reset the scram.

So you would not have had a second shot to rescram for certain trip conditions. And there are perhaps a half a dozen of these, important ones, in the BWR RPS logic.

Sort of along with that, the next item is that if a scram condition exists which cannot be bypassed in shutdown or refueling mode, then the failure to close either one of the SDV vent or drain line valves can result in an unisolatable blowdown of reactor coolant outside primary containment.

As you recall, during reactor scram these valves are supposed to close to limit and contain the water exhausted from the reactor. If one of them fails to close, it's just going to be discharged into the clean rad waste system, which is outside primary containment in the reactor building.

The only hope you would have of isolating the system from blowdown is reclosing the scram valve switches upstream of that open valve. But you can't do that in all cases, because you cannot reset RPS for about half a dozen trip conditions. So there is a worry there about a valve sticking open.

And finally, we reviewed the emergency operating instructions or procedures up at Browns Ferry when we visited there, and we didn't really see anything in the way of emergency procedures or operator guidance following a partial or complete scram failure. This is completely consistent with the bulletin requirements that said that you're going to have to develop such procedures and provide training.

I would not call this peer review, even though I&E and AEOD were saying the same thing. It was basically, we were working over here and really weren't conscious of exactly everything they were working on. It was basically truly independent belief that there should be emergency procedures for scram failure events, sort of like the presidential commission and Rogovin Commission and all the other ones saying the same thing. That just shows that everyone is consistent and it's not really peer review.

(Slide.)

I say that because there has been some question about what motives AEOD had when it put that finding in its report after the bulletin had already said it was going to be required or there was a deficiency there.

Recommendations. Now that we have seen there are certain vulnerabilities, you might say, in the SDV system, which is clearly important to scram capability, what shall we do? Well, the first thing we thought was that the operability of the scram instruments should be independent of any venting or draining type phenomenon. That is to say, we believe that to the acceptable configuration -- it would be to place the instrument volume tank right up under the SDV tank, which would permit spillage, you might say, of water from the SDV into the instrument volume and you wouldn't be depending on any venting or draining through small lines to get that accumulation into the tank where the instruments are.

We also recommended that there be two tanks, one on each header, to allow for that kind of arrangement. It turns out that that recommendation is consistent with what had been installed on the later BWR plants, the most recent plants.

There was a change in the design philosophy or requirements among the last several plants. So I believe plants like Hatch 2 and Brunswick already have that, are operating with that. But most of the older plants, in fact most of the operating BWR's, have the Browns Ferry type arrangement.

MR. CATTON: Is there any reason not to discharge directly to the suppression pool?

MR. RUBIN: I think bill explained that pretty well. There is a need basically to contain and limit the amount of water exhausted during a scram for at least a couple of reasons.

One is that you want to be able to limit the amount of water that goes past the drive seals. If you just would continue to allow water to go past those seals, you could have seal damage, and after each scram you would have to spend two months rebuilding your seals. So you want to provide a pretty reliable limited volume that you will get discharged into during a scram.

Also, from the point of view of a LOCA, you might say a system with a couple of valves that have to close provides reactor coolant pressure boundary protection, and therefore would limit the water discharged during a scram. If you had relief into the suppression pool, there might be additional concerns in these areas.

Another problem is that the reactor water is not all that clean and you do not want to unnecessarily discharge primary water into the suppression pool, which you are trying to keep pretty clean because people have to work in there during outages and so forth. So you want to limit the amount of reactor water that would normally get in there from normal radiation dose purposes during maintenance and so forth.

Okay, where are we? Okay. With regard -- so that gives us the configuration that we thought we had to have to get rid of these vent and drain vulnerabilities.

The next thing that we thought, based on the recent operating experience where : couple of float-type switches were inoperable at the same time, we thought it would be wise to provide diverse type level sensing instruments for this uniquely important function, which is to protect against the loss of scram capability. And we suggested a few concepts, and that was basically that.

The third item here was, because of the concern that if one of the valves were to not close during a scram you could get into problems with an unisolatable blowdown outside primary containment if during a scram you could not close the scram outlet valves as an alternative to stop the blowdown. And that process itself has a lot of questions as to whether or not that would be successful, which goes beyond the RPS logic, and I will get into that at the end of the day.

So to protect against single active failures, given reactor blowdown outside primary containment, we thought redundant vent and drain isolation valves would be appropriate.

Emergency procedures. We recommended that emergency procedures be set in place at Browns Ferry and other plants totally consistent with the I&E bulletin requirementS.

And finally, we thought that consideration for improving the drain reliability of this new system that we were suggesting be set in place to reduce the number of challenges to the high level scram switches. In other words, even with the tanks underneath the headers, try to make the system drain fairly reliably so you never get water accumulated in those tanks in the first place and reduce the number of challenges in the instruments.

MR. LIPINSKI: How far does four go? Does that cover an ATWS? Number four up there, does that cover an ATWS or just partial failures?

MR. RUBIN: I think most of the staff's review as far as the equipment deficiencies, as far as ATWS goes, really relate to ATWS as caused in the SDV system. There are a lot of other ATWS possibilities.

MR. LIPINSKI: But four, because I can interpret that to -- if I take four in total, where both have failed to scram, that's an ATWS, okay?

MR. RUBIN: I thought you were talking about five, I'm sorry. Oh, certainly.

MR. LIPINSKI: So they are effectively having to consider ATWS at this point?

MR. RUBIN: Bill is planning to talk about that in a fair amount of detail later on today, about exactly what the procedures are now and why they are the way they are. So that we feel that we are in good shape as far as procedures go.

MR. LIPINSKI: Back in April, you became aware of it, because Dr. Catton and I toured the simulators and they gave a demonstration of an ATWS with two operators at the panels. We walked up to the BWR and asked for the same thing, and they said you can't have it.

MR. RUBIN: Well, I think operating experience might show that to be the case. One could argue whether or not Browns Ferry was an ATWS. We had "without scram," but I'm not sure we had it without transient. So it didn't happen yet.

But you're right. We found, after going through our procedures, we think that Browns Ferry was enough of an ATWS at least on the second part, to say let's get the procedures out there; knowing that the long-term modifications would take some time, at least get some human factors improvements in the picture.

(Slide.)

As far as conclusions of this part of my presentation, basically we concluded that the cause of the Browns Ferry event was water in the SDV system, which the whole world is saying now. The current scram capability protection system we believe is unacceptable, that is the configuration of the SDV system, its drainage characteristics, and its vulnerability to drain impediments, makes the current SDV system arrangement failure unacceptable, unreliable, nonfunctional, you might say.

The other point was that an unisolatable blowdown potentially exists outside containment if you fail a single valve and you cannot reset the RPS. And we concluded that there would have to be some modifications to the system to reduce the ATWS risk.

That completes my 15-minute talk, review of the Browns Ferry event and the scram system. If there are no questions, I am now scheduled to move right into another subject, which will be relatively brief.

MR. MATHIS: One question. You mentioned that the newer GE plants had changed their design. Was there any feedback to the older plants as a result of that change? There must have been a substantial reason for the change. Somebody must have been suspicious or something, that there was a potential problem there.

MR. RUBIN: That's an area that AEOD did not pursue. That's not to say that it's not worth pursuing. I think, though, that Vince Panciera did look into those questions.

MR. PANCIERA: We tried to pursue that same logic with GE. We were never able to pin down exactly why GE changed fromt the single IV design to the two IV design. The only thing we got is general statements that these were -- the newer design appears on Brunswick, on Hatch, and on Duane Arnold, and on the newer plants that are in the current licensing process. All other plants have the single IV design.

MR. LIPINSKI: I think if you check historically with ATWS, running for 12 years, each time the conversation came up with GE they became more sensitive, because this is the Achilles heel for their ATWS problem.

MR. PANCIERA: Yes, sir.

MR. RUBIN: That certainly might be something that ACRS consultants might look into.

Okay. Following our case study review of the Browns Ferry event, AEOD continued to investigate potential problem area and vulnerability of the BWR scram system. Our finding in LER's on a loss of air event at Browns Ferry sort of made a lightbulb over our heads to illuminate.

What I will be talking about basically to explain this issue is the requirements for control rod scram insertion. With degraded air on the scram outlet valves, control rod motion which one would expect with degraded air, with the same time with the SDV header in-lekage to the cracked-open scram valves would be doing to the SDV system, reflecting upon the SDV system drain rates, and then push through what the eventual hydraulic condition of the scram system would be after some time, comparing that with what other things might be going on in the plant in the way of disturbances created by the degraded air situation.

We will see that there is a lack of assurance that automatic protection will be timely, and so there is reliance on operator action to avoid possible evolving ATWS. We will touch upon some operating experience and give some conclusions.

(Slide.)

Okay, let me back up a bunch of slides.

(Slide.)

It might be helpful to look at this slide. To begin with, you may recall earlier I said that to achieve control rod insertion a minimum of about 550 psi must be applied across the index tube drive piston to cause a scram. As differential pressure decreases from this volume, a greater percentage of the under-piston fluid will simply act as piston seal bypass flow, with a lessening percentage actually going into moving the piston.

The drive-in blade, including the effect of the restraining collet fingers, do create some resistance to rod motion, mechanical resistance to rod motion. So that with decreasing the differential pressure we approach the situation of under-piston cooling flow, in which all flow bypasses the drive piston with no rod motion at all.

So if the differential pressure is large enough, we will get fluid flow, but very little if any rod motion.

(Slide.)

Now, consider the effects of degraded air on the scram outlet valves. Here's a picture which tries to integrate it. If the control air pressure were to drop in the system to somewhat below the normal 40 to 45 psi opening pressure of the scram outlet valves, shown here in the single drives, the scram outlet valves will begin to crack open, acting as throttling valves.

A large differential pressure will exist across the valve, with small differential pressure drops due to limited fluid flow upstream of the valve. Across the drive piston, we get into a seal cooling situation, a flow past the CRD seals to the drive motion.

However, in this case the flow past the seals is going into the SDV headers. According to GE, from one to two gallons per minute could occur without significant rod motion for this cracked-open scram outlet case. The actual amount of leakage would depend on the condition of the seals.

Thus the cumulative leak rate of 93 of these things on either drain could be in excess of the drain rate of those headers. So water would start to accumulate in the headers as a result of this degraded air situation.

At the same time, as shown on the figure, the rapid drain rate of the instrument volume -- because of that, the water level will build up there slowly, if at all. If left unattended, say within a minute or two depending on the degraded air situation, one would find that the CRD's would perhaps have moved slightly, if at all, up into the core.

The SDV headers would be becoming full and no automatic scram would occur, since the water level did not rise high enough in the instrument volume. We would be approaching a "can't-scram" situation.

At the same time, the degraded air control supply would also be adversely affecting regulating valves, for example in the power conversion system, for example the feedwater system. Thus a plant transient such as water level drop in the reactor could also be initiated, eventually leading to a need to scram.

Considered all together, unacted-upon, the plant within a few minutes could be evolving by itself toward an ATWS because of the degraded air condition. Automatic protective action could very well come too late because of the drain characteristics of the SDV system.

Well, what do we do? Obviously, timely and appropriate operator action in as little as two minutes would be required as a result of this issue. The adequacy of the human factor for this event was closely examined.

With regard to -- that basically is the scenario. With regard to previous operating experience, there have been numerous degraded or lost air events in operating BWR's. All of them obviously were successfully terminated, in some cases by the operator manually scramming the reactor and others by some automatic trip of a reactor.

Although little good data was available for most of these events, one of our analyses of Browns Ferry 1 on November 24th, 1976, indicated that the SDV was partially full when the automatic scram occurred. We believe that a slightly different air pressure history may provide a different result, however.

The conclusion, therefore: As a result of this study, AEOD concluded that the degraded air scenario had important safety issues involved and thus should be immediately addressed and resolved by both the NRC staff and the BWR Licensees. And we issued a memo on this subject. Vince told you when.

MR. WARD: Could you go back and explain the two lower level switches there?

MR. RUBIN: This is kind of like a perhaps situation. Water level has risen to the point where we have activated the SDV system, not field switch and the rod block monitor switch just for the sake of argument, and have not gotten to the protective switches. So that's all I'm trying to show there.

MR. WARD: But I guess this situation could exist with the level below those two.

MR. RUBIN: There is no analysis to say that's exactly where the water level is, but simply based on the drain characteristics of the SDV system, where this thing has a big hole in it and a very narrow, constricted flow path, we wouldn't expect that water level would rise up in the instrument volume very quickly and in a timely way to initiate a scram before water accumulated in the headers, which have to be free to accept water discharged.

MR. LIPINSKI: From what you said earlier, it would not rise. You would drain faster from the instrument volume.

MR. RUBIN: Of course, here we have the contribution of two at the same time, and there is the question of the contribution of two headers draining into that header when compared to the drain rate of the instrument volume.

It's not clear what the level rise buildup would be. One would have to perform this kind of test on the system to see if you got those switches to actuate before you accumulated too much water in the system. Those kinds of tests were not run at Browns Ferry.

The tests were run, the systems were filled, and the plugs pulled to see what would happen. There's another test you could run, just pouring water in here and watching it fill and then see how water might accumulate down here. That's a different hydraulic model.

MR. LIPINSKI: But you had identified a common mode failure that leads to an ATWS, and there may be a time window to eventually get to the PBS. But in the mean time you're vulnerable.

MR. RUBIN: Yes. The switches may actuate too late. In other words, you may have filled to the point where the rods won't go in because there isn't enough available free volume by the time the level rose in the instrument volume to actuate the scram.

MR. CATTON: Have the hydraulic calculations been made?

MR. RUBIN: Well, there was a lot of hand-waving arguments. Basically, I don't think I ever saw any hydraulic calculations.

The thrust of the GE arguments was that the manual scram has always been timely, the operators know what they're doing, they are trained to provide that manual protection should the loss of degraded air occur, and so why worry about it.

MR. CATTON: So no calculations are made. I find that really very upsetting, for such a simple hydraulic system, that no calculations were made. As a matter of fact, I find it hard to believevw.

MR. MICHAELSON: Let me comment on that. I am inclined to agree with you, all right, except that these are not maybe as simple a calculation as you might envision. For one thing, what's the condition of the piping interior? We know it's extremely dirty and whatever. So what type of coefficients are you going to use?

It's very plant-specific, you know, particular arrangements. So the test data was probably the best, although it was not a true simulation of this particular kind of a possibility.

But it doesn't take much looking to realize that for a certain combination of circumstances the condition indeed would result in a full discharge volume before you got the automatic scram.

MR. CATTON: But those are straight runs of pipe. That's a tank. Given the head, you can make the calculation. You can even ask yourself, what kind of crudding-up of that line do I have to have.

MR. MICHAELSON: I thought you were trying to do the dynamic calculation. For a while it's an open channel flow. It just doesn't seem like a worthwhile exercise, if you want to do it precisely, when you have enough test data to show how these things really work.

And then you get into the question: What's the condition of the sewer system that it's going into, the drain system, since it's closed at both ends? Is it full of water at the time, for instance? Is the four-inch drain that you're channeling into full?

And that affects all those answers, because it is not a self-vented system necessarily. It's venting into the same pipe you're draining into. And if that pipe is full, it creates an entirely dynamic condition.

MR. CATTON: I would sue my plumber if he did that.

MR. MICHAELSON: Right, you would not let that happen. But that's what this is.

MR. LIPINSKI: I see a direct correlation between this and TMI-2. The system is not behaving like it should because the rods aren't moving, and I'll bet those operators stood around and scratched their heads, but fortunately got their rods down before any damage took place.

MR. RUBIN: Well, if you just look at the system and don't know much about hydraulics, you say, well, water flows downhill and water should accumulate at the bottom before it gets to the top. So you have to get into some hydraulic thought process.

MR. LIPINSKI: The thought I'm trying to make is the hydraulic process is --

MR. RUBIN: Exactly, there are fundamental deficiencies in the system, and they are serious.

And by the way, the recommendation that we made on our initial report, which is now being pursued and being implemented through NRR, as well as based on our own independent assessment, will change the system in a way which puts the instrument tanks directly under those two volume headers, and so you don't have that drain rate problem giving you the problem I just described.

Water will be accumulating quickly in the instrument volume tank, even with degraded air, and you should get activation of the scram switches before water accumulates in the SDV header tanks.

MR. MICHAELSON: There is one more complication before he gets into it too far.

(Laughter.)

MR. MICHAELSON: You have to look at the big picture. All the drain lines go down to a seal tank in the basement. There is an unknown state of all these drain lines, is what I am trying to emphasize, and we're venting into the same line that we're draining into.

It's very difficult to predict on a given date, depending on what else is in the system at the same time, as to what the drain rate would be out of your instrument tank. However, we can predict a little bit better how fast it's going into the discharge volume. So it isn't quite that simple a problem.

If it were an open atmosphere and draining into a sink, it would be extremely simple.

MR. CATTON: It's my understanding that the testing of this system, the functional testing before acceptance by TVA, did not include any hydraulic testing. That's my understanding, that they test the circuits and see the level switches work, but they really don't test the system as designed.

Have there been any changes as a result of that, that you do a complete test?

MR. RUBIN: Well, I think Vince can answer that, and I will let him.

MR. PANCIERA: Your understanding is correct. There was no preoperational test done on this system.

MR. CATTON: Other than the electrical?

MR. RUBIN: That's not precisely accurate. There was some data that we found at Browns Ferry which basically -- during pre-op testing they had some scrams and they opened the vent and drain valves during RPS, and somebody made a note of the time it took to clear the high level switches. That was simply to confirm that the thing drained, there were no plugs in the system.

MR. MICHAELSON: Let's not lose sight of the fact that all you have to do is be sure you've got an empty pipe. So what kind of test would you propose to make sure you have an empty pipe?

MR. CATTON: Well, if you've got an electrical-hydraulic instrument -- and it was my understanding that the electrical part, but not the hydraulic, was tested.

MR. MICHAELSON: I'm not sure I agree with that. We filled the tank and watched the instruments, I think, but I'm not quite positive on that. However, keep in mind the safety function is simply to be sure you've got an empty tank. So what kind of test do you want to do, you know, to show that the empty tank would work?

Well, we scrammed and we scrammed a lot of times, and the empty tank works. But if it isn't empty, then we've got a real problem. But I don't know of any preoperational testing in that respect unless you had had the foresight to realize all of this. That, of course, clearly there are tests you could do.

MR. CATTON: We can continue the debate or the Chairman will cut us off.

MR. MATHIS: I'm going to cut you off, because Ed Jordan wants to say something.

MR. JORDAN: There was inadequate preop testing of that system under all of the possible combinations of conditions. There were preoperational tests done of this facility, as well as the other GE facilities. But no one had the foresight to test it under the various conditions that it could encounter in operation, and I think that is an overall deficiency.

We really don't test all those combinations. And this design sort of evolved from plant to plant. There are significant differences that Vince and Bill can describe in detail, that were not individually tested as the evolution went.

MR. MATHIS: Ed, in that connection, I just got some notes here, and I can't tell you where I accumulated these, but I put this under the heading of quality assurance on construction. And in one case a valve was installed backwards, and this apparently had gone on for quite a while before it was detected.

Solenoid coils and relays were not properly installed. This is something that should be picked up, I would think. At least electrical ATP's that have been run, as Ivan indicated, apparently have not been that thorough, either.

MR. JORDAN: Some if those problems apparently occurred subsequently in plant life, as opposed to initial installation, during subsequent maintenance. And it continues to point up the problem of not only preop testing, but testing after maintenance in a comprehensive way.

Those deficiencies were found as a result of testing that the utilities did based on the lessons learned from this particular event. So those were out of the bulletin responses.

MR. WARD: No one seems to pay much attention to those bottom two level sensors. All the analyses are always run when it fills up. There's probably some simple explanation for that. Could you give it?

MR. RUBIN: Well, they are not tied into the reactor protection system. So you don't have assured actions or preventive measures. You rely on the operator to do something.

It's simply to tell the operator that --as far as the instrument volume not drained alarm, it simply tells the operator that water is starting to accumulate in the system and he should perhaps investigate why that is so.

The next one up, at the 25-gallon level, is a rod block inhibiter. If the guy is pulling rods out of the core during a startup, should that switch activate, he will be prevented from pulling any more rods. So there is a hard-wired circuit in that one.

MR. WARD: Does he get an indication of that in the control room?

MR. RUBIN: Oh, yes. There are annunciators that tell him these things are happening.

But as far as technical specification requirements on the operability of those particular instruments, there are none. They can be inoperable -- I don't believe that there are required surveillances on those particular instruments. Is that not correct, Bill?

MR. MILLS: Previously, there were no requirements on those switches. But we saw on Vince's first slide the bulletin that went out before the Browns Ferry event, which required they do surveillance on those two switches.

So the requirements are there in the bulletin, in sample tech specs, when the bulletin was sent out later. I don't know the status on the tech spec itself, but the requirements are there in the bulletin. And the tech specs are being implemented that would also pick that up.

MR. WARD: Did I understand him, in the June 1980 incident those switches were inoperable?

MR. MILLS: They operated during the incident. But after the event was over, when they did the callibration, then they did not operate. There was no indication that their inoperability contributed to it.

MR. WARD: Thank you.

MR. PITTMAN: I think there is another implication we can imply from those switches. The fact they are singular and non-redundant, they were by design not intended to be part of the safety system.

MR. RUBIN: It's simply there to provide a warning, of whatever reliability we can imagine, for a system that had not been surveilled and operability checked. That's about it at this point.

MR. BUCK: There really isn't any way you could tell what the level is. It is just between what levels the water would exist, given that the switches were working properly.

MR. RUBIN: That's right. It's a go-no go. It's simply activated or not activated condition.

MR. BUCK: Was any consideration given to a gauge type of mechanism for detection?

MR. RUBIN: Is this in the sense of our recommendations?

MR. BUCK: Yes.

MR. RUBIN: We have never looked at a need to know the precise height of water. I think it's more important that you have an instrument that takes action when it reaches a height that everyone agrees upon is a height that you don't want to go any higher. So you don't need to know the exact height. So a switch without a gauge is, I think, adequate.

MR. BUCK: Unless you want to know a rate.

MR. RUBIN: What I mean is, if you are talking about a protection system -- if you talk about rate, you're talking about the operator looking at it, and then you get into the human factors aspects of protection. And I don't think you want to be occupying the time of the operator looking at rates necessarily in a protective function.

MR. CATTON: Possibly it's better for it to be a surprise?

MR. BUCK: That's what I was thinking.

MR. JORDAN: The problem is the instrument volume was looking at the wrong water, anyway. You're really concerned about the water in the discharge volume, and there was no measure of that water. So you were diverted by looking at those level switches and they were meaningless.

MR. CATTON: But that's because it was a bad design.

MR. JORDAN: That's correct.

MR. RUBIN: At Three Mile Island the level in the pressurizer being an untrue, quote, unquote, indicator of water over the core.

MR. MATHIS: Anything more, Stuart?

MR. RUBIN: No, that's it for now.

MR. MATHIS: I'm going to suggest a slight change in schedule. I understand that we have somebody coming down at 1:00 o'clock from the ATWS calculation.

MR. PANCIERA: Yes, one of the people will be here.

MR. MATHIS: Well, Vince, would it be all right then if we break for lunch now and take up the ATWS calculations at 1:00 o'clock? And then we will go back and pick up the schedule as you have it laid out?

MR. PANCIERA: That would be fine. We put the ATWS calculation in at 1:00 because of convenience.

MR. MATHIS: I don't want to disrupt that. If it isn't going to disrupt any of your other activities, we will adjourn and reconvene at 1:00.

(Whereupon, at 11:55 a.m., the meeting was recessed, to reconvene at 1:00 p.m. the same day.)

AFTERNOON SESSION

(1:00 p.m.)

MR. MATHIS: The meeting will resume.

We start out now on the ATWS calculations. Mr. Graves.

(Slide.)

MR. GRAVES: I am here in place of Dr. Spies. My name is Charles Graves, and the subject of my presentation is BWR plant transient analysis conducted at Brookhaven National Laboratory.

In recent years the NRC, in conjunction with technical assistance from Brookhaven, has developed a reasonable capability of analyzing the consequences of a full ATWS. This capability has been used before in calculations for selected ATWS events in BWR's. These calculations were only for a BWR-4 type plant.

The calculations have been used to improve the staff's understanding of consequences of ATWS events and to formulate the staff position with respect to ATWS which is now under consideration.

As a result of Three Mile Island, there has been a recent staff interest in the development of proper procedures to give appropriate guidance to an operator in the case of various transient events, including ATWS. Finally, we had the recent Browns Ferry 3, where there was a partial scram. We had not analyzed such an event before, and as a result asked Brookhaven to conduct some calculations of the consequencies.

I would like now to summarize the Brookhaven program and discuss briefly some of the consequences of an ATWS event that they analyzed, and talk about some of the other transient studies which will be conducted in the future at Brookhaven.

(Slide.)

The first slide is concerned with the program scope at Brookhaven, and this scope is for the program to be conducted in fiscal '81 and fiscal '82.

First of all, they were given the job of modeling a BWR-4 partial ATWS event, such as occurred at Browns Ferry. This was done for the case of inadvertent MSIV closure events.

The second part of the program scope is for them to prepare input tapes, and that's what I mean generic models, of typical BWR-3, 5 and 6 plants for ATWS and other transient consequences. As I mentioned before, at the present time they have done this for the BWR-4, which would be for the Peach Bottom plant. They will have to expand this to include the other models.

Finally, under the contract with Brookhaven they will be performing audit analyses of a series of loss of feedwater events. These are events which the staff asked General Electric to analyze. The results of the GE calculations are reported in NEDO-24708.

(Slide.)

MR. KERR: Excuse me. I'm not sure I understood your comment concerning the meaning of "generic plant models." You said something about that meant preparing input tapes. That to me means a tape that has data, that sets out boundary conditions. But that isn't what you meant?

MR. GRAVES: No. What I meant, for example, is the dimensions, flow path resistances, characteristics, and things of that nature. In other words, right now, for example, they have this set up for Peach Bottom and analyzing the Peach Bottom event.

MR. KERR: Who developed the plant model they are using?

MR. GRAVES: I do not believe Brookhaven developed it. I believe it was done at Idaho. I'm not sure of the answer to that question, but I can find out for you.

MR. KERR: I would be interested to know who developed the model and what it is, or a report that you can refer me to. There probably is a report to which you could refer me.

MR. GRAVES: Yes, sir, there is a report. But I don't know the originator of it.

MR. KERR: Thank you.

MR. GRAVES: The main idea is to extend the capability to other plants.

MR. CATTON: What code are they using at Brookhaven?

MR. GRAVES: Right now they're using RELAP 3B, which was developed at Brookhaven, I believe around 1976, at the staff request. And I believe the first use of it was for ATWS calculations. There are other codes that we'll be talking about later, however. That is a their own line code.

MR. CATTON: It's also -- the state of the art has gone quite a bit beyond that.

MR. GRAVES: That's right.

MR. KERR: Are these calculations being done as best estimate or conservative, or can you comment on where in the spectrum of things?

MR. GRAVES: I think they are more like best estimate, to my knowledge. There are conservatisms in the choice of, for example, on the heat exchangers, considering 104 percent of rated power as an initial condition. But these are --

MR. KERR: I guess what I really should have asked is whether the aim is to get a best estimate result or a conservative result.

MR. GRAVES: I think I would consider it best estimate, and guidance for procedures and understanding processes.

MR. KERR: Well, is Brookhaven being asked to develop best estimate results?

MR. GRAVES: Can you answer that question on best estimates?

VOICE: They are primarily best estimate.

MR. GRAVES: I think there is a mixture, however, in terms of things like heat exchangers, the maximum temperature, the temperature of the service water inlet, the temperature of the condensate, the suppression pool, for exampe.

MR. KERR: At this point I'm not interested in the details. I probably wouldn't understand all of them.

You are telling Brookhaven what to use?

MR. GRAVES: We haven't come to that point in the contract. The work on the generic plants will not be until later in the year, and I just joined the project, so I cannot say.

MR. KERR: So in a sense it's yet to be decided?

MR. GRAVES: That would be in 1982.

MR. KERR: Are the results of this to be used as guidance to operators?

MR. GRAVES: My reaction on Browns Ferry 3 and the ones they did with RELAP 3B is I think those calculations are very useful in understanding the event. In other words, they're talking about time for operator actions.

MR. KERR: I'm not making my question clear. Do you anticipate that the people who operate plants will do other calculations which they will use for instruction of operators, and these won't be used for that?

MR. GRAVES: I'm sure there are plants there would be calculations by GE, as in the past.

MR. KERR: These calculations are going to be done as an effort on the part of the NRC staff to establish independent capability?

MR. GRAVES: Yes, and also to be able to run problems, to try to understand the sequence of events, not just limiting conditions, but to understand what is happening and when.

MR. KERR: If that's the case, are you going to make an effort to compare your results to those of GE?

MR. GRAVES: I'm going to talk about the comparison in just a minute.

MR. KERR: Does that mean that you probably also are going to use the same input data?

MR. GRAVES: In terms of the calculations we have run in the past -- and I am going to mention this -- we used a mixture of GE data plus Brookhaven data.

MR. KERR: Okay. I will wait, then.

MR. GRAVES: If you would, please.

Now, as far as this slide is concerned, it's a discussion of program objectives and it is a repeat of some things we were discussing. We would like to have the capability to audit vendor/Licensee analyses. We would like to Brookhaven to be in a position to generate some calculations of plants other than BWR-4's. We would like to develop a better understanding of the processes, and this would help in the guidelines.

We would like to make independent audits and assessments of the safety features.

(Slide.)

I will try to answer some of your questions, Dr. Kerr, about the input data as we go along the best I can.

MR. KERR: Sure.

MR. GRAVES: Now with respect to Browns Ferry 3, it was a partial scram event. They were at the point, where the scram was initiated, with about 30 percent power. And in the first scram only about 76 rods went in.

I have people to back me up if I make a mistake, so I feel perfectly comfortable here.

As a result of the Browns Ferry 3 partial scram event, the staff asked General Electric to consider -- to run calculations on the consequences of this type of an event, not from the initial conditions for Browns Ferry but from initial conditions of rated power, 104 percent. The main steam isolation -- I'm sorry, I better get the slide up.

We asked GE to run the calculations simulating the Browns Ferry partial scram configuration, and we also asked them to run calculations simulating the case of one-half of the rods fully in and one-half of the rods fully out after an MSIV closure. Roughly, the conditions are that the partial scram event that simulates Browns Ferry, if it had initiated at 100 percent power, would have resulted in a semi-equilibrium power of 10 percent as you go into the event, wereas a half and half scram configuration would have given you a power of about 20 percent.

MR. LIPINSKI: Is that without the recirculation pump trip?

MR. GRAVES: I'll define the events as we go along. The event was MSIV closure, inadvertent, a scram fro the MSIV closure, which was partial scram.

The pressure goes up, and it assumes that the ATWS pump trip occurred at a pressure of about 1165 psia. So we have reached a condition early in the event where we have a scram, an RPT a few seconds after the scram, and then the main feedwater is still on for a short time after that. And when you are boiling off the plant with the MSIV's closed. You are charging off steam to the suppression pool and the vessel inventory is decreasing.

As a result of decreasing inventory, then, you would have reactor core isolation cooling system coming on at a low level system, level two, and high pressure coolant injection going on. This would raise the inventory and you would go through a cyclic process, which I could show later.

We had asked GE to analyze the consequences of this event. The consequences of real interest are not reactor coolant pressure. The reactor coolant pressure doesn't get very high. It's well below 110 percent design pressure of 1375.

The consequences of the event would primarily be the load to the suppression pool, and the question of whether the suppression pool temperature increases to the point where you would have dynamic loads resulting from the steam discharged from the safety relief valves which goes to the pool, to go from those pumps, that would occur at a high enough pool temperature to have excessive dynamic loads.

So the problem of interest was not the peak pressure of the reactor, but pool heatup, did the pool heat up high enough to give you unacceptable consequences.

MR. CATTON: How good is the model of the pool on things like stratification and circulation?

MR. GRAVES: As far as our calculations and GE's calculations and as far as I'm concerned, it's an extremely simple model. What we are calculating is the increase in the average pool temperature.

MR. CATTON: So you could be quite a bit off, then?

MR. GRAVES: I think I have a reasonable idea of what has been found so far. There are two types of pipes discharging to the suppression pool. One is called a ram's head. I'm talking about the safety relief valves. One is called a ram's head, which comes from a vertical pipe into two elbows. And the second is the quencher, which, if the elbows go to the surface of the water, if you add a perforated pipe, you would have a quencher.

Now, the pool temperature limit as far as excessive dynamic forces associated with these relief valve discharge piping, is for a Mark I containment and would be a maximum local pool temperature of 160 degrees Fahrenheit with the ram's head. If you put the quenchers on -- by the way, the 160 is the acceptable value as far as the staff is concerned in that it's a local maximum.

If you have quenchers, the acceptable local peak pool temperature would be 200 degrees Fahrenheit. That's the staff-accepted value, although GE says there is data tc indicate you could go up to the boiling point.

MR. CATTON: I think GE is probably right.

MR. GRAVES: I think the interest here was how long it would take to get up to 160 or 200.

VOICE: Wouldn't the pressure pulse have been more severe if the turbine trip --

MR. GRAVES: Turbine trip without bypass is very similar to MSIV closure. For a BWR-4, as I recall, the peak reactor pressure following a turbine trip without bypass is about 15 pounds psi less than that for closure. On the other hand, the pool temperature is slightly higher for the pool temperature without bypass.

VOICE: I don't understand what's going on.

MR. GRAVES: The turbine stop valves would close very rapidly. MSIV's are closing closer to containment, closer to the vessel.

The point is that the generic calculations that were made -- and I think I have a table in my briefcase for it -- BWR-4's, for GE's report -- the consequences are fairly close in terms of pressure and peak pool temperatures.

MR. CATTON: GE has two codes, one called READY and the other called ODIN. One's good and one is bad as far as rapid pressure is concerned and they use the bad one in their ATWS calculations, and they maintain things are so slow it doesn't matter.

MR. GRAVES: I would like to divide this type of problem into two pieces. We are talking about times of 10, 20, 30 minutes. But there is a point -- and I appreciate what you're asking.

In doing a calculation like that, they did use READY, by the way, for an extended period of time. They went up to over a half hour to an hour. That's long-running.

But one interest in the early part of the event is how much energy was generated, because that's going to heat up the pool. That's a small correction because you're going to be discharging to the pool for a fairly long period of time before this standby liquid control system shuts off the plant and you are on decay heat.

MR. KERR: Excuse me. What is a long period of time? 10 minutes, 30 minutes?

MR. GRAVES: If you had an MSIV closure, a turbine trip without bypass, the key parts of the calculation would go into typical Chapter 15 calculation in the first 60 seconds. By that time your reactor pressure has peaked in five or ten seconds, there are neutron fluxes in a few seconds.

And as you go through this, if you went through a scram, for example, everything of interest would be pretty much over as far as, say, minimum critical power ratio or maximum reactor pressure, would be over with.

However, I think it has been demonstrated so far to my mind that the question of peak pressures is not the problem. It is the question of loads to the pool. And now we are talking about something where, for the Browns Ferry 3 calculations, we asked them to run a calculation and said, do not put on the poison system until 10 minutes, or until 30 minutes, and what happens.

Now, in that time the reactor has been perking along at 10 percent power, and any uncertainties in the first 15 seconds have no meaning.

MR. KERR: You're answering a much more sophisticated question than I asked, but I accept it.

MR. GRAVES: We asked GE to run the calculations. Then we went to Brookhaven and said, you run the calculations. GE at that point in time was in much better shape to run this calculation than we were, because we are talking about not a full ATWS, but a partial ATWS.

MR. KERR: In effect, then, this part of the calculation is finding out the energy output to the pool?

MR. GRAVES: Also, you are interested, of course, in [illegible] inventories and things like that, but primarily for these calculations it was heat load to the pool, maximum pool temperature.

MR. CATTON: I'm not sure whether you run a code to do that.

MR. KERR: That was going to be my next question.

MR. GRAVES: I don't have the slide to explain that, but I can explain it in words.

MR. KERR: I can think of one reason. It looks more accurate if it's spit out by a computer than if you do it with a pencil and a piece of paper. One cannot neglect that.

MR. CATTON: That's certainly true.

(Slide.)

MR. GRAVES: All right. In terms of the Brookhaven calculations, that was run on RELAP 3B. They used the Peach Bottom data they had because they had already set this up for comparisons between Brookhaven and CDEN calculations that you raised the question on, Dr. Catton.

The reactivity feedbacks were best on previous calculations which they used with Peach Bottom data.

MR. KERR: Excuse me. I understood from what you said earlier that the model is one which predicted that the reactor would be sitting there at about 10 or 20 percent power almost steady-state.

MR. GRAVES: After the first few minutes, the three minutes, it's sort of steady-state -- it's not steady-state. You go through some cycles.

If after the ATWS had occurred, if you could imagine a situation where you controlled the feedwater to match the power, then you would have like a steady-state. You'd be discharging to the pool and adding makeup water.

MR. KERR: Why do I have difficulty in imagining that situation?

MR. GRAVES: We will have the feedwater off, however, because that will go off, depending on whether it's electric motor drive or steam turbine drive, in the first minute after the event.

With an MSIV closure, you have lost steam supply to the turbine-driven main feedwater pumps. For a short time, those control systems will force the feedwater to go through some gyrations because of the fact that you're going through a case where there is a mismatch between steam flow and feedwater flow. So that will affect the control.

The second thing is vessel level will affect the controls. So you find a gyration in feedwater flow. But it ends in about a minute. After that, you have to have makeup water.

Now we go to makeup water. Where does it come from? Were it high-pressure and discharging from the safety relief valves at 1100 pounds -- the only thing we have available is high pressure injection and reactor coolant system.

Now, what will happen then and what makes this not a steady-state calculation as far as the system is concerned is, as soon as the vessel level drops, you've lost the feedwater, and when that drops HPCI and RCI go on. For the Browns Ferry event, they had more than enough capacity to bring the water level up again and it will go to a trip and those systems will cut off.

So now its stopped flow in the vessel, and the water boils off, the level drops off, and eventually they will start up again. So you go through a cyclic process with HPCI and RCI. That in itself is a transient, although if you look at the power that is associated with this it's fairly flat.

In other words, in terms of power there are some wiggles that are caused by the relief valves going on and off and caused by the fact that when HPCI and RCI go on or off the vessel level changes and this affects recirculation flow through the core and affects subcooling of the core inlet, which affects voids. So there are some things which --

MR. KERR: Professor Catton could almost assign this problem to his freshmen by giving them the kilowatts out of the reactor and the pool volume.

MR. GRAVES: There are a few other things that are happening.

Shortly after the event, there is no boron going in. You have a void fraction which has changed from the original steady-state value of 40 percent, because the pumps tripped and the power has changed. We have come down to 10 percent power, let's say, for Browns Ferry. Your Doppler has had some reactivity. The void collapse has had some reactivity.

There is a very slight effect of the coolant temperature. But I say, if you forget about HPCI-RCI coming on and off, and there is no boron coming on, that's like a steady-state problem and I would tend to agree with you.

However, it becomes not steady-state when you consider that you have to shut the plant down, and in doing that you have to put boron in. As boron comes in, you'd think that would shut the power down, but it doesn't. Because what happens is, the power starts to go down. But when the power starts to go down, the voids collapse and that compensates for the negative reactivity.

So it tends to remain in a relatively steady state. This is a rare event in my mind. Normally in transients which you will see in Chapter 15, the major change in reactivity you'll find is about a dollar, a dollar and a half. The voids collapse with the pressurization, you get about a dollar and a half insertion.

Here we're going to an event where all the reactivity components are changing over the complete range. Void fraction, originally 40 percent; when the plant is turned off, you go on decay heat at about two or one percent power. Your float of power ratio in the core is larger than it is at design point. You end up with about five percent or three percent voids.

That means you are getting the entire worth of all the voids. Depending upon who calculates this, this could be 15 dollars or 6 dollars. There is some uncertainty there.

MR. MATHIS: Well, all through this you say Browns Ferry 3 partial scram. Are you still, through the entire transient, half in, half out?

MR. GRAVES: Yes, the control rod were unchanged.

MR. LIPINSKI: What happened when you dropped the rods in in one-half of the core and you're producing power in the other half?

MR. GRAVES: Core stability was not investigated. It's an interesting point.

MR. LIPINSKI: When GE first proposed recirc pump trip and they coasted that pump down, they said core stability was not a problem. Evidently they went back and thought about and said next time that it might be, and they were still looking at it.

MR. GRAVES: The calculations I'm describing have nothing to do with core stability. It's a lopsided core, and you've got a very unusual situation with decay heat in one-half and fission power roughly equivalent to ATWS on the other side.

It's a good point you're raising, but what I'm saying to you is that in the calculation that was not investigated.

MR. KERR: Are you going to tell us in roughly how many minutes the pool heats up so that you have a problem?

MR. GRAVES: Yes, I'm coming to that. Let me see if there's anything left on this slide to discuss.

Oh, yes, I want to point out where we were in terms of what Brookhaven did and what GE did. Brookhaven used the basic Peach Bottom data they had used when they were checking out the ODEN code on Peach Bottom tests. The reactivity feedback models were used to check with Peach Bottom.

They added for Browns Ferry HPCI, RCI, and automatic initiation in RELAP 3. So you will see, when we get to the point, if you are interested in seeing the history of the event, you will see HPCI going on and off.

The RHR characteristics were obtained from the FSAR. They did not have enough information to run the problem. One of the problems is, what is the worth of a partial scram, such as Browns Ferry.

We had the RAMONA code, but RAMONA wasn't ready.

It has a three-dimensional capability, but it was not available at the time. And so we compromised. We took what GE got in terms of reactor power. Remember, RELAB is -- what is the scram worth that you put in the point kinetics reactivity question.

GE used their 3-D simulator and READY to make an analysis. Essentially what they did is make -- you're talking about going through a partial scram. Imagine you put in the feedwater just to make the power. It's like an iterative effect, to keep the situation at steady state. But when the pumps tripped in actual circulation in the core, the scram configuration simulated 3-D.

The simulator is not a systems code. It has to be supplied parameters for the coolant and for the flow rate. Now, that would have to come from natural circulation calculations.

So what this means is you try to iterate between 3-D steady-steady simulator, which needs coolant conditions, and a READY code, which could supply you the conditions, but not the power. So you juggle it until you come to steady-state in agreement with the systems code and the 3- physics calculation, and from this you get a power.

The power that was obtained for Browns Ferry was 10 percent. For rods half in and half out it was 20 percent.

MR. CATTON: Could we go back to the two-phased ability for a moment? It seems to me you're going to blow all the water out of one side, on the high power side, and the voids are going to completely collapse.

I'm not in the neutron business, but it seems to me that's going to give you one heck of a spike in power.

MR. GRAVES: I guess I'm not sure.

MR. CATTON: When you get to two-phased flow stability, one of the characteristics is that you see void, no void, void, no void. When you have no void, don't you get a lot of power?

MR. GRAVES: Well, I agree, what we are seeing here is half of the core, roughly, which has decay heat. We are talking about one or two percent power there.

MR. CATTON: But when the voids collapse on the side of the rods, what's your power going to be?

MR. GRAVES: The power would go up.

MR. CATTON: Then you're going to blow all the water out.

MR. KERR: Ivan, I don't see why you have to have an unstable situation.

MR. CATTON: Any time you have parallel flow and one has more push than another, you get into instabilities.

MR. GRAVES: This might be equivalent to a large reactor with a large bypass. In other words, half a core is still a big reactor. And on the other side, instead of 10 percent bypass, I've got a lot of bypass.

MR. CATTON: With RELAP 3, it's easy to do it right. I don't know why you don't do it.

MR. GRAVES: RELAP 3 has the --

MR. CATTON: So you've already checked this out?

MR. GRAVES: No, I haven't.

MR. CATTON: It sounds like an antequated version of RELAP.

MR. GRAVES: But in fact, the core was divided. We felt this might be an improvement over the GE point kinetics. One-half had decay heat and the other half had fission.

MR. CATTON: You did this hydraulically, too?

MR. GRAVES: Yes.

MR. CATTON: And nothing happened?

MR. GRAVES: Nothing that I saw.

But you're raising a good point, Ivan. I like the questions. I'm not arguing with them. I'm saying we did not look at it. But I think I could look back at RELAP 3 printouts and try to find out.

But I think it's not very good for this problem. Possibly RAMONA will do it.

MR. CATTON: It seems to me it's almost a major code development program.

MR. GRAVES: Well, unfortunately for me, core instability such as you're asking about is not the responsibility of the branch I'm in. So I don't get involved in the details of that and I'm not the person to answer the questions you're raising. I think it's a good question to ask, but I think you will have to ask the appropriate person, and I'm not that one. I cannot supply you with information. I wish I could.

MR. WARD: Charles, I'm not quite clear as to whether the calculations have been compared with what there was observed of the transient at Browns Ferry.

MR. GRAVES: No, they are not comparable. In other words, these calculations are for a plant which was initially at full power.

MR. WARD: Are there any plans to do that?

MR. GRAVES: There have been calculations -- no, I am not aware of any calculations that have been made to directly check Browns Ferry. It's possible GE has, but we did not. That was, in a sense, a minor problem. They ended up like one percent power, wasn't that right, Bill? It was a small thing and I don't know what one could get out of the calculation.

MR. WARD: The point is, would that give you some confidence in the code, in the modeling you have done?

MR. GRAVES: I see what you mean. The major point one might get out of that, I think, might be to say, okay, the 3-D simulator said the power should be such and such and they got something else. This is the only thing I could say.

But I am not aware of any calculations which simulated Browns Ferry with one percent power after the first initial scram. I think there might be an interest conceivably in the physics side, but on the systems side the things are just not there to compare.

Now, Brookhaven then used the average power obtained by GE using their 3-D code. Brookhaven took the feedwater transient that GE gave, because they did not have the details of the control rods and the feedwater that was put into the Brookhaven calculations. And Brookhaven used the worth of the boron added to the system.

GE had run a number of calculations and had specified that 350 parts per million of boron in the reactor coolant system would bring the system subcritical. That was from the full ATWS, and it's the same as the half-ATWS, because it's half a core and you would need the same amount of boron to shut down half a core, what was left at Browns Ferry.

MR. KERR: These are calculations that have already been done.

MR. GRAVES: By GE.

MR. KERR: And Brookhaven?

MR. GRAVES: That is what I'm trying to
distinguish. At the time these calculations were made for
Browns Ferry, we did not -- I'm sorry, I've got to watch
myself. You're raising a good point.
On the previous ATWS calculations, we ran full
ATWS calculations on the source of the boronworth.

VOICE: It was a full ATWS.

MR. GRAVES: Then it was Brookhaven calculations.

VOICE: Boronworth was double that was used in
your calculation.

MR. GRAVES: I wasn't involved in those
calculations. For these calculations, they used the GE
boronworth and put it in RELAP 3.

MR. KERR: The calculations you describe are
calculations that have been done. Why did you do them?
What were you looking for? You did them apparently because
either you didn't trust GE's calculations or something.

MR. GRAVES: Well, I guess I'll put it this way.
After Browns Ferry occurred, General Electric was after the
calculations and we tried to run ours as best we could.

MR. KERR: But from what you're telling me -- and
I realize I'm hearing what is probably an oversimplification
-- much of what you used was GE calculation anyway. So I am
puzzled that --

MR. GRAVES: The GE calculations used were the 3-D partial scram.

MR. KERR: That's pretty key.

MR. GRAVES: The feedwater transient effect I think is minor. The boron reactivity effect is important.

MR. KERR: So what I'm really wondering, sort of, is what you checked. Maybe what you checked is, given ten megawatts output, how long does it take to heat the pool.

MR. GRAVES: We didn't quite stop there. We are planning to do more work. This was done last year.

MR. KERR: I'm not trying to be critical. What I'm worried about is that I may be missing some fine point.

MR. GRAVES: One of the reasons for this slide was to apprise you that not all the calculations were in that complete shape when Brookhaven ran the calculations right after Browns Ferry. People didn't not think of half-scram or of partial scram. It was full ATWS, and they were not set up for this.

The vendor in cases like this --

MR. KERR: I must sound as if I'm trying to be critical and I'm not.

MR. GRAVES: I realize that, Dr. Kerr. What I'm trying to say is, after the event occurred there was extreme interest in partial scrams. There was the question of asking GE to say what the consequences might be, and we like to have our own backup calculations as much as we could. We could not get a complete set of them, primarily, I would say of these items, primarily because of the 3-D effects of this partial scram configuration.

So on that basis, rather than do nothing, we decided that we would try this, knowing that we could later try to run RAMCNA in a 3-D calculation and see the partial scram, but not in the future.

I am saying, here is a comparison of the MSIV closure event using Browns Ferry 3 partial scram, suppression pool temperature -- it's a partial scram and we have suppression pool temperature versus time. This is one of those situations where I told you you go through rather wild gyrations in reactor power and pressure and so on in the first minute, and then after that it tends to settle out roughly to a constant power, because, as I say, the first thing is you are just losing inventory in the vessel, no makeup water supply, but you still have natural circulation.

And it tends to come to approximately constant power. And then as you go on in time you come to various changes.

As I said, we asked GE to assume that the standby liquid control system was put on in ten minutes, and Brookhaven did the same thing. So at 600 seconds, around here, we're starting to add boron.

In these places in between here, where you see gyrations, part of this is due to the fact that HPCI and RCI are going on and off, and this affects reactor power. When you add HPCI water, the power goes up.

MR. KERR: Is that what causes the plateau?

MR. GRAVES: In terms of temperature?

MR. KERR: If that's what this is.

MR. GRAVES: This is not the peak pool temperature yet. Brookhaven calculations at the time of Browns Ferry were at 780 seconds.

MR. KERR: The point I refer to occurs at 420 seconds.

MR. GRAVES: There's a point where the power is fairly low. HPCI and RCI go off. What happens, as soon as those come on, they put in cold water in the core and you're collapsing voids. When you turn them off, you get no subcooling to the core inlet and you get a sharp reduction in power.

So you're cycling as you go through here. They calculate it out to about 780 seconds.

MR. KERR: And that was one cycle?

MR. GRAVES: Two cycles at that time. HPCI was off and then it was on for 150 seconds, then it was off and turned back on again in this period of time.

MR. ABBOT: When this trips on high level, the operators reset. So you're taking credit for some operator actions.

MR. GRAVES: Unless I missed a point, the major operator actions were that operator action would have had to have been taken here at ten minutes to start the liquid control system. It would have had to take place at ten minutes, to start the RHR heat exchangers.

MR. ABBOT: What about RCIC? HPCI will reset, but --

MR. GRAVES: RCIC does not. That's only 10 percent of HPCI. That I agree with you, HPCI is automatic. That supplies 90 percent of the makeup flow. RCIC is about 10 percent. But there are other manual actions besides that.

MR. KERR: I didn't understand what you were agreeing with that he said.

MR. GRAVES: That is, as I understand it -- and there may be other people here who I'm sure know more than I do about this particular RCIC. But I believe it has to be reset. But it's one manual action.

The other manual action is the standby liquid control system has to be put on.

MR. KERR: Mr. Abbot points out that the operator has to do something?

MR. GRAVES: Yes, operator actions are required, and there are about two or three other operator actions.

MR. LIPINSKI: The Brookhaven data is higher than the GE analysis, and you have assumed perfect mixing throughout the suppression pool. So from this I conclude that the Brookhaven calculation assumes there is more power getting from the vessel to the pool than GE does.

MR. GRAVES: It does not include stratification or differences around the periphery of the pool, because we only have a finite number of places to do that. It does not include that. That is an average temperature.

MR. LIPINSKI: Brookhaven and GE is the same assumptions in doing the calculations?

MR. GRAVES: Yes. As far as the pool is concerned, the pool temperature calculation is like an independent calculation. You run it and you get steam coming out. So now you go to a pool calculation. Essentially you are saying the time rate change in the bulk temperature of the pool is equal to the heat added minus the heat removed.

Now, the heat added came from the RELAP 3B. The heat removed comes from the use, the assumed use of both RHR heat exchangers, with a service water temperature of 85 and a UA that is used in there -- they use a different form. They don't use the log mean delta t approach. It's pool temperature minus service water temperature, inlet temperature. It's an effective way of using that.

That is a generic number which includes the volume, and that was used in both sets of calculations.

MR. LIPINSKI: Then why the difference between the two sets of calculations? How is that explained?

MR. GRAVES: I guess I really didn't go into the details of this. The first thing was to get the 10 percent power from GE. Now I've got to run a RELAP calculation, and in the point kinetics of RELAP I've got row total is equal, reference to the steady state operating point equal to the sum of reactivity, row void fraction, row Doppler, row boron, and row control rods.

Now, what Brookhaven did not have is -- these are all delta rows -- is the delta row associated with the partial scram configuration. They got that by adjusting the row with RELAP to get 10 percent power in a fictitious steady-state situation that GE set up for the 3-D simulator.

In other words, they took the power as the input variable and juggled the worth of the control rods and came up with 10 percent power after you had the partial scram. The reactor coolant pump tripped the main feedwater in, and they used that GE power number to get the reactivity insertion worth of the control rods.

Now, given that and the Brookhaven worth associated with void fraction, Doppler and temperature, you will track power versus time as you go through all these system variations. That doesn't have to equal GE's numbers. So they will not match.

MR. KERR: The GE power and the Brookhaven power did not match?

MR. GRAVES: The matching point was to say, after you went through the MSIV closure from full power initially, and imagine you're in a situation where you level out with main feedwater coming in to match boiloff, with steam going to the suppression pool and main feedwater -- a steady-state condition, but partial scram.

GE wrote a 3-D simulator, combined it with READY to set that up. They got a power.

Brookhaven took that power and said --

MR. KERR: All I want to know is, did GE calculate consistently larger power than Brookhaven -- I would judge that to be the case from that curve -- as a function of time -- I'm sorry, GE calculated smaller. They consistently calculated smaller.

MR. GRAVES: Up to this point in time, but it's fairly close.

MR. KERR: Now, had they calculated the same power, would they have calculated using the two methods the same pool temperature? Or was that calculation different also?

MR. GRAVES: They did not carry the calculations out past this point and did not reach the maximum pool temperature.

MR. KERR: I'm talking about pool temperature as a function of time, which is what I thought you were plotting here.

MR. GRAVES: Brookhaven carried it out to this point and stopped. GE went all the way.

MR. KERR: Suppose they had used the same power as a function of time in the two calculational methods. Would they have gotten the same curve?

MR. GRAVES: They should have.

MR. KERR: So the difference in the curves is because GE calculated a lower power as a function of time.

MR. GRAVES: During the transient, after that first initial 10 percent loss. In other words, they would go through power oscillations as HPCI went on and off. But the pool volume, the pool initial temperature, the heat exchanger capacity, the service water temperature, are the same for both calculations. So the power history is the same.

Now, GE did run the calculations all the way. There is reasonable agreement between the two calculations. You might say the burden now is, what is the worth of the partial scram. That's a major uncertainty to my mind. That type of calculation will come from RAMONA later.

MR. KERR: If you had to estimate the uncertainty in pool temperature, what would you estimate it to be?

MR. GRAVES: The estimate on pool temperature is too -- that's extremely tough. One uncertainty in the pool temperature is obviously the difference between the bulk and the local maximum. That would be true for a ram's head and --

MR. KERR: What I'm trying to get at is how you're going to use this. The staff has set a maximum pool temperature as an acceptable limit. Now you're going to use these calculations, I assume.

MR. GRAVES: In the future there will be other calculations. This was just a specific set following Browns Ferry.

MR. KERR: You're going to try to find out whether you're exceeding the limit. In order to do that, you need to have some idea of the accuracy or the uncertainty associated with the calculation. Do you think it's 2 degrees or 20 or 50?

MR. GRAVES: I think it would be remiss of me to speculate too much. I would say the point of interest in one sense is not the average, but the maximum, the local maximum in the pool. There is a fairly significant difference between a pool average and a local maximum.

MR. KERR: Then why are you doing these calculations, if you're not interested in the average?

MR. GRAVES: You have to start with the average.

MR. KERR: If you start with the average and you're going from that to calculate the maximum?

MR. GRAVES: Well, in the Mark II containment, I believe as part of the generic issues program, the individual owners as I understand are supposed to supply information on the differences between average and maximum for their individual plants, because it's not an easy number to come up with.

MR. KERR: Does one use a multiplication factor which multiplies by the average to get the maximum?

MR. GRAVES: No. The difference between maximum and average for the pool I do not believe is expressed that way. When I have quizzed containment people about this, it has been expressed as a difference between maximum and average in degrees Fahrenheit.

It averages from 10 to 40 degrees.

MR. KERR: If I have a 10-degree error in the average, I will also have a 10-degree error in the max.

MR. GRAVES: That's right.

MR. KERR: Rather than it being remiss of you to speculate on that, it's very remiss of you not to try to find out what the uncertainty is.

MR. GRAVES: I thought you were asking me to speculate at this point in time.

MR. KERR: I was asking you to give me an estimate, which to me -- I don't see how the calculations have much significance.

MR. GRAVES: We are talking about an initial pool temperature which was 120 degrees, and we are talking about limits that might be associated of 160 if it had been a ram's head or 200 degrees if it was a quencher. So I'm talking about 80 degrees.

A significant part of that 80 degrees could be the local difference between the local and the maximum in the pool itself. The question is, what's the uncertainty in the average, because the average came out of the system calculations. Those other numbers are going to come out of experiments of the pools.

MR. CATTON: You're going to have to decide how you define "maximum," because the local maximum is 212. You're condensing steam right at the exit to the ram's head. So you must define "maximum" some other way.

MR. GRAVES: As I understand it, it was the maximum temperature obtained in the vicinity of the pool of a ram's head. Again, I think I am responding to situations where --

MR. CATTON: If I mention temperature above the ram's head, I'll get one thing. If I mention it above the ram's head, I'll get another.

MR. GRAVES: As I understand it from talking with containment people, the difference between what they call a local maximum, however that's determined --

MR. KERR: At some point, I presume somebody who may have to understand containment as well as pools is going to have to make a -- at this point you're simply reporting to us on very preliminary results which don't have anything to do with an ultimate decision.

MR. GRAVES: That's right. These results I'm talking about were the calculations which were run last fall in response to the Browns Ferry event. They are not to be used in the future.

MR. KERR: What did you do with them?

MR. GRAVES: We were trying to do the best we could to see if GE came up with some numbers. That was the intent for us, to see what we could come up with as a check, as best we could.

But to my mind --

MR. KERR: At the end did you say, we feel pretty good because the pool temperatures were okay, or we feel bad because --

MR. GRAVES: I felt reasonably well, as a matter of fact, because as you go through some of the calculations I came to a better appreciation of what's going on physically, not details of calculations, and I --

MR. KERR: Suppose you calculated a maximum temperature of 200 degrees. Would you have felt bad?

MR. GRAVES: Not if they had had a quencher.

MR. KERR: Suppose you calculated 215. Would you have been concerned?

MR. GRAVES: If containment pressure has gone up and they got 215, I think I would have to defer to a containment person who has investigated dynamic loads of the pool, and I would never come to any conclusion about whether it's good, bad or indifferent. That would not be my responsibility.

I would feel uncomfortable with it, however.

MR. CATTON: The pool temperature is really not known. In Zimmer, I recall with instrumented -- it was instrumented to obtain some of this information because they couldn't answer these kinds of questions.

MR. GRAVES: I may be wrong, but I believe I'm correct that the individual plants are asked to demonstrate the difference, in other words measure the difference.

MR. CATTON: Deciding where to put the measurements is important, and a lot of extra instrumentation is --

MR. GRAVES: There are things like elbows and RHR piping to promote mixing in the pool. And there are quenchers to promote mixing, because it was found that there were fairly large differences between local and average. But it's not my field.

MR. MATHIS: Charles, one question. And maybe I'm jumping ahead, but we've got to move on.

All these calculations were used in a different type unit than Browns Ferry. You've got an ongoing program.

MR. GRAVES: I'm sorry?

MR. MATHIS: It was used on Peach Bottom and Peach Bottom and Browns Ferry aren't the same units. And Mr. Udall has requested us to give him some kind of idea of the level of confidence in calculations on such things as the Browns Ferry type event from full power and using some different design basis.

Now, you've admitted that you're going into some different codes and so forth, and a lot of this work will go on into '82. And I guess what I'm looking for is, on down the road when are we going to have some kind of confidence level that says, yeah, we think we know what would happen?

MR. GRAVES: There would be two parts, and I guess I'm not sure. Let me put it this way: A full ATWS to my mind is much worse than a Browns Ferry event. At Browns Ferry we did not calculate 3-D effects of a partial scram. If a full ATWS had occurred, it would have been much worse.

If that had occurred Ashok Tadani would have been down here telling you about lots of problems. They don't have standby liquid control system. The ATWS fixes have not been put in. They have things like alternate rod insertion. They have things like automatic injection of the standby liquid control system.

They are going to put twice as much boron in, in the jet pumps, possibly, depending on the plant design, or high pressure core spray has to be put in. Lots of things involved with ATWS fixes.

MR. KERR: But how does one know these are fixes if one doesn't know how to calculate the behavior of the core in the system in order to see what effect the pump trip and safety injection have? I mean, I don't understand how one knows how good the fixes are if one doesn't know either how to experimentally determine or calculate.

MR. GRAVES: In the past, it has been a series of calculations which I did not get involved with and should not be discussing. But there were calculations at Brookhaven. GE supplied calculations for all the BWR's and generic-type calculations of the full ATWS, showing the consequences, the results of the fixes.

I have not been involved with ATWS for the full ATWS, which was the real problem in the past. And I'm looking through the audience to find someone who might be. But I'm not sure that I can find one at this point in time.

You're asking for confidence in the full ATWS, because that's where the problem is. If the full ATWS had occurred at Browns Ferry, we really would have been in a fix.

These calculations indicate that it was low enough that you could still take manual action and get away with it and be all right. But in terms of the uncertainty --

MR. KERR: If you had had a full ATWS at Browns Ferry, the fix you would have been in would have been a pressure problem or a pool temperature problem?

MR. GRAVES: I think in the full ATWS it has always been that the RPT -- there has never been a peak pressure problem. And again, I haven't been on ATWS. It has always been such that it was within vessel limits.

But the ACRS, I believe --

MR. KERR: I thought you made the statement, if you had had a full ATWS at Browns Ferry we would have really been in a fix.

MR. GRAVES: In terms of suppression pool temperatures.

MR. KERR: So it was suppression pool temperature that you were referring to?

MR. GRAVES: Yes, because they would have exceeded the allowable pool temperatures very rapidly. With no boron going in for 10 minutes or 30 minutes, it would have been a very sad situation.

MR. KERR: About how long would it have taken the pool temperature to be exceeded?

MR. GRAVES: Well, if I visualized an ATWS event, in the first minute at constant power, and then enough boron comes in and shuts it off, if you visualize it like straight lines, Browns Ferry was going at 10 percent power. Full ATWS would have been something like 40 or 50 percent power, I believe. 40 percent, I believe that's right.

MR. KERR: It levels off at 40 percent?

MR. GRAVES: Roughly 40 percent. Now, that is four times the rate of heatup. In this first part of the curve, the RHR heat exchangers, two of them seemed to work in these calculations. Two of them handled two percent power. So RHR wouldn't cause any change at all when you had 40 percent power and pumping steam to the pool.

So you would have gone up with a factor of four increase.

MR. CATTON: That's about 100 seconds.

MR. GRAVES: Well, actually, for the Browns Ferry event, let me put it this way. Assuming that we're eventually going to turn it off, if you keep on going at 40 percent everything's gone. I'm assuming that boron came in at a certain point in time. The question is, how long did it take to get it in?

Before it came in and shut the power off, you reach 355 parts per million. The power is so high, the RHR heat exchangers don't make any difference. So the energy is equal to the DDT of MCBT.

MR. BENDER: At what point does the system come into operation?

MR. GRAVES: It's not automatic. So in the calculations it comes in at ten minutes.

MR. BENDER: What are the heat removal mechanisms?

MR. GRAVES: There are no heat removal mechanisms of consequence. Essentially what you're doing is pouring steam in and raising the temperature. There are effects like metal in the pool walls, but that was neglected.

So for these type of calculations, ten minutes for the poison system, ten minutes for RHR. And there were some operator actions besides that that are involved in the event.

(Slide.)

I have one slide. Do you want me to continue or stop? The only slide I was going to do was have one quick slide that says "RAMONA."

There is another code that Brookhaven is working on, that is under support. The work is supported by Research. This is a code which hopefully would be -- it has two advantages. The biggest one for us would be three space dimensions down here in the core physics. Conceivably, partial scrams could be handled.

Another condition of interest is it should be faster-running than the other codes. It doesn't couple energy, momentum, mass, like RELAP. It's more like a READY code. We have a pressure node here, a pressure node there, and it's a much simpler way of calculation.

So if they take RAMONA and make this calculation, as believed by people up there, that will be quite fast relative to the RELAP. So Research is doing the following: They are changing this code to include boron mixing. They are going to verify that in fact they can run 1-D and get good answers by comparing it with 3-D.

They are going to put in automatic initiation of HPCI, RCI, and the safety relief valves, and the main steam isolation valves, which are not in the present code. There are a number of modifications in the works right now with respect to RAMONA. One of the uses would have been to check the partial scram at Browns Ferry.

MR. CATTON: Why is it that you don't use something like RELAP 5?

MR. GRAVES: We are certainly considering that very strongly, because --

MR. CATTON: It's a lot better than this. Why even spend your money on this?

MR. GRAVES: RELAP 5 is not available for boilers at the present time. It is going to be available this year.

MR. CATTON: But the kinds to do with this code, it seems to me --

MR. GRAVES: The changes they are talking about here are fairly minor.

MR. CATTON: But controls are a big headache in getting they all put together.

MR. GRAVES: The controls I'm talking about are somewhat simpler. It would be like the RELAP 3B. That is, level 2 and level 3 are assimilated by mass in the vessel. So it's not a large effort at all.

But we are definitely going to be working with RELAP 5. The problem at the moment is it does not at this time have the capability to handle boilers. It doesn't have jet pumps in it. It doesn't have the boron mixing model we would like.

There are arrangements being made so that it will have that capability. The Brookhaven people have gone to RELAP 5 school so they will be ready to use it. But they are not going to modify the code. The code modification is going to be done by the people who wrote the code.

MR. MATHIS: Any other questions?

MR. WARD: You said RAMONA was going to be able to check the reactivity-worth of the partial scram. Does that mean it's going to be checked against the observations from Browns Ferry?

MR. GRAVES: I'm not sure. The answer is it's not ready to run yet, and it's a point you're raising and I think a very valid one. Certainly we couldn't get anything out of the system side of it, but there's a possibility of getting something out of the core physics side.

MR. KERR: What are you going to do with the results of the calculation of the Browns Ferry event?

MR. GRAVES: Well, hopefully, when we first started, it would have been lovely if we could have gone the whole way. We tried. But the capability was not there at the time.

As far as the Browns Ferry event was concerned, there was a massive staff effort on this. And I guess I was maybe in a discussion today about the scram system, and there were corrective actions taken. I don't know whether a half-scram is more probable than a full scram. I have no idea. But it is certainly of interest, because it happens.

MR. MATHIS: Anything else?

MR. KERR: I guess you still want to calculate the Browns Ferry event?

MR. GRAVES: I think we have some calculations that were set up. In other words, in our attempt to get our answer for this Browns Ferry event at the time. The RAMONA calculations were set up late. They have been run to try to simulate the Browns Ferry partial scram event. We got reasonable agreement with General Electric on it.

But there's no sense beating a dead horse if it's not that important. Full ATWS I think is very important. But we will have completed those calculations at Brookhaven and we will be ready to report on the results of the calculations.

MR. MATHIS: Thank you, Mr. Graves.

MR. BENDER: May I make a comment?

MR. MATHIS: Would you use the microphone, please.

MR. BENDER: One of the questions was, was there a difference between Browns Ferry and Peach Bottom. As far as the geometry and the power levels are concerned, there is not too much difference.

The difference would be that in the calculations the reactivity coefficients, they are dependent upon exposure. At Peach Bottom reactivity coefficients was obtained by a certain type of fuel, and also by the live conditions. They may not be exactly the same as Browns Ferry, so this may explain some of the discrepancies. But that was one of my comments.

The other comment was the use of RELAP 5. I think Dr. Catton raised that question. Concern was raised here for a partial scram with a 3-D calculation capability, and we do not have have 3-D calculation capability. It won't be able to calculate the problems you have raised. The code will require an extensive modification to acquire 3-D capability.

So these are my comments.

MR. MATHIS: Go ahead, Bill.

MR. MILLS: I am Bill Mills, I&E staff headquarters.

Since we are running quite a bit behind schedule, I am going to go through some of these areas rather quickly, I hope. I plan on discussing the concerns raised within the staff immediately following the Browns Ferry 3 event, the short-term actions that we took through Bullet 80-17 to provide a basis for continued operation, finding some of the deficiencies that were uncovered, and then ATWS procedures requirements that were put in the bulletin for the boilers, and then a survey that we did which picked up all the operating plants.

I will go through the first part rather quickly, because I think some of that has been discussed before and will be a little bit redundant in the justification for continued operation, and get to the ATWS procedures.

(Slide.)

The Browns Ferry 3 event immediately raised concerns within the staff on the reliability of the scram system as we have previously perceived it, and our understanding of the as-built condition of the scram discharge volume because of the poor hydraulics and interties with other systems.

So we took short-term actions to provide a basis for continued operation for the other boiling water plants, and also started long-term actions to provide improved reliability in ATWS-related procedures and modifications. Bulletin 80-17 went out within five day after the Browns Ferry event, and the main thrust was to keep the scram discharge volume empty and operable.

(Slide.)

And then have periodic verification that the scram discharge volume was indeed empty, and the plants were required to do that within three days after receipt of the bulletin. And the thrust was the scram discharge volume is empty and the plant will scram, based on what we saw at Browns Ferry.

Also, the plants were required to do some scram testing to confirm that there were no other problems that existed in the scram system and confirm that we didn't overlook something. And it had to be verified empty after these tests, plus any other scram that occurred, because it fills up with water during the scram.

Plants were also required to develop operating procedures to ensure that they could respond to a Browns Ferry type of event.

(Slide.)

As a result of the testing that was required by Bulletin 80-17 and the emphasis on the scram system, there were a number of deficiencies uncovered. The first two we have already discussed, which were uncovered before the Browns Ferry event. The Dresden 3 and the Browns Ferry 1 involved situations were the scram discharge volume did not work as it should.

At Dresden they had an inoperable vacuum breaker and the water was held up in the scram discharge volume. At Browns Ferry 1, they were doing single-rod scrams and the water was retained. These deficiences here highlighted the importance of the vent in a correct configuration, and that led to a bulletin supplement that was sent out later.

There were some other problems picked up along the way, and some of these were mentioned earlier today. They were indicative partly of the lack of a good preoperational test of the scram system.

MR. BENDER: Excuse me. Would any of those conditions have resulted in the Browns Ferry event, given the circumstances?

MR. MILLS: I would say no. However, if you take these two here, these draining the vent problems, where water was actually being retained in the scram discharge volume, since we don't know the exact cause of how the water did get into the east side at Browns Ferry, these two here have the potential of saying, if I have a vent problem I could get water in and it may stay in following a scram, like Dresden 3.

MR. BENDER: How about the loop seal?

MR. MILLS: No, that was very minor. It would have had no significant effect on the drainage.

MR. BENDER: I expect you've done this somewhere to be useful, to have something that said more about the significance of these deficiencies that were found?

MR. KERR: Mr. Chairman, I don't want to miss what Mr. Bender is saying, because I know it's important. Can you encourage him to use the microphone?

MR. BENDER: The point I was making is simply this: Most of these things probably do not represent events or circumstances that were like the Browns Ferry event, and it would be useful to have the staff or someone out on the significance of these deficiencies in terms of their relationship to the Browns Ferry, so that when we're answering Mr. Udall's letter we could address all of the points.

MR. MILLS: We can do that to quite an extent already, because these items were subseqently put in the bulletins that were sent to the plants. And these first two items resulted in immediate modification of the system. So I think through the bulletin requirements the significance of these was addressed.

MR. BENDER: I don't think you understand the point. Sure, the bulletins will correct them all. The point is, they were all found. And it would be better to say they existed and here is the significance of their existence. And I think that hasn't come out very clearly yet. But we really ought to have that.

MR. JORDAN: Are you looking for a commitment that we provide the ACRS with that sort of a description?

MR. BENDER: I would expect you to do that, yes. Say, given that set of deficiencies, here is how they might affect a Browns Ferry type of event. And hopefully you can show that none of them will lead to a Browns Ferry type of event.

But if you couldn't, I wouldn't start being worried about the fact that you corrected those and what other ones exist, because I don't know how many others you may or may not have found.

MR. JORDAN: I think that's the what-if that carries on forever. This was a rather comprehensive set of tests that we had the utilities go through and examinations, verified by inspectors, and these were the problems found in the systems. One can then take those problems and extend them and connect them with other problems and say you would have had another ATWS precursor.

If that's what the ACRS wishes, we will provide that.

MR. BENDER: I would like to believe that the tests that were done were as extensive as needed. I hope they were. But I don't have a basis for judging it personally, and I'm not sure any of us know how good that test program was.

MR. JORDAN: I'm trying to give you confidence there that the staff has reviewed it, the resident inspectors at the site observed portions of the testing, and the combined NRC staff, I&E, NRR, and AEOD, have evaluated the submittals and come up with a safety evaluation report on a plant by plant basis substantiating continued operation with the interim fixes. So that is our basis.

MR. BENDER: I hear what you're saying. But I still have to say that I'm not comfortable that I know that the tests prescribed were all that were needed, and I'm not comfortable that I know that the people that observed the tests were adequately qualified to say that the tests showed everything was okay.

MR. JORDAN: Well, that puts you in the position of being a judge.

MR. MATHIS: I have a little problem with what you're requesting, and that is you're saying it was your what-if list. There are enough for 30 percent, and I don't know whether we could answer that.

MR. BENDER: I have to have more than just that the I&E organization witnessed it. That worries me a lot, to say that I&E witnessed it. I think we need something more substantive than that.

MR. PANCIERA: The appendix deals with the staff's review of each Licensee's response. We tried to, as best we could, evaluate the Licensee's response and the actions that he had taken as a result of the requirements, and make a judgment as to whether or not that plant was safe for continued operation.

Now, I am really at a loss to figure out how we go further from here.

MR. BENDER: Well, let me start this way, I guess. First, I would like to have some independent critique of the test program by somebody that perhaps isn't totally biased by the fact that he was involved in witnessing the test. It think that would be helpful.

Secondly, I would be inclined to the view that I would want to be sure that the people that were witnessing the test program were qualified in some way to know that the test program was executed properly. And just saying that it's the report of the I&E organization does not constitute that much assurance for me, because I don't know who they are.

But if you have that information -- and don't misunderstand me. I'm not trying to say what I&E did was wrong or right. I'm saying if we're going to reply to Udall, then we ought to be replying in the context that, here's why I&E is qualified to support the results, and here is how we know that their judgment about the test program was based on well-qualified knowledge. I think that's an obligation which we have to Udall in order to give him an answer that we want to stand behind.

MR. JORDAN: Then I guess I misunderstood, because I got the idea you were impugning the quality of the people who were doing the testing.

MR. BENDER: I was only trying to find a way to substantiate their comments, which is a little bit different than impugning them.

MR. JORDAN: Then I think I can help you there, because the examination of the Licensee's activities was against criteria the staff had developed, presented and at least transmitted to the inspectors, and they had then implemented.

As far as the qualifications of the inspectors, I can give you that either in detail or in a general fashion.

MR. BENDER: I personally don't want it now. I think you ought to document it.

MR. JORDAN: Then let me express the problem. The staff has expended an incredible amount of effort in Browns Ferry and follow up activity, a large part of it in documentation. We have briefed the ACRS, this makes the fifth time in Subcommittees, on various aspects. And the staff is also working on a lot of other problems that may have equal or greater consequence.

MR. BENDER: Look, if you're saying you don't want to do it, that's fine. That's fine with me. But I think you ought to do it. And if we don't get it, I'm not inclined to support the view you stated, that you validated the evaluations in a way which we could say would enable Mr. Udall to stop asking such questions.

And that's all I'm saying, that if you don't want to say it, then we will probably have to find some way to deal with it without that validation.

MR. JORDAN: Maybe the best thing would be for you and I to discuss exactly what you need and we'll try to provide it.

MR. BENDER: Exactness is not something which I find practical to discuss here. I think you want to think about it a little bit and then come back, maybe, and make a proposal, because if I have to do it you won't like what I'll suggest.

MR. JORDAN: Okay. We're playing a rock game now, and I've done that before.

MR. MATHIS: Okay. Go ahead, Bill.

(Slide.)

MR. MILLS: After original Bulletin 80-17 was sent out, we went out with Supplement 1 when we got more information on the as-built configurations for various plants and more information came in. The supplement required that a continuous monitoring system be installed in the scram discharge volume by September 1st or other actions be taken to state why it couldn't be in by that date, and provide a schedule for when it could be in.

And also, it required a design review of the vent system, because reports of that had been highlighted; and other procedural controls on the standby liquid control, plus a verification by the Licensee of his as-built system that he had in his plant.

(Slide.)

Supplement 2 was then issued, based on the Dresden 3 and the Browns Ferry event that we discussed earlier, where they had water retained in the scram discharge volume, and that required that a positive vent be provided directly to the atmosphere to eliminate the potential that a vent problem would result in retaining water in the scram discharge volume. As a result of this requirement, about 15 plants modified their vent system and cut their lines so they were open to the atmosphere.

(Slide.)

MR. ABBOT: When that line was cut, one reason was when you reset the scram and open the vent and drain valves, the high pressure water inside the scram discharge volume discharges from the line, and the depressurized spray goes all over the reactor building. I guess we are back in that situation.

MR. MILLS: To some extent on various plants. It depends on the plants. Some plants install stem pipes so it would blow inside that. Other plants routed it to an area that was already contaminated, so it didn't make too much difference. But that was of concern from a radiological standpoint. It was just a tradeoff.

MR. ABBOT: Was that accounted for in the bulletin?

MR. MILLS: Yes, it was. That was mentioned specifically in the bulletin, to have them consider the radiological consequences and do what they could. And some plants did more than others.

MR. MATHIS: Bill, scoot on through these.

MR. MILLS: Supplement 3 was issued after the concern raised by AEOD on the loss of air effect, that it could result in the loss of scram capability. And Supplement 3 required the operator to manually scram in the event of loss of air. This subsequently was looked at in more detail because of the very short time available to the operator to do the manual scram.

(Slide.)

MR. BUCK: How much time is available?

MR. MILLS: In the worst case you could postulate, like one minute, two minutes, in that time frame, that the operator would have to scram the plant if everything went wrong. Otherwise, the scram discharge volume could fill with water. So you're talking in the order of a minute to two minutes.

MR. BUCK: And this includes detection time?

MR. MILLS: This includes the time from the time the air was lost up to the time that he would have to do something for a worst-case scenario.

I would point out that it's a very low likelihood scenario. For example, the air pressure would have to come down and level out maybe in a range of about three to five pounds and stay right there. So it would have to drop down and level off and stay right in that small band.

MR. BUCK: Well, that would make it more difficult, if it occurs with such low likelihood, that anybody would be standing there watching and waiting for it. Is there enough precedents there that --

MR. MILLS: In the bulletin we did identify what the operator would see in the control room and what he should manually scram the plant on. He would have some rods that would drift, plus he would have an alarm. When his air pressure came down, he would get an annunciator in the control room. And the bulletin required as soon as he got that annunciator he would manually scram the plant.

MR. BUCK: Then he is about ten minutes, almost, from there.

MR. MILLS: Right. And that's what led to a change in that position, which will be discussed later.

(Slide.)

The confirmatory orders. I discussed the continuous monitoring system that was put in as a bulletin requirement, and the response back on that bulletin requirement was not real firm, that plants did not have it in by September 1st and did not provide definite schedules for installing continuous monitoring systems. So we did go out with a confirmatory order that required everyone to install it starting December 1st, and that would continuously monitor for water in the scram discharge volume, from whatever source, however it got there.

(Slide.)

Again, the thrust was to keep the scram discharge volume empty.

Then, after the scram discharge volume continuous monitoring system was put into place -- we discussed that briefly this morning. It was kind of a hurry-up job, and some of the plants did not do an appropriate installation or in-place testing. So Supplement 4 required in-place testing, and that has been completed in all plants. And since that has been done there have been no failures and it has worked a number of times when called on.

(Slide.)

So our current status of Bulletin 80-17 is that on the original 80-17 and the three supplements, those have been reviewed by I&E and NRR and these have been closed out in the December 1st SER. Supplement 4, as I said, plants have made the continuous monitoring system operable and we are in the process of reviewing their written responses right now.

We are also doing ongoing review of the scram system for other problems that might be there. Some of the things we're looking for might be right here. Brunswick recently had an event where both control rod pumps tripped at manual pressure and the operator scrammed the plant. But it does raise some questions as to what might have happened if he hadn't taken manual action so quickly.

Improper location of the alternate rod insertion solenoid valve at Pilgrim could conceivably result in a reactor scram due to that location of the valve in the air system. That would then result in a loss of reactor coolant through that open vent and drain line.

That problem has been corrected at Pilgrim, and we surveyed other plants and no one else has that problem at this time. And we are sending out information notices on these two.

We are reviewing loss of air events. One recently occurred at Monticello and the operator responded properly in that event.

But one other item on the loss of air: I&E has a position that was recently sent to NRR in a memo that we think operating plants should be looked at and perhaps backfitted with the requirements of the standard review plan regarding loss of air and operational testing on air systems.

(Slide.)

One of the items in Bulletin 80-17 was ATWS procedures. We required that some things be added to the procedures, because we found after the Browns Ferry event that Browns Ferry did not have basically anything in their procedures that addressed that kind of event. We then did a survey of all the plants, including the boilers, and they were inspected for the acceptability of the procedures. Acceptance criteria were taken from Bulletin 80-17 requirements that were put together following Browns Ferry and involved Ashok Tadani and NRR people who followed ATWS. I will discuss in just a minute what some of those acceptance criteria were.

We found all the plants had acceptable procedures to respond to an event of the Browns Ferry type and ATWS events, to the extent they are identified in today's current position.

I will show you the things that are in a typical BWR ATWS procedure.

(Slide.)

And all the plants have been reviewed to show that they have these. Following reactor scram and determination that there may be a problem, the operator takes the mode switch out of run and it will put another scram signal into the reactor protection system. So that may move the rods in.

If that doesn't work, he looks at the control rod display and determines if he has rods out that would indicate an ATWS, five or more adjacent rods below position 6, or 30 rods anywhere in the core that are not inserted below position 6. So if he has rods out, then he has further actions he has to take.

The first one is trip the recirc pumps. Next he tries to get the rods in manually, and he can try to do that individually as well as resetting and putting in another scram in the reactor protection system. So he tries to get the rods in that way.

If that is unsuccessful, he vents the scram air header. And taking the air off that header should result in the scram valves opening. Also, if he has water in the scram discharge volume, he can manually open the vent and the drain valves on the scram discharge volume so that can drain, so that won't block the scram.

And if at any time he has the control rods not fully inserted and he gets low level in the reactor vessel or suppression pool temperature can't be maintained below the scram limit, those are the criteria and he has to initiate standby liquid control and reverify that. He doesn't need supervisory approval to do that once these two -- either of these two conditions are met. And the key is readily available to the operator.

So the main thing is, get the rods in, trip the recirc pumps and put on the standby liquid control.

And what we saw in the presentation that Chuck Graves just went through is that for a Browns Ferry 3 type event the operator would have ten minutes to do these things, also to get the RHR on. So for a Browns Ferry 3 type of event, the procedures would work and the operator would have time to do it.

And then some of the more generic questions on procedures and system designs that might be coming down the road -- the procedures would have to be looked at again at that time, but we think these cover the main points an operator can do for the condition of the plant that he's in right now.

MR. WARD: Let me see if I understand this.

You're saying any time he gets an automatic scram indication he inserts a manual scram, in essence? Is that the idea?

MR. MILLS: Right.

MR. WARD: Then the second step is indication of whether the scram has been effective, is whether he sees the rod drive lights go on. You don't have him look at the flux or something like that?

MR. MILLS: The power was not a direct requirement because even if it was subcritical and you had a large number of rods out, you still want to do these things because you may go critical again at a later date if you get voids collapsed, temperature comes down, and that kind of thing. So even if you have the rods out, there is a potential that you can go critical at some time in the event.

So you try to get the rids in and get the recirc pumps off. So it's conservative to do it that way.

MR. LIPINSKI: How are five adjacent rods defined? Can there be five rods in a line?

MR. MILLS: Some of the procedures have changed that to two adjacent rods. But I think whenever you have a situation where you have any rods that are next to each other, there's going to be some judgment involved there. We didn't really go any further than that.

And the operator, rather than sit there and figure out whether he has exactly the right thing, hopefully he will -- like I say, some have changed it to two. Hopefully he will see the rods out and do the right thing.

MR. LIPINSKI: If I were an operator and you told me five, I can think of a lot of geometric patterns where five things touch each other. And if they're all important, then I should concern myself with all of them. But if it's one rod in the middle and four around it, that is something else.

MR. MILLS: I agree, and all I can say is that we really did not define any further what five adjacent rods were here in the bulletin. I do know generically that GE did provide guidance on what was meant by these. Now, whether all the plants followed the GE guidance or not, I don't know.

MR. WARD: But you're saying a utility that doesn't know how to interpret that either -- they're saying, if there are two adjacent rods, you go to the next step?

MR. MILLS: A number of them have.

MR. WARD: A number of them have, but not all of them?

MR. MILLS: I don't know. I didn't check that on all of them.

MR. MATHIS: I don't think we want to be so prescriptive as to say, this is the five-rod configuration kind of thing. This is the kind of thing you have to leave generic and let the operator use some judgment, in my opinion.

MR. BUCK: In 3B you said "insert rods manually," and then you said individually, and I was thinking, that's about 90-some rods. Or am I off on the magnitude here?

MR. MILLS: No, you're right.

MR. BUCK: And he's just going to have ten minutes to do precisely that. They're super-agile operators?

MR. MILLS: You can reset the scram and put the scram in. Now, if you wanted to do it individually, you have toggle switches on the panel that's used for tests. But all you have to do is flip those toggle switches and the rods would scram individually.

Where this would be important is if you did have a lot of water in the scram discharge volume and you only wanted to put certain rods in, so you didn't put a large amount of water in the scram discharge volume. All you have to do is flip this toggle switch. So you could go through the whole core and flip all those switches very quickly.

MR. BUCK: I wasn't sure what the whole procedure was, physically.

MR. MILLS: The other thing you can do there is, actually, even if there is no scram capability at all, you could bypass some of your rod sequence control or rodworth minimizer and insert the rods with normal drive pressure, and that doesn't require any scram discharge volume on any part of the system.

But that would take more time, because you're talking about a minute per rod to drive those in that way.

MR. ABBOT: How would you bypass RSCS?

MR. MILLS: You would have to go down locally and push buttons.

MR. LIPINSKI: Where are these individual switches located? So you have a human factors problem associating a switch with a particular light?

MR. MILLS: Well, the operator knows where those switches are.

MR. LIPINSKI: But if I have 30 lights out of 180, I've got to pick out the right 30 I want to throw, unless I throw them all.

MR. MILLS: That's true. I think if the person were to try to do them manually and individually, he would have to have a good reason for taking the individual rods and just doing them individually. You would have to be pretty determined that you've got a particular problem.

The way you do it typically in a control room, you could have one guy in front and another guy at the panel flipping the switches, and you could call off the numbers and just give the right identification and you could flip them that way.

MR. LIPINSKI: The indicator is in the front and the switches are in the back now?

MR. MILLS: These individual rod scrams come off the test panel.

MR. LIPINSKI: And that's somewhere in the back?

MR. MILLS: Yes.

MR. LIPINSKI: So it's got to be a two-man operation, at least.

MR. MILLS: Yes, to do it that way, you would.

MR. LIPINSKI: Sounds like it's going to take a while.

MR. MILLS: If he had to insert them individually, it would take longer, certainly, than putting in just the regular scram.

MR. LIPINSKI: And by the time he gets around to it, the scram may be no longer possible, unless he's got a drain operation going.

MR. MILLS: But if he does have a drain operation going, in putting them in one at a time he's not putting much water in the scram discharge volume. So he may be able to scram at a slow rate and keep up with what's coming out of the scram discharge volume.

It would depend on the event. But the operators are not typically going to spend a lot of time trying to individually insert these rods.

I have, for example, a copy of the Browns Ferry procedure here and it specifies: Try the scram and the reset of that a number of times before you go to individual rod insertion. You'd have to have a good reason and some particular thing in mind to do it individually.

MR. LIPINSKI: Again, where you say reset the RPS, there are a number of trips that don't allow you to do this. I've forgotten what they were, but there's a list of four or five in your report.

MR. MILLS: That's right. During certain types of events, you would not be able to reset the reactor protection system.

This thing here was the various ways -- there are others, but it lists a number of various things that he could do. In some cases he would not be able to reset it. In a case like that, he would have to go over and perhaps manually open breakers that go directly to the reactor protection system and try to kill the power that way, or send people out there and open manual vents on the air header if the reactor protection system won't do it, or open the vent and drains in a discharge line, or go out there locally and take control so he could correct whatever the problem was.

It's really going to depend on the particular event, and I don't think you can really identify everything in a procedure like this and still get the flexibility to make a decision and do what really has to be done for that particular case.

MR. LIPINSKI: Have any procedures been drawn to date?

MR. MILLS: Yes, these have all been drawn up. All the boiling water reactors have met these criteria and have all these steps in their procedures.

MR. LIPINSKI: Are they drawn up in the form such as an event tree, so that you've got an event and you go downstairs and do so and so, or does he have to stand there and try to figure that one out by himself?

MR. MILLS: They're listed in the normal procedure format, with various steps that look a whole lot like this one, just how to go through this.

MR. LIPINSKI: But are the "if" conditions in there, such as if certain things prevent him from doing it, then he automatically knows what his option is?

MR. MILLS: The ones I have looked at, no, we have not had a lot of "if" things in addition to this. But this thing is set up so the operator could reasonably go through the sequence of events starting out with doing the things that would do the most good quickly, and then getting down to doing things locally that would get the rods in.

MR. LIPINSKI: Well, unless he's thought about it beforehand, where it says, can you reset the RPS, if he hasn't thought about what conditions prevent him from doing that, it could take him a while if he's in the wrong condition and he's got to stop and think about it, if it's not on paper for him in advance.

MR. MILLS: I'm sure in the procedures he's going to try to reset and scram. And he will have to try it, and if there's one of the signals in there he is going to have to move down the list and try something else.

MR. MATHIS: Well, Walt, the ones I have read are based pretty much on that, some kind of an outline, and I think it's one of those things, you cannot expect the guy to have a detailed procedure for every little potentiality. He doesn't have that kind of time.

MR. LIPINSKI: Well, on the Westinghouse procedures at Zion, they have those things laid out like a computer program, where you hit a branch, if you had a condition you went this way, and if you have this condition you went the other way, and you worked your way through the branch depending on what the condition are. And somebody else had pre-thought that out for the operator and they gave him that logical diagram so he could work his way through.

MR. MILLS: We also surveyed the pressurized water reactors, and George Schwenck is going to discuss that in a little bit, in just a minute.

This sequence here was applied to the boilers pretty much in this way. Maybe part of it is because we had the bulletin and we provided these criteria in here, so these criteria -- so they put it in in that sequence.

There may also be additional aids to the operator.

MR. KERR: I don't understand. You're referring to that as a set of criteria. It seems to me it's a set of instructions.

MR. MILLS: Yes, it really is a set of instructions. They were criteria in the bulletin. It is a set of instructions.

In the generically -- General Electric has gone through all of these instructions here as well and has agreed with them and has provided written communication to the utilities on implementing these instructions.

MR. BUCK: I'm still not clear. What do you mean, "criteria in the bulletin"? What was criteria there? I'm not clear on the English.

MR. MILLS: We actually listed each one of these items in the bulletin and said, in order to meet the bulletin requirements you must have in your procedure each of these items.

MR. KERR: So in effect you wrote a procedure for them.

MR. BUCK: Right.

MR. MILLS: In essence, we did, right. But it wasn't without generic discussion with GE and people in the staff that have followed ATWS, as well as the Browns Ferry event. I think that, given the situation, the way the plant is today, I think it is probably a very good and appropriate procedure for the BWR.

MR. WARD: Bill, what is it that turns the blue light on for each rod drive? Physically where is the switch located?

MR. MILLS: The blue lights are turned on when both the scram inlet and outlet valve have opened, which tells you you have completed --

MR. WARD: So it's not an indication of rod position, then?

MR. MILLS: No. The matrix, the core map that we had on the slide this morning, that showed the numbers from zero to 48, those are the actual rod positions. The blue lights --

MR. WARD: If I go back to number two there, what is the operator looking at for number two, whether the light's on or --

MR. MILLS: For this one, for number two, he will actually look at the rod position. And the blue light is right below the rod position, all in the same matrix. He has the matrix directly in front of him that shows the rod position. Then it shows the blue light, and then it has another light for the accumulator. And also, his lights to --

MR. WARD: What I'm driving at, is the rod position indication an unambiguous indication of the actual position of the rod in the core?

MR. MILLS: Yes, that's a good indication of where the --

MR. WARD: He can't be wrong? There's nothing indirect about it?

MR. MILLS: Only to the extent of individual failures, like if he had a light burned out or a problem with the particular switch or something that way. But otherwise it's a good indication.

MR. MATHIS: Bill?

MR. KERR: I was just going to add, it's a good indication if it's working, it seems to me.

MR. MATHIS: Is that it, Bill?

MR. MILLS: That's the BWR procedures, and I just had one slide on conclusions.

(Slide.)

And Vince will discuss this a little bit more later. The Bulletins Group provided a necessary and sufficient basis for continued operation, and it is based on keeping the scram discharge volume empty during power operation. And it is monitored continuously. So no matter what the source of the water is that gets in there, it will be detected by the continuous monitoring system.

And George Schwenk will discuss the PWR procedures.

MR. KERR: Mr. Chairman, would you consider a break?

MR. MATHIS: All right, we'll consider a break. Ten minutes -- wait a minute. He has got a five-minute presentation. We'll take it after that.

MR. SCHWENK: I'm George Schwenk of the IE staff, headquarters, and I'm going to talk about the results of a survey that was done by our resident inspectors to determine the adequacy of the Licensees' emergency operating procedures to respond to ATWS events.

(Slide.)

What I'm going to talk about first is some of the actions that we were looking for Licensees to take following a trip. Since there was no bulletin requirement specifically identified for PWR's, some guidance was given in the survey to the resident inspectors for what they should look for in the procedures that were in existence in BWR's at the present time.

These were the types of things we were asking residents to look at: the press trip manual button; if rods still don't move, begin immediate emergency boration and attempt to drive rods in. If rods fail to move, have power disconnect switch or breaker to rod holding coils open. Continue efforts to effect shutdown.

Those were also similar to the BWR's in having the operator have the complete authority to commence the emergency boration procedure.

(Slide.)

Now, the inspectors were told to --

MR. KERR: Let me see if I can understand this process of making it take more than five minutes. The plant operators were told to write emergency procedures, is that what started this?

MR. SCHWENK: No.

MR. KERR: They weren't?

MR. SCHWENK: No, sir, not for PWR's.

MR. KERR: But you thought they might have, so you asked the inspectors to see if they did?

MR. SCHWENK: Yes. The purpose of the survey was to determine the adequacy of the existing procedures of PWR's.

MR. KERR: Well, if they had not been told to write procedures, they might not even have had any, or did somebody give them a hint?

MR. SCHWENK: No, no hint.

MR. KERR: So you expected it, but you didn't find any plants that didn't have procedures?

MR. SCHWENK: I'll get into that in a results. I'll get to the results of the survey.

MR. KERR: I'm trying to understand the basis of things. Somebody showed up one day and said to the PWR operators: Do you have procedures for an ATWS?

MR. SCHWENK: That's correct.

MR. KERR: And then you determined whether they did or not, and if they were acceptable?

MR. SCHWENK: Yes, sir.

MR. KERR: And they had no hint before that that you expected them to have procedures, or did they?

MR. SCHWENK: For the operating plants, no.

MR. MATHIS: Dr. Kerr, maybe I could simplify that. When Browns Ferry 3 occurred, it became very evident that they did not have emergency procedures for an ATWS. So naturally, you go out then and say, well, gee, if Browns Ferry didn't have it, I wonder who else has. And that started the whole chain of events.

MR. KERR: I was not trying to make any judgment at this point.

MR. MATHIS: I'm just trying to explain. That is the way it started.

MR. KERR: Thank you.

MR. SCHWENK: Certainly plant conditions would be inspected and looked for in procedures to see whether they covered those actions, and the type of conditions we were looking at were: failure to trip when required; failure to complete trip when initiated, automatically or manually; inability to move or drive control rods; failure to automatically trip when a parameter exceeds the trip value; criteria for use of emergency boration system; reactor trip; and anticipated transient without trip.

So the inspectors took these procedures, went through them, and weighed against the criteria that would be set forth, and then made a judgment of the adequacy of those procedures.

(Slide.)

MR. KERR: How would an inspector inspect for failure to trip?

MR. SCHWENK: That would be the condition, and what he was looking for for those conditions were the things I had on the first slide, for something in the procedures which told the operator to depress, manually trip the plant, initiate emergency boration, and so forth, trip the breakers.

MR. KERR: So the procedure would say something like: If I don't get a trip when I should, then, and the "then's" would be --

MR. SCHWENK: Yes, sir. And I will get to it a little bit later. I Xeroxed a few pages out of a procedure. We may talk a little bit about that.

I have tried to group the results of this survey. We got it on an individual plant basis. But for better understanding, I grouped it in this fashion.

20 plants have procedures with no exceptions to the inspection requirements as outlined. Five plants meet the inspection requirements, but did not have them labeled in one place under specific ATWS procedures. And 20 plants had some minor exceptions to these inspection requirements.

MR. KERR: I thought you told me earlier -- maybe I don't know what an inspection requirement is. That's not the same as a plant requirement?

MR. SCHWENK: No, this was just guidance given to the inspector from headquarters, what to look for.

Some of the exceptions were in the area of clarity, connection between procedures, specific identity of an ATWS, and efforts to effect the shutdown.

So that's the results that we have gotten from this procedure.

MR. LIPINSKI: How do the results compare with the different vendors? Were the 25 associated with the vendors directly, or are they mixed?

MR. SCHWENK: They're mixed, except for one exception was that B&W doesn't have identified with [illegible] an emergency boration system. So it was difficult for the inspectors to judge the emergency boration system for that plant.

But following that I did my own survey of those B&W inspectors to find out whether they had adequate procedures for boration of the plant, and we found that was the case. But they didn't have a system labeled "emergency boration."

MR. LIPINSKI: Of the 20 plants that have emergency procedures, were there three vendors in this group of 20?

MR. SCHWENK: B&W would not be.

MR. LIPINSKI: So we find CE and Westinghouse. Now who is in the five? All three of the vendors? And the last 20?

MR. SCHWENK: A mixture of all three.

Well, that completes my presentation, if there are no questions.

MR. MATHIS: No questions?

MR. KERR: Who wrote the guidance for the inspectors? Who determined what sort of procedures?

MR. SCHWENK: Members at I&E headquarters staff.

MR. KERR: A number or a member?

MR. SCHWENK: I believe it was a single member, in consultation with others.

MR. KERR: And in the process he consulted with vendors and operating plants and people like that?

MR. SCHWENK: Yes, sir. And I myself, in my latest connection with this, which has been in the past few weeks, have been in touch with the various vendors to assure myself that these procedures are adequate.

MR. MATHIS: Any other questions?

(No response.)

MR. MATHIS: We will now have our ten-minute break.

(Recess.)

MR. MATHIS: The meeting will reconvene.

Mr. Rubin, you're on.

MR. RUBIN: Okay.

(Slide.)

The slides that go with this portion of my presentation are at the back end of the handout I gave you this morning.

I would like to now talk to you briefly about AEOD's assessment of the interim protective measures at Browns Ferry 3, required by the first I&E bulletins in the '78 series. This addresses the measures which were put in place a few weeks after the event and were intended to provide a basis for assuring continued safe operation of the plant pending long-term and hardware modifications to the SDV system.

Because of the importance of assuring scram capability and the length of time that temporary equipment and procedures would be in place, AEOD decided to initiate a detailed assessment of the interim measures. It should be pointed out, however, that the interim measures which we evaluated at that time have by now been substantially upgraded and strengthened.

This part of AEOD's presentation will briefly describe the interim equipment and its operation, discuss the equipment reliability and the human surveillance aspects of the man-machine, water monitoring system, and then talk about the safety procedures which were used if water was detected in the SDV, characterize the interim man-machine safety capabilities and limitations, and talk a little bit about the issue of degraded air, and then summarize our findings and recommendations.

(Slide.)

The interim measures at Browns Ferry consisted of both the original, but substantially discredited, RPS instruments in the system, together with some newly installed detection equipment and associated procedures. The new equipment basically consisted of an ultrasonic water detection system. The transducers were mounted directly to the east and west header low points.

(Slide.)

The detectors were mounted here and here, at low points, as well as several other header locations. These transducers --

(Slide.)

Let me go back to this one.

These tranducers were driven by a signal generating and processing device which incorporated both a CRT output display and a continuous strip chart recorder. A technique was used in which sound waves would reflect off an air-water surface. Electronic gating was used to screen out impulses from water accumulations of one inch or less in depth.

An alarm which was also provided when water depth reached one inch -- all this equipment, transducers, CRT, recorders and alarms, were all locally located at that time, right at the SDV header location. No equipment was installed in the control room.

With regard to the equipment reliability and surveillance, all transducers were tested prior to use to assure adequate performance. The equipment was callibration and operability checked once per shift by use of a standard pipe containing a known depth of water.

The system's local recorder output was observed once every 30 minutes by an auxiliary operator. In the event water accumulation was observed by the local operator, the control room would be immediately notified by walkie-talkie.

At that point, depending on the reported depth of water, the control room operator would or would not dispatch a more qualified QA inspector to the equipment to verify the reported readings. The control room operator's safety procedures, that is, his actions, in effect at that time, whenever water accumulation was reported in the SDV was as follows:

He would dispatch a QA inspector to verify the readings which were reported to be less than one and a half inches, and try to correct the problem. If reported readings were greater than one and a half, but less than two inches, a QA inspector was sent to verify the local readings, and if verified an orderly shutdown would be initiated within one hour. If water depth was reported to be greater than two inches, the control room operator would be required to initiate an immediately orderly shutdown without verification.

(Slide.)

It should be pointed out that since these scheme or system involved human diagnosis and actions, the attendant human factors contributed significantly to the capabilities and limitations of the system. The equipment response time and accuracy were very good. However, the human element contributed to diagnostic unreliabilities and time affecting the protective and corrective actions of the operator.

Obviously, for SDV filling scenarios in which water would be accumulating over several hours or many minutes, the time delays of the man-machine system would be considered to be acceptable. However, when water could quickly fill the SDV system in one or two minutes, these human time delays clearly would be critical, if not unacceptable.

The degraded air vent, as discussed earlier, is potentially such an event which involves rapid filling of the SDV headers. Also as discussed earlier, automatic detection against the loss of scram capability may not be assured in all cases. Clearly, a situation which involved a local operator looking at a recorder once every 30 minutes would not be adequate where water could accumulate within a couple of minutes.

We looked at what other control room indications and alarms would be available to the operator in such an event. There is a single low HCU header alarm in the control room, a local pressure gauge is available at the HCU's themselves.

The procedures in effect at the time of our investigation called for dispatching an auxiliary operator to take the local presure gauge verification readings if the control room alarm sounded. If air header pressure was verified to be less than 60 psi, the control room operator would be required to initiate an immediate manual scram.

AEOD believed that reliance on this sort of time-consuming scheme for timely reactor scram in the event of degraded air was not accurate. There are, however, other likely control room indications available to the operator in the event of many, but perhaps not all, degraded air situations. These would include multiple control rod drifting alarms, as well as multiple control rod drive high temperature alarms.

In response to these control room indications, I&E Bulletin 80-17 required immediate manual scram. However, AEOD could not be categorically assured that all degraded air events would result in these indications. That is, depending on the air pressure history decay, scram valve opening characteristics, control rod drive seal leakage characteristics, and the like, these indications may not be present for all cases.

At the same time, there would likely be other control room alarms sounding in the control room during this period as a result of the adverse effects of degraded air at other plant systems. These could divert the operator from the required protective action of immediate scram.

Accordingly, we believe that the degraded air event did not have adequate interim measures.

(Slide.)

From our review at the time, we arrived at the following principal findings: the then-existing interim system, which involved newly installed ultrasonic water detection equipment special procedures, together with the previously installed but discredited instruments, did not restore the level of scram capability protection thought to be assured in the original design.

Be that as it may, we believed that these temporary arrangements were adequate, however, for sources of water which would involve slow accumulation in the SDV headers, that is, say, over several hours. For fast-fill scenarios, and in particular for degraded control air situations, the interim measures in place at the time we looked were considered to be less than adequate.

Accordingly, we made the following recommendations: An immediate and early manual scram should be required based solely on control room HCU pressure indication of low air pressure, without first verifying pressure or waiting to observe indirect indicators, such as rod drift, that the SDV is filling. Do not wait, since other later control room alarms may get operator attention.

We all felt that redundant air header pressure instruments should be installed in the control room. Also, to aid the operator to focus on immediate protective action, a distinctive alarm for degraded air could be provided.

To improve the operator response time for other unidentified fast-fill conditions, we felt it would be wise to move the UT monitoring condition into the control room. Finally, we felt consideration should be given to providing an automatic scram off HCU air pressure if others who would be reviewing these same issues felt that the current recommended measures were still less than adequate.

And that's it. So again, the measures at that time left something to be desired. However, perhaps as a result of or because of other activities on the staff, matters have improved.

And with regard to the degraded air, by now an order has gone out that requires an automatic reactor scram, if you will, on a degraded air scenario. And UT monitoring systems are installed in the control room for other unidentified sources of water that can come in quickly, one of which came up just about a week ago.

I forget the plant, but one of the RPS channels was out and they were doing some maintenance work on the other RPS channel, and they ended up with one of the four subgroups in the energized channel becoming de-energized. The effect of that was that 25 percent of the rods had their scram valves open and the other 75 percent of the rods did not.

25 percent of the rods went in. And left unattended, the system would have filled up. I'm not sure exactly what -- I think the operator's action in that case was to scram the reactor. But that's an example of one of the things that we did not identify when we did our investigation, and we felt it would be wise to install the UT system in the control room for those kinds of things that we had not anticipated.

MR. BUCK: What does the UT system in the control room tell the operator? What precisely does it tell him, the depth of water in the tank?

MR. RUBIN: I believe the recorders now are required to be in the control room, and the depth measurement is read directly. There is no ambiguity in the level. Six -- six hash marks on a scale of six inches. And there are alarms for accumulations up to set depth.

So there is no need any more, under the most recent I&E bulletin requirements, to have the operator talking with an auxiliary operator on a walkie-talkie and the time delays involved there and the miscommunications that could come up there.

MR. PANCIERA: I'd like to say one thing on the cntinuous monitoring system. I would just like to point out that some plants have chosen to go a different route than the UT monitor. And there is one plant -- I believe it's Vermont Yankee -- uses a capacity probe. And there is another plant that actually uses float type switches right on the scram discharge box.

So while the majority of plants have gone with a UT monitoring device, there are exceptions to that.

MR. RUBIN: Our investigation was not intended to look at all the possibilities. In fact, at that time there was only Browns Ferry to look at. They were among the first to install a continuous monitoring arrangement, and it turns out that most of the plants have opted for the ultrasonic system, from what I understand.

And I think the value of the investigation was simply to point out the limitations of the system, since it is a man-machine system.

MR. KERR: You may have answered this question to either the Subcommittee or others, but help me some in trying to understand how you synchronize with the rest of the NRC staff. You investigated this and made some recommendations and some other parts of the staff also investigated and made some recommendations.

Do your recommendations go to somewhere in the NRC, to TVA? Were your recommendations and the rest of the staff recommendations distilled somehow to make a single set of recommendations? How does this work?

MR. RUBIN: On the front end, we do our own independent thing. We investigate where we feel there is a need to look into matters, and we utilize the good offices of the agency to obtain data from the vendors, from the licensees and so forth.

We then analyze it and if we feel that there are certain deficiencies from what we are looking at, then we develop recommendations. Some of these recommendations could be in the form of a short-term type recommendation, something that would be more appropriate for an I&E function, to implement in the way of a bulletin, a procedural type recommendation, say.

Some of them may be a longer-term design criteria requirement type, and so those would more appropriately go to NRR, in which case we would send them there. At that point they do not reflect the position of the agency. They simply reflect the recommendations of one office. And at that point they would be considered by the offices that we would send these documents to for review and comment or implementation or to disagree with.

MR. MATHIS: Vince, do you want to add to that?

MR. PANCIERA: I just want to say, this is what I was going to try to discuss, is how we took the AEOD recommendations, as well as the advice of the BWR Owners Group and other things and melded it into the safety evaluation report.

MR. KERR: Well, who decides when you do a parallel investigation of something that some other part of the NRC staff is investigating? Is that sort of up to the director of your Office? He decides whether something should be --

MR. RUBIN: The director has the final decision authority on what we call case study reviews, which involve a significant amount of staff time. And so the office director would authorize that we perform such a case study. And the Browns Ferry event investigation was one.

So it has his blessings, if not his motivation.

MR. JORDAN: Could I make a self-serving comment? The discussion we had earlier with Dr. Bender was the effect of some independent review of this event and the actions that we were taking. I believe the AEOD function is precisely that within the NRC staff, and I would commend that as perhaps a basis for part of the explanation back to Udall.

MR. KERR: Would you like me to pass that comment on to Mr. Bender?

MR. JORDAN: Would you, please.

MR. KERR: I would be glad to.

MR. MATHIS: Thank you, Steve.

Vince, you're on.

I'll make my other comment. If you miss the last shuttle, it's your own fault.

(Laughter.)

MR. PANCIERA: We're going to miss it, so I'm not going to worry about it.

(Slide.)

MR. PANCIERA: During the morning session, I tried to give you a chronology of staff actions that extended over about a six-month period. I would now like to tell you a little about how we developed the safety evaluation report and the major elements that were considered in the development of the report.

The first slide shows what I consider those major elements.

MR. KERR: Help me a little bit. Is the purpose of this so that we understand how NRC operates?

MR. PANCIERA: Yes. This would maybe answer your question as to what happened to the AEOD reports that went over to NRR, how did we use those reports, how did we factor them into getting the document that then we could sent to the Licensees and implement.

MR. KERR: That's probably a question I should have asked, but I really didn't. What I was asking was to whom they reported, whether to the NRC or to whom did they make recommendations.

MR. PANCIERA: Well, in this case here, the three reports that Stu Rubin has discussed earlier were sent by memo to Harold Denton. Harold Denton referred these reports for staff consideration in developing this SER. Does that answer your question?

MR. KERR: I would predict that in the not too distant future you're going to need a two out of three system, though, because you now have an unstable system.

MR. PANCIERA: Why is it unstable?

MR. KERR: Well, if the two of you disagree, who decides?

MR. PANCIERA: Well, that's what management's role is. If Stu Rubin and I disagree, then by God it should go up.

MR. KERR: Then management is the third channel, then. So you now have the two out of three?

MR. PANCIERA: That's right. And there is one Executive Director for Operation, and there is one Commission, if it ever got that high.

The four basic elements that went into the SER development, one I mentioned this morning, are the regional meetings. These meetings occurred at the end of July and the beginning of August. The purpose of these meetings was to really understand the system, understand the as-built conditions that existed in the field.

And I would like to show a slide that shows what we got out of that meeting.

(Slide.)

The objective was an in-depth understanding of the as-built conditions in the SDV, the instrumented volume interconnecting piping and vent and drain systems. We actually went to three regions -- Chicago, Atlanta, and King of Prussia. We sat down and had approximately two-hour discussions with each Licensee.

We had asked the Licensees to prepare to respond to two questions that we generated ahead of time. I think it was a very worthwhile set of meetings. And my strong recommendation would be, if we have a generic problem, a good face-to-face meeting in the regions with the Licensees is a highly desirable exercise.

The general areas we covered were system configuration, general layout, system design requirements. We were extremely interested in the interties between the SDV and some of the service systems, like the vent and drain.

And this morning I was asked questions about the NSSS-AE interface. We spent some time discussing that aspect. We went over the recent test results required of Bulletin 80-17, the valve open and close tests, the drain test. And then we also discussed with each Licensee emergency procedure, verification. Primarily at that point in time we were more interested in if the operator had to use the standby liquid level control system, did he have the key available to actuate that system and did he have the authority to do it?

And so that scopes out what we tried to accomplish during the regional meetings.

(Slide.)

On the next slide I would like to show --

MR. KERR: How did you find out if he had the authority to do it?

MR. PANCIERA: We asked them the specific question, did they have the authority. In some cases we found they did; in other cases we found they had to check with their boss.

MR. WARD: Which meant what, typically?

MR. PANCIERA: That before the operator could just actuate the standby liquid level control, he would have to check with some higher authority.

MR. WARD: Yes, but who would that be? The shift supervisor or an off-plant phone call or what?

MR. PANCIERA: I think in one case it was off-plant. I think in some cases it was his supervisor. Right, Bill?

MR. MILLS: It was shift supervisor in the cases I am familiar with. It might have been off-plant.

MR. PANCIERA: I think there was one case where he had to make a phone call.

I would like to discuss the following items: One is the SDV-IV hydraulic coupling. There are two basic configurations. I will show one briefly. We discussed it enough this morning that I don't think I have to go into a lot of detail.

(Slide.)

This is the first configuration.

The second configuration is the configuration that exists at Duane Arnold, Hatch and Brunswick, and some of the near-term OL's that are being licensed today. In this case you have an instrumented volume that is attached directly and integrally with the scram discharge volume header. The scram discharge volume header is shown schematically as a block.

It consists of a series of four-inch, six-inch, or eight-inch pipe, in some cases in the form of fingers, like this, in some cases in the form of an oblong doughnut, in some cases even having pipes at different elevations. In other words, you would have at this elevation connected to a header and another pipe at this elevation.

We found an extreme degree of variability as far as the actual configuration. We really did not find any plants that really looked -- well, maybe that's an exaggeration. A few plants looked like other plants. Most plants looked like they were custom designed, if I might use that term.

MR. WARD: Were any of them worse than Browns Ferry?

MR. PANCIERA: No. Let me get into that in just a moment.

(Slide.)

This is the Browns Ferry design. Browns Ferry -- we found, as far as the scram discharge volume to instrumented volume piping connection or piping run, we found in all plants of this design that this line was a two-inch IV line.

However, we did find that the runs of piping varied from plant to plant. They went all the way up from over 150 feet down to about 90 feet for the short run -- I mean for the long run. In the short run, they varied between about 15 feet to 30 feet.

We also found that the vent configurations were quite a bit different. In some cases, each scram discharge volume header had a separate vent. In other cases, the vents were tied together, so the dotted line shows a single vent valve.

We also found that this vent system, when it left this -- beyond this vent valve, tied in, and we found a large degree of variability on how they tied the system into other systems. In one case, Monticello, the system was a dedicated system. It went directly in its own run of piping to the reactor building equipment drain tank.

Similarly, for Monticello, this line went directly to the reactor building equipment drain tank. In other cases, we found a large number of interties. And I think it was mentioned this morning that in some cases the vent piping and the drain piping connected into a drainage header, which had a large number of other drain connections that eventually found its way down either to the reactor building equipment drain tank or the clean rad waste tank.

So we found a large degree of variability as far as what happens beyond this point, downstream of this point or upstream, whichever way you're looking at it, and downstreamm of the drain line.

This system downstream of these valves is basically designed by the architect-engineer with, in my judgment anyway, very little configuration control as far as the NSSS supply goes.

MR. LIPINSKI: This morning you said we were going to get on this subject in terms of what GE's requirement were and in terms of why all this variability appeared.

MR. PANCIERA: I will get into that very shortly. I think it's two slides down.

(Slide.)

Similarly, on the newer plants, here again you have the same tie-in or the same kind of configuration, either separate vent lines or combined vent lines. Here you have a two-inch line connecting the two instrumented volumes, then going as a single line to each drain valve. So that's the kind of configuration.

Here again, a large degree of variability in the vent systems and in the drain systems and how they intertie with other systems. This is one of the things early in the investigation, in the development of the SER, that at least convinced some of the people on this multi-disciplined team that was asked to write the SER that we should not depend on the vent system to provide adequate drainage to the IV and therefore adequate communication between the scram instrumentation and the hydraulics and the hydraulic fluid in the scram discharge volume.

(Slide.)

Now let me go back to this slide.

We discussed the two basic configurations. We discussed the scram discharge -- the SDV vent system and the SDV drain system. I would like to now get into the design requirements, and this is what you mentioned.

GE had provided a specification -- let me say this. As fear as the scram discharge volume, this system was really farmed out to Reactor Controls, Incorporated. This was a small outfit, as I understand, based in California. They did the primary design of the scram discharge volume system as a subcontract to GE on the turnkey contracts, the contracts where GE had retained full responsibility for the design and construction of the plant.

Later, when the turnkey concept I guess changed and a lot of the balance of plant work was given to an AE, we also found in those cases the AE, and in some cases the Licensee who was doing his own design work, also farmed this out to Reactor Controls.

But GE did supply the vent valve and the drain valve, and they did supply a specification. Now, the specification, for instance, here SDV volume requirement presently would call for 3.34 gallons per rod. In other words, the volume should at least have 3.3 gallons per rod. If you have 100 rods, then you have 334 gallons.

This is a fairly new requirement now. Prior to that time, it was somewhat less than that. I believe it was about 1.8 gallons per rod. And GE put out what they call an information letter which changed that to 3.34. That's why you find in some cases where you have a configuration were one pipe, and then at another elevation you have another pipe.

In other words, the Licensee in order to provide the adequate volume did take and add on piping to provide that volume. We found two plants -- Nine Mile Point and Oyster Creek -- that do not meet this volume requirement right now. But they will have to meet it when they adopt the criteria that's been developed for the long-term fix.

I mentioned the piping slopes. The GE document did call for piping slopes, and this was one-eighth of an inch per foot. And we found that in almost every case that one-eighth of an inch per foot was adhered to, both in the piping that connects the scram discharge volume to the instrumented volume as well as the vent piping.

Dynamic loads. The scram discharge volume basically meets the seismic requirements from this valve --

(Slide.)

-- up to the drain valve.

We couldn't find anything where there was any kind of foresight as far as designing the system to take the kinds of dynamic loads that were seen because of the Brunswick event, where the floats were crushed and some of the drain piping was pulled away from the support. So that's where we stood on that.

(Slide.)

I mentioned the design interfaces. If you have any questions, I will be glad to answer them. But as far as we could tell, this was a farmed-out system. I felt it did not get an adequate review, either at the Licensee level or at the staff level, for that matter. It looks like it was put together -- it was a hydraulic nightmare.

MR. LIPINSKI: Reactor Controls must have done quite a few of these. How many of all the BWR plants did Reactor Controls do?

MR. PANCIERA: They did every one of them. Even in the case of TVA, TVA farmed this work out to Reactor Controls.

MR. LIPINSKI: And they put all the variations --

MR. PANCIERA: Well, variations as far as the header positions. They did follow the minimum requirement, the minimum volume requirement. They did follow the slope requirement that GE had laid out.

The actual geometric configuration of the scram discharge volume varies quite a bit. I'm not sure that particularly hurts you as far as whether you have two pipes side by side that are eight-inch or if I have three pipes six-inch side by side. I'm not sure that really hurts you that much.

I think what we found was that where there was a lot of variation that really hurts you was downstream of the vent and drain valves, because -- yes, sir?

MR. RAY: Didn't you find that Reactor Controls actually issued construction drawings or did they leave to field designers the physical construction details?

MR. PANCIERA: My understanding is they actually issued drawings.

MR. PITTMAN: I know at Browns Ferry, where I got the drawings over in my office, the drawings themselves that Browns Ferry used to construct it actually had Reactor

Controls title blocks on it.

MR. PANCIERA: But downstream, it was strictly up to the AE or the Licensee. So there was very little control downstream of those valves.

But upstream of those valves, including the scram discharge volume, it appears that Reactor Controls actually did the design work.

Any other questions on this slide?L

(No response.)

MR. MATHIS: No. Let's move.

MR. PANCIERA: Okay.

(Slide.)

I would like to go to the next line item on the slide, AEOD evaluations. We did use the AEOD evaluations. We found them very helpful in trying to arrive at a staff position. And I will discuss a little bit more how we took these and developed our own position in working with the BWR Owners Subgroup.

But I would like to go into this next item. About the time of the meeting that we had with GE, about the 7th of August --

(Slide.)

-- we decided that at that time -- I guess there was a lot of criticism that the staff in some cases was toc prescriptive. We decided that we would try to solicit the assistance of the BWR owners to work with us on trying to develop a fix on the long term.

And so about the 6th of August, when we were meeting with GE and with a lot of the owners, Paul Check made the suggestion that a BWR Owners Group be formed to address this problem. This Owners Group was established around the 20th of August. I would like to just go through and give you a feel for how this worked.

The owners met shortly after their establishment, and by the 19th of September had come in with criteria that they felt addressed all the problems, the problems that had been uncovered by the Browns Ferry and also the problems that had been uncovered by the Hatch-Brunswick problems with blocks.

They came in with draft criteria at that time. We had some problems with the way the criteria were organized. We discussed these problems. They went back, worked on it, came in on 10-15 with another set of criteria.

We met with them. They identified areas where there was some disagreement and we tried to iron out those. There were two areas of disagreement. One was we did not want to depend on adequate venting to assure that the instruments -- that the water got to the instruments.

The second area that we disagreed with them on, or they disagreed with us on, was this question of diversity.

And I will discuss that a little bit later.

This chart was made out, this flow chart was made out, before we even met with the owners, and it pretty well followed this flow pattern. And even today it is a good history of what happened.

ACRS comments were considered. We considered the AEOD recommendations. We reviewed the I&E bulletin responses and reviewed the as-built information that we got as a result of the meetings.

We came along here and developed what we considered were minimum acceptable requirements. At the same time, the owners developed system design and performance criteria. They came in, they proposed the criteria. We met with them. There were two iterations.

Basically, then, our SER endorses the owners' criteria, with one particular exception on diversity. The Owners Subgroup then presented it to the full Owners Group and these criteria were endorsed by the Owners Group.

I might point out that GE's recommendations were also factored into what the owners came up with. And GE participated in a lot of the owners meetings.

I think it was a good experience from our point of view. I think it tended to get the owners involved. I think they understand their plant better than we do. We had good interface with them and I think it was a worthwhile experience.

I will say one thing, and I will show you the criteria as we go through the presentation. The criteria are somewhat general, and at first my inclination was to get very prescriptive. However, I think the owners felt they couldn't be too prescriptive because they were dealing with a large variety of plants.

I think what finally came out of the Owners Group -- and you might find it somewhat general -- however, we did take the owners' criteria and for those criteria that were important from the point of view of design we did specify the SER and means acceptable to the staff for complying with the criteria.

So we start with general criteria and we gave specificity by coming up with, here is a means acceptable to us for complying with it.

MR. RAY: Did this process of reconciliation apply only to long-range fixes or did it apply also to the short-range?

MR. PANCIERA: No, it did not apply to the short range, because the short range were really established by the bulletin requirements. We did get the Owners Group involved when we were trying to come up with a solution to this degraded air problem. But the owners were not asked to address the short term. They were asked to address the long term.

(Slide.)

I would like to get into the major sections of the safety evaluation report. There are a lot of other sections where there is the introduction or the definition of the problem. I think you have heard all of that before.

I think the two big areas that I want to address here are: one is the justification for continued operation; and two, the long-term program. I think that is really the heart of the SER.

The justification for continued operation, I mentioned that back in October -- originally, the way we had conceived this SER, it was really going to address just the long-term program, the criteria, the technical basis for the criteria, the acceptable compliance that I mentioned, and the implementation.

The decision as made that we ought to really look at justification for continued operation, and the basis we used is we took each one of the bulletin requirements -- we actually did it in a systematic way. We made out sheets that addressed each one of the bulletin requirements, 80-17, Supplement 1, Supplement 2, Supplement 3, and 80-17. So we had the bulletin requirements on one side.

We went through and laid out the Licensee's responses to the bulletin requirements. We got input from

Inspection & Enforcement through the resident inspectors that gave us an evaluation by the resident inspectors. And then finally, we reviewed the whole thing and made a judgment as to whether or not they had complied with the bulletin requirements, and that was the basis for continued operation, with one exception.

The exception was this question of degraded air and the fast-fill scenario that could result from degraded air. We did address it by addressing the bulletin requirements, the requirement that when you get an air system pressure that is 10 psi above the pressure of the scram discharge valves, you manually scram the plant, or if you get other indications, like rod drift of hot rise. So we did address it.

But during that time one of the things we had to come to grips with is, could the operator respond in a timely fashion to a loss of air scenario, the kind that might fill up the scram discharge volume in something between 85 seconds and two minutes. And that was not covered by any system to automatically cause a scram because the degraded air event was not covered by bulletin requirements.

And so in the SER you will find that we specifically address a requirement to install an air dump valve in the air system that will automatically dump the air once you get down to this pressure or 10 psi above the pressure of the valve.

And let me just quickly put that slide on. I've gone a little bit out of sequence, but I think it's worthwhile.

(Slide.)

The SER addresses this one here: Install an air dump valve in the control system to initiate rod insertion when you get down to roughly 52 psi. So the basis for continued operation was satisfaction of all the bulletin requirements and its supplements, as well as implementing the short-term modifications. And that's what formed the basis, in our judgment, for the continued operation of these plants.

Now, we also did -- and you will see that the SER has an appendix that's half again as thick as the SER itself. And that appendix does take each one of the bulletin requirements and treats each plant on a specific basis. And we did find some discrepancies in the Licensees' response.

For instance, we did find some plants that were still, upon a loss of air event, would still send a man from the control room down to the local station to read the gauge and then make a decision on whether or not to scram the plant. We did find situations like that.

And in the review, working with I&E and its residents, we did correct those problems. So it wasn't all a clean deal where the Licensees' responses were suitable in every case.

MR. KERR: Remind me again. What is the problem with making a decision when you see air pressure going down, that you just don't have time to make a decision?

MR. PANCIERA: No. There is an air pressure alarm in the control room that alarms and annunciates. However, there is no direct-reading air pressure gauge in the control room. That is only located locally, or it was.

So what some of the Licensees were doing is, they would get the low-pressure alarm -- and they had the low-pressure alarm set at something like 70 psi. They would then send a man down to read the local gauge and verify that the pressure was going down. And then they would make the decision to scram.

We did not feel that that was an adequate response to the bulletin requirement.

MR. KERR: How did you conclude that what you are requiring is in the long run less risky than what they were doing?

MR. PANCIERA: Because what the bulletin required was an immediate manual scram.

MR. KERR: I understand that. But how did you decide that that provides less risk in the long run than a procedure which goes and looks at what is happening to the air?

MR. PANCIERA: Because we felt on a degraded loss of air you might not have the time to go down and investigate.

MR. KERR: No. But every time you scram the reactor you introduce some risk. How do you balance that? How did you balance that against the assumption that every time you get an alarm you scram without investigating further?

MR. PANCIERA: Well, it was a judgment, doctor. It was a judgment on our part that we felt, if you had that kind of a situation, you might have a situation where you would --

MR. KERR: If you have a situation in which you scrammed the reactor, you have the reactor out of control. And every time you scram it, you subject the plant to stresses which limit its ability to withstand further stresses.

So how do you make a decision?

MR. PANCIERA: As I say, it was a judgment.

MR. WARD: Is this going to result in more scrams or is it going to result in those utilities who had the alarms set at 70 psig setting them at 40 or something?

MR. PANCIERA: The utilities basically have pulled down the pressure set point on the alarm. In other words, that utility that had it at 70 has brought it down to something less than that.

MR. RUBIN: I think, as I pointed out earlier, the degraded air event or the connotations or ATWS concerns, in that you are potentially evolving it into a can't scram the reactor, because water is getting into the SDV at the same time that other plant systems are being perturbed, which will require a scram.

So I guess the judgment by the staf is that, weighing an ATWS concern against a simple tripping of the unit --

MR. KERR: Tripping of the unit is not simple. If the staff thinks that tripping of the unit is simple, then it seems to me the staff ought to take another look. Believe me, that is not simple.

MR. LIPINSKI: You have imposed a minirum safety requirement with respect to averting an ATWS. If I were a utility and wanted to watch the availability of my plant, for a few extra dollars I could install another pressure sensor that would give me an alarm before I hit the scram trip point, so if there's any measures I could take I could restore air pressure before I went into the scram.

You're not insisting they take the scram? They could also put in another sensor and --

MR. PANCIERA: Sure they can. The point we were saying, that if you get down to a pressure that is 10 psi above the nominal scram discharge unseating pressure, then you have to scram the plant.

MR. LIPINSKI: Right, because your analysis shows that the time remaining is such that you could be in trouble.

MR. KERR: Walt, they didn't tell me they had done an analysis which said that the time remaining would show they would be in trouble. They just said there were circumstances in which they felt one potentially could be in trouble.

MR. LIPINSKI: There's a plot in here showing how the pressures are coming down.

MR. KERR: But you can't know how it's coming down unless you know what's causing it to go down.

MR. LIPINSKI: Based on the leakage rate through the valve, you can then show how the level is building up with time. That was an assumed air pressure that was picked as the value for that point; am I correct?

MR. KERR: Are you saying that every time the air pressure goes down it goes down just because of one mechanism and at the same rate?

MR. LIPINSKI: No. If the air pressure comes down, the particular discharge valve is partially opened and you have got a certain leak rate coming out of that valve. Based on the amount of time for fill, you then reach a condition where if you did call for a full scram you couldn't, because the volume is full.

MR. KERR: But this assumes a decrease in air pressure or something, doesn't it?

MR. LIPINSKI: Yes, it does.

MR. KERR: Well, I think we are arguing details. And I am not trying to take a position. I am just trying to understand how the staff made its decision.

MR. PANCIERA: Well, as I said, it was judgment on our part. And in one case, if you had this kind of degraded air situation, you had the risk of having at least a failure to partially scram the plant against the other case of scramming the plant. I recognize that every time you scram the plant you take some life out of the plant.

It was strictly a judgment that here you had what we considered a real live scenario, and we were weighing that against some harm that might be done by scramming that wasn't really that specific, and we just made the judgment that you had to scram the plant.

MR. KERR: Since TMI-2 it seems to me there have been a number of situations in which it is assumed that the safe thing to do is scram the plant. I guess I am skeptical of scrammed plants being all that safe, both during the time when they are coming down from power and during the restart, and the stresses that this puts on the plant.

MR. PANCIERA: Sure. In fact, I remember a couple of years ago discussing the seismic scram, and that was one of the considerations, that you might not want to scram the plant at that point in a seismic event because of the damage you might do.

MR. PITTMAN: If I remember right, some place along you are looking at the situation and you look at what the effects would be on the plant and the operation with the loss of instrument air. And I think at one time it was asserted that there was a very high probability that a scram would be commanded, on down some further time with the loss of instrument air.

And so what we have is a very close coupling. If we lose instrument air and don't scram, eventually a scram will be commanded, and they we probably would not be able to get it.

MR. PANCIERA: When you're getting down to 50 psi, you're on your way to a scram whether you like it or not, that's true.

Okay. I would like to show this table and then go back to the short-term modification.

(Slide.)

But this is entitled "Generic Applicability and Major Interim Actions to Be Provided Until Design Deficiencies Have Been Resolved." By that we mean the long-term fix, which I will get into later.

But here we have tried to mention the design deficiencies, inadequate coupling, and the major action that was taken as a result of the bulletins was to monitor the SDV for water accumulation.

Here, complex vent piping; applicability, all GE BWR's. In this case here, Brunswick, Hatch and Duane Arnold were exempt from this monitoring because they have a close coupling between the instrument volume and scram discharge volume. In the case of the complex piping, the requirement was to provide a positive vent directly to the reactor building atmosphere, and that was done.

Level switch problem; the requirement was to functionally test level switches after each scram using water, and that would be where you would actually fill the volume that contains the switch and observe its actuation to assure that you did not have a faulty switch.

The last item -- and we discussed this partially -- here again, plants that have the good hydraulic coupling were exempt from it, but an automatic air header dump on low air pressure, the thing we just discussed, with the interim backup of a manual scram on low air pressure on the low air pressure alarm when the pressure of 10 psi above the unseating pressure is attained.

So this summarizes the bulletin requirements. In our judgment, that satisfied the bulletin requirements and providing a means for automatically scramming the plant on loss of air is sufficient for justification for continued operation.

Let me go back to the short-term modification.

(Slide.)

We have been in contact with the various Licensees. Some Licensees are going to go with an air dump valve in the control air system, which basically, when you reach a certain air pressure, quickly dumps the air. So it basically forces the rods to gc in. It dumps the air, causing the scram inlet valve and outlet valves to open, because it pulls you through this critical pressure range and actuates the system just like a regular scram.

Two alternatives being considered by Licensees is: One -- and I guess this is based on recommendations by GE -- is providing pressure sensors in the control air system which are in series with the scram level instruments, and that's another alternative being considered.

A third one, also recommended by GE, is to provide a separate trip channel with control air sensors -- or pressure sensors in the control air system.

MR. KERR: Has anybody thought of trying to improve the reliability of the instrument air system?

MR. PANCIERA: Not as far as this SER goes. We did not address the overall improving.

MR. KERR: Because it seems to me -- and this is a superficial opinion; I haven't looked at this in nearly as much detail as you have -- that you and they are still going at things which say, if we get in trouble let's trip. And that's probably necessary.

But at the same time, it seems to me one ought to look at possibilities that you won't need to trip. I don't know what the instrument air reliability is on these plants, but I get the impression it could stand improvement on some.

Have the people involved maybe concluded on their own, without the NRC telling them, that maybe instrument air systems ought to be somewhat more reliable than they are?

MR. PANCIERA: Let me give you one point on the curve. I went down to Browns Ferry a couple of month ago to look at their problems associated with the air system. And back about three years ago, there were quite a number of trips because of the air, and from then on you see virtually no problems with air.

And I asked them what had happened. And what they did was, basically they increased the redundancy and capacity of that system by more than 100 percent, and as a result they have not had a lot of problems with loss of air.

And I guess that is a very good approach. Bill, do youy know if the Stello memo that talks about control air, does that address improvement in the air system?

MR. MILLS: Yes, I think the effect of that memo would be an improvement on the air system. But it really says, generically, let's look at the air systems and try to improve the reliability. And maybe the way to do it is to backfit an operating plant.

There are requirements in the standard review plans which do address air systems, but are applied to new plants and construction.

MR. LIPINSKI: If air systems are electrical, you could have a Class 1E specification, and that puts it to the top of the list and it gets treated accordingly. You don't have anything like a Class 1E air system, do you?

MR. PANCIERA: No.

MR. LIPINSKI: Everything's hung on the air system and it may be a good or a bad system. And we now have an air system interplaying with the PPS.

MR. PANCIERA: In fact, part of it may not even be seismic. I think we looked into that. Part of it is not even seismic.

MR. MATHIS: This also gets into the age-old question of everything that we're talking about up to now has bee mitigation. And Bill says, why don't we go back and prevent for a change?

MR. LIPINSKI: Prevention is again an economic question. Once an operator is faced with a scram, he can avoid that and a half million dollars a day by investing in the other end of the problem. And as soon as he knows he is faced with a scram, he's got an economic incentive to pay attention.

MR. PANCIERA: This modification is an interim modification. But once you improve the hydraulic coupling in the scram discharge volume so that you have the instruments almost integral with the headers, then this problem really goes away, because then any water going into the scram discharge volume immediately goes down to the low point and you scram the plant in a very short period of time.

So the installation of the air dump valve or any of these other alternatives are interim until you effect or implement the long-term modifications.

Now at this point, we talked about this and I would like to have Mike Goodman --

MR. KERR: I'm a little puzzled about that in terms of the long-term modifications. Could you put that slide back you were just showing and let me see if I understand what your point is?

MR. PANCIERA: Surely.

(Slide.)

MR. KERR: Does that mean alternative short-term or alternative short term.

MR. PANCIERA: That's short-term.

MR. KERR: I understand. Thank you.

MR. PANCIERA: At this point I would like to stop for a minute. In arriving at the decision to put in an automatic -- a system to automatically insert rods on loss of air, there are a lot of considerations, human factor considerations that went into our decision. I would like to call on Mike Goodman, who is from the human factors -- Division of Human Factors, and ask him to give you a very short presentation on some of the considerations that went into their objection to depending on the man-machine interface to solve the problem.

Mike?

MR. GOODMAN: I'm Mike Goodman with the Division of Human Factors Safety.

Let me start out by saying there are a number of aspects of the operator, the control room, in a specific emergency situation which can have an impact on the ability of the operator to act in a timely fashion. It's the uncertainty associated with these aspects that forms the basis of our assessment that with a loss of air event the operator may not be able to act in a timely manner.

In evaluating the human factors aspects of the situation, we assumed a limited time frame of approximately 85 seconds from rod drift indication to the point where the operator could no longer achieve full rod insertion with a single scram. Based on the uncertainty of the conditions that would exist at the time of an event, it was our judgment that 85 seconds was insufficient time to be assured that the operator would be able to scram the plant.

This judgment was reinforced by our observations and discussions with the personnel at the Browns Ferry facility, where characteristics of the loss of air annunciator system and the inconsistency among the operators in regard to what the appropriate response would be to a loss of air event rather supported our concerns.

It was therefore our recommendation that automatic insertion of the rods was in fact necessary.

And I will entertain any questions.

MR. WARD: This question is really meant maybe for Vince. But there is just the variability among the BWR's for the vent and drain systems. Does that make this 85 seconds variable?

I get the idea that most of the analysis and certainly the little experimental work that was done was based on the Browns Ferry 3 design.

MR. PANCIERA: Yes, the AEOD work was primarily based on the Browns Ferry design and Quad Cities.

MR. WARD: It was from that that you deduced 85 seconds? Might it be significantly different for 80 plants?

MR. PANCIERA: George, do you want to answer that or do you want me to?

MR. SCHWENK: Go ahead. But I think it's based on the common characteristic from a two-inch drain line, and also the fact that you have about half the control rod drives feeding each header, and the fact that the volume in the east header or the west header does not vary. It's usually about 3.3 gallons per drive.

So the actual volume of the different sites is rrelatively constant.

MR. WARD: But you don't have the two-inch drain line in some of the plants, do you? Well, not between the header and the instrument volume, anyway.

MR. PANCIERA: No. In the older plants, you have a two-inch drain line that connects the SDV header to the instrumented volume. In the newer plants you don't have that. You have basically an extension of the SDV into a pot which contains the instruments.

In those cases we don't worry about this loss of air event because you have good coupling between the SDV and the instrumented volume. Any water that comes in there doesn't run the danger of being held up in the scram discharge volume. It runs right down.

MR. WARD: So you're not applying this to Hatch?

MR. PANCIERA: Right.

I would like now to go into the long-term criteria. I will try to speed this up a little bit. If I go too fast, stop me and I will come back.

MR. MATHIS: Just speed on.

MR. PANCIERA: The long-term criteria that were developed by the Owners Group consist of one functional criteria, five safety criteria, five operational criteria, ten design criteria, and three surveillance criteria.

(Slide.)

There is a certain degree of overlap between safety criteria and design criteria. The safety criteria are more general in nature, and when we get down to design criteria we're more specific.

I'll try to just hit the high points of these criteria. The technical justification for the criteria as far as the criteria themselves are included in the SER, the generic SER. If any of you don't have copies of that generic SER, we could make copies available to you if you would like a further look at these.

But let me quickly go over these.

(Slide.)

The first one is the functional criterion. It's the only one -- it is a general criterion, and it basically says that you should have sufficient capacity to receive and contain any water exhausted by full reactor scram without any adverse effects. It forms like the basis for the other criteria as we go on.

(Slide.)

Safety criteria. The first one basically satisfies the single-failure criterion. It says, under the most degraded conditions that are operationally acceptable, here again no single failure shall prevent uncontrolled loss of reactor coolant.

This is the concern about the vent and drain valves, the single vent and drain valves. It provides that the instrument shall provide sufficient redundancy to operate reliably under all conditions and shall not be affected by hydrodynamic forces.

This addresses basically two problems: One is single failure-proof requirement for instrument -- this is the scram level instrument, the ones that are up at the 50-gallon point in the instrumented volume -- and it also addresses this question of hydrodynamic forces that were generated as a result of either scram or reset at Brunswick and Hatch.

So it's rather general, but it kind of lays out or scopes out what are the safety considerations.

This one: System operating conditions which are required for scram shall be continuously monitored.

The last one, that's the requirement that you shall not bypass the scram instrumentation when you're working on it. In other words, basically I guess right now the tech specs require that if you work on a scram system -- in the scram system, that you have to take at least a half scram.

And so these are the five safety criteria.

MR. RAY: Could you discuss number two a little bit? I'm a little confused on what that means.

MR. PANCIERA: Number two says no single active failure shall prevent uncontrolled loss of reactor coolant. I'll give you a for-instance. Suppose in the system we have a vent valve, and suppose the vent valve doesn't close upon scram. So now I have reactor coolant coming through my seals and to the scram discharge volume, filling up the scram discharge volume, and then going out the vent.

MR. RAY: Well, the word "prevent" is bothering me. I wonder if you mean "promote" or "cause" rather than "prevent." You know, you want to prevent uncontrolled loss, don't you?

You do want to prevent it.

MR. RAY: But the failure is not to prevent it. The failure is going to cause it. No single act of failure shall cause or permit uncontrolled loss. I think that's what you mean, don't you?

MR. PANCIERA: That's what is meant. It might be a typo. I'm sorry. But one act of failure should not allow water to go out of the system, especially if you lose the ability to reset.

MR. RAY: This is what I thought you meant, but that isn't what that says.

MR. PANCIERA: I think that's a typo.

MR. MATHIS: Vince, one other question on that same item:

If you interpret that the dump valve is open, and if you didn't control it, you'd continue to lose reactor coolant. Does that mean you are going to have to put in a second valve, remotely operated, so you could shut it off?

In other words, I'm getting back to the boundary problem of the primary coolant.

MR. PANCIERA: You put in double valve isolation, and then if one failed to shut, you would have the other. And I will show that one. We show acceptable means to implement the criteria.

MR. CATTON: You have to be able to open them, too.

Does that you have to put two trains?

MR. PANCIERA: Well, if you design the system hydraulically in a correct way, then you are really not depending on either the vent valve or the drain valve operations from the point of view of scram. You see what I'm saying?

If I have the ability to get any water that's coming in there down to my instruments and I scram the plant, then whether the valves change position or not, it may affect my ability to go back into operation.

MR. CATTON: Okay. I understand.

MR. PANCIERA: Do you have a question, sir?

Now the next set of criteria are covered in the SER. However, we regarded this subset for basically faciitating reactor operations. The owners agreed that these had no safety implications, as such, but they were concerned and they wanted to make sure they did not adversely affect the ability to operate the plant. So they are included in the SER.

But there is a statement that says that these really cannot bear on safety. They are mostly for operational convenience, and they deal with causing scram or causing spurious scrams. Vent paths shall be provided to assure adequate drainage in preparation for scram reset.

Now if you get the good hydraulic coupling, you don't need a positive vent to assure that you are going to scram, but you may have a problem in getting the water out of there if you want to go back in operation.

So these five are included. They were included at the -- the owners developed them and they were included in the SER, mainly to make the criteria complete, and to at least address the owners' concerns.

Any questions on these?

MR. WARD: Could you go back to the safety criteria again?

MR. PANCIERA: Surely.

(Slide.)

MR. WARD: With the first one, the single failure criterion, are you trying to parallel there the IEEE requirement?

MR. PANCIERA: Well, even a single failure requirement on the general design criteria ---

MR. WARD: As I understand it, there is a requirement that if a component isn't monitored, it can't be monitored, it's considered failed -- it has to be considered in the failed mode, or something like that?

MR. PANCIERA: Yeah, I think so. I'm not sure.

MR. WARD: Are you requiring that in your definition of single failure here?

MR. PANCIERA: No.

MR. WARD: In other words, does every block valve in the system have to be monitored somewhere?

MR. PANCIERA: You mean here or the first one?

MR. WARD: The first one.

MR. PANCIERA: No, I think we were looking at primarily the -- I don't think we felt that every block valve had to be monitored. I'm not sure -- in other words, no failure of the valve or any component or even, for that matter, service function, should stop you from scramming the plant, and that's primarily with instrumentation, but I think it covers other things.

(Slide.)

Now we go to the design criteria. As I mentioned, we will see some duplication. The first criterion refers you to the GE OER-54. This is the 3.34 gallons per rod. So the owners wanted to put that right in the criteria.

This really, in my mind, anyway, is one of the most important of all of the criteria, and basically this establishes the need for good hydraulic coupling between the scram discharge volume and the instrumented volume.

It also requires that there be no need for either a vent or a drain --- that you should not need a drain or vent to get adequate scram function.

So this really is one of the key criterion, and this is where we had some of the problems on working with the owners -- not that they were a problem, but negotiating, because we felt very strongly that you should not depend on -- you should not have to depend on an adequate vent in order to assure scram -- the scram function. And right now, many of the plants, prior to the requirement to install a positive vent to the reactor building atmosphere, a lot of the plants depended on a positive vent to allow the water to go from the header down to the instruments.

Here the level instrumentation shall be provided for automatic scram initiation while sufficient volume exists in the scram discharge volume.

Here again this criterion is tied to this criterion, in that you should be able to initiate scram long before you lose your volume. The way you do that is couple the instrumented volume with the scram discharge volume.

MR. MATHIS: Vince, maybe I'm reading that wrong, but if you said provided for automatic scram initiation while sufficient void exists in the scram discharge volume?

MR. PANCIERA: That might be an improvement.

MR. MATHIS: To me, it would read better.

MR. PANCIERA: Let me point something out: These criteria were developed by the owners. We made comments on them.

However, it's their words. I think that at least in my own opinion in general they did a good job. But I think there may be areas where there is some word improvement that can be effected.

But one of the things I religiously did in the development of the SER is once we got their final criteria, I didn't change their criteria. I didn't change a word.

In fact, there might even be one place where there was somewhat of a stilted wording, but I didn't change it because I figured they're staff criteria, and I had no business changing it. I can take exception to it, I can comment on it, but I can't change their criteria.

The third item, instrumentation taps shall be provided on the vertical instrument volume and not on the connected piping, I neglected to say that during our original meetings, when we were looking at specific designs, we did find that some of the scram instrumentation was not attached to the instrumented volume itself, but was attached to either the vent or drain piping.

There was concern both on our part, as well as on GE's part, that tying it to the vent-drain piping was aggravating the situation where you could get a high large hydrodynamic force, because here you are tying a line to a vent piping and you could get large pressure imbalances across that particular instrument.

So the requirement was put in by the owners that all the instrument taps shall be provided on the instrumented volume, and not on the connected piping.

I think the most important thing here is the single failure in the instrument system, or the plugging of an air instrument line shall not result in your inability to detect water accumulation in the instrumented volume.

(Slide.)

Design criteria continued.

Some of these are general, and I am going to skip some of them.

This deals with loading on the system and adverse environmental effects. It's rather general in nature. It was included in the original GE spec that went out with the system.

MR. KERR: Vince, if I can go back briefly to No. 4 -- I think it will be brief ---

(Slide.)

-- was there a deliberate use of the word "detecting" as contrasted with "measuring"? It seems to me the purpose of the instrumentation is to measure the water accumulation, rather than detect it.

MR. PANCIERA: Well, it measures only in increments, though. You have a three-gallon --

MR. KERR: So from your point of view, "detecting" is the right word to use?

MR. PANCIERA: In fact, we discussed this originally. One of our proposals was to say measuring, and that was the reason.

(Slide.)

I won't go through all of these. If you have any questions on it -- here is the requirement on system geometry shall encourage continuous draining. Instruments shall be provided to aid the operator in the detection of water accumulation in the instrumented volume prior to scram initiation.

There is some question in people's mind whether this should be an operational criteria. I guess our thought was this is the first line of defense. This alerts the operator that he may have a problem with water accumulation and this requirement basically is satisfied right now with the alarm and rod block instrumentation that exists today.

MR. KERR: Tell me what No. 9 means. I thought all of the instrumentation was to aid the operator in the detection of water accumulation.

MR. PANCIERA: This is primarily -- this deals with the alarm and rod block. Once you get up to the scram level instrumentation of the 50-gallon point, you have lost the ball game and you scram the plant. There is three levels of instrumentation:

There is the alarm level, which is at about three gallons.

There is the rod block, which prevents withdrawal of rods, usually at about 18 to 25, depending on the plant.

And then there is the high level instrumentation, which is around 50 gallons, which actually initiates a scram.

So that's why I think the key here is prior to scram initiation.

MR. KERR: But isn't all of the instrumentation supposed to work prior to scram initiation? I don't see the distinction between 9 and the purpose of the whole thing. That's the problem I'm having.

MR. PANCIERA: Well, this says he should have instrumentation to detect water accumulation before he gets to the point where he's going to automatically scram the plant.

MR. KERR: But won't any of this instrumentation give him a level of water in the scram discharge volume before scram occurs? I thought that was the purpose.

MR. PITTMAN: I think you are right, but I think to make sure that they don't take it off, that they leave it there.

MR. PANCIERA: Well, you're not talking about the high level scram instrumentation, the scram flux, because once you get there, you have scrammed the plant.

MR. PITTMAN: But you still keep the high level which is on there, and the rod blocks. So the operator is continuing, with the new design, to have a warning before he gets a scram.

MR. KERR: If it's clear to everybody but me, I'll --

MR. RUBIN: There is more to it than just having an alarm there that tells the operator that he should wait a little longer and wait for the scram. It presumably gives him a chance to maybe correct a water accumulation problem and correct the problem and avoid a scram. It is not tied into any automatic protection actions. It simply gives him a warning and perhaps gives him some time to take some corrective actions.

For example, maybe the drain valve is starting to drift closed for some reason, because of a pinhole leak developing in the actuator, and maybe he can dispatch someone down to the main valve and correct the problem before things would get to the point where the high level switches would automatically scram the plant.

It gives them a chance to correct the problem.

MR. PANCIERA: It's the first line of defense. It gives him some prior warning that he might be able to take action to prevent an automatic scram of the plant.

MR. KERR: I was misreading some of this other level instrumentation. I assumed that level instrumentation meant that you had an indication of where the water was, and that in addition it scrammed. Apparently it doesn't mean that at all. It just means an automatic scram switch, sort of. But it doesn't read out to the operator.

9 says there needs to be a readout.

MR. PANCIERA: There is a readout on the computer, but it's not evident to him right then and there. You don't have continuous level instrumentation.

MR. KERR: Does 9 ask for continuous level indication? What is 9 asking for?

MR. PANCIERA: It's asking that you have instrumentation to let the operator know when you are accumulating water in the volume before scram is initiated.

MR. LIPINSKI: As a minimum, it's a switch. It could be an indicator if they chose to install it.

MR. RUBIN: It's equivalent to like an amber light coming on before your red light. It gives the driver warning that the red light is coming.

MR. MATHIS: Let me go back to No. 6. Power-operated vent and drain valves shall close under loss of air and/or electric power.

Now we want the valves to open, don't we?

MR. PANCIERA: No, the vent and drain valves will close on loss of air. The scram inlet andoutlet valves will open on loss of air. This is addressing just the vent and drain valves.

MR. MATHIS: Okay.

MR. PITTMAN: No, it's different valves.

end 20

MR. PITTMAN: I mentioned one area where there was some disagreement between the Staff and owners was in this question of diverse level instrumentation. The owners felt that this question of diversity or treatment of common cause failures like the scram level instrumentation should be taken up as part of the ATWS rule.

The Staff felt that that question should, because of the problems associated with common cause failures at Brunswick and Hatch, should be addressed in the SSI. The owners chose not to address this question of diversity.

The Staff then put in an additional requirement in the Safety Evaluation Report that says we agree with you, as far as redundancy of instrumentation. However, you have not addressed diversity.

MR. KERR: What was the common cause failure at Hatch?

MR. PANCIERA: Flux.

MR. KERR: What assurance do you have that diversity would have cured that?

MR. PANCIERA: We feel we have cured that problem by changing the taps and providing double valve isolation on the drain.

MR. KERR: So you don't need diversity to cure it?

MR. PANCIERA: But there may be other things, other common cause failures that are in the wind. We felt also that you should address common cause because of the extreme importance of this level instrumentation. When you start to fill up your scram discharge volume, this may be the only thing that permits the plant to safely go to a safe operational state.

MR. KERR: What you really want, I think, is a good reliable system, and the Staff's position is that the reliability of it will always be greater with diversity than with redundant systems that are identical.

MR. PANCIERA: Well, I can't really say that is the Staff's position. There was some concern --

MR. KERR: It has to be your position if you're being consistent. Otherwise, you wouldn't require diversity. Diversity is not an end in itself, it's an effort to achieve reliability.

MR. PANCIERA: It's an effort to eliminate cause, about common cause failures.

MR. KERR: That's because you think it would decrease reliability so you have to assume that diverse systems are always more reliable than nondiverse systems; otherwise you don't always specify them, and I guess I would have some skepticism about that. If I have a good reliable system, I'd rather have two of them than one that has diversity.

MR. PANCIERA: Let me tell you the position we took.

MR. KERR: I am aware of the gospel according to St.

Hanauer, and I have great respect for it, but I shall continue to ask these questions when I can.

(Laughter.)

I should say St. Stephen. Excuse me.

MR. PANCIERA: One course of action would be to require diversity of function. In other words, a scram level switch.

MR. KERR: Vince, you don't have to convince me. I recognize the alternatives, I have listened to the argument.

MR. PANCIERA: Let me just say one thing: One course of action which the SER permits is diversity of function, as I said. The floats and DPS cells or floats and hot thermocouples, because of the concern that the licensees had that they may not be able to get as good a reliability using functionally diverse instrumentation. Manufacturing is also permitted diversity, so it says either you provide functional diversity or you provide manufacturing diversity for having manufactured switches might prevent a common cause problem, where one manufacturer designs a linkage arm or something that's too weak. See what I'm saying?

So that's the second course of action permitted.

The third course of action permitted, which has been since repudiated by the Staff, is to permit the continuous monitoring system in conjunction with operator action. The orders that will be issued will not permit this alternative method, primarily because here again the dependence on the operator-machine interface, and secondly, because of some of the -- at least initially some of the problems we had with the continuous monitoring system, although it looks like those are cleaned up.

MR. MATHIS: Vince, I don't want to rush you, but we've got three more items on the agenda, and I know some of the people have to leave here by 5:30.

MR. PANCIERA: I've got two more slides. This is the last design criteria.

(Slide.)

We have discussed this before. It's containment of reactor coolant, and I won't go any further on that.

(Slide.)

Surveillance criteria, three of them.

Vent and drain valves shall be periodically tested. This is to assure that they close in a reasonable time. The GE spec allows 30 seconds. We found some cases where the valves could not meet that spec.

The second item, verifying and level detection instrument shall be periodically tested in place.

The third criterion, under surveillance criteria, is that on a periodic basis there should be an integrated operability test, where it is done periodically, and data from the previous test is compared to the present test.

So let me just quickly go to this last slide.

(Slide.)

When you really boil down all this criteria and what the Staff feels is an acceptable means of complying with the criteria, separate instrument volumes integral with the SDV. We talked enough about that. Minimum SDV volume of 3.34 gallons per drive, assume a single passive failure of a pipe not less than 2 inches diameter.

This is a plugging type failure. Instrumentation, single failure proof and diverse, and we have discussed the diversity question.

Instrument taps to be on the piping, not on the vent and drain piping. Functional tests of the level switch after each scram and half-scram during repower or replacement of level instruments.

MR. LIPINSKI: Could you clarify that?

MR. PANCIERA: If you got half the instruments out and you have got one out of two twice, double valve isolation on the vent and drain lines.

MR. KERR: You don't mean half scram, you mean half of a scram signal.

MR. PANCIERA: Yes. A poor word on my part. Vent and drain closure times less than 30 seconds. And last, service functions not adversely affected -- I mean scram function not adversely affected by loss of service function.

For instance, the air. If you lose the air service function, it should not affect the scram.

So there are other small items in this acceptable compliance, but this basically says that this is an acceptable way of --- the Staff considers this an acceptable way of meeting the criteria. If the licensee chooses to go this acceptable compliance route, then we have said the Staff does not have to specifically review his modification or his proposed modification. If he chooses to go a different route of keeping a single instrumented volume, increasing the size of the pipe to a 10 inch or 12 inch pipe, then, by God, we sure as heck want to review it.

So far, it looks as if -- I can't say every one of them, but I think most of the licensees are going along with this acceptable compliance.

That's all I have.

MR. KERR: What choice do they have?

MR. PANCIERA: Well, they could go ahead and put in a 10 inch pipe and run a 150 foot pipe that connects the instrumented volume to the scram discharge volume header.

MR. KERR: That would still be acceptable compliance, wouldn't it?

MR. PANCIERA: It is not as far as we are concerned.

MR. KERR: You said they were going along with this, and if that's the only acceptable way of compliance, my question is, what choice do they have?

MR. PANCIERA: I hope none.

MR. RAY: Well, do you really mean that they have influenced this development in their thoughts? Don't you really mean that they have gone -- not by saying they have gone along with it, that they have influenced, their comments and suggestions have been input? That's really what you mean.

MR. PANCIERA: We really got very good cooperation from the owners' group. The chairman, Tom Denty, from Northeast Utilities, did an outstanding job. He worked very closely with us. I think this is a way of getting licensee input into the regulatory process that maybe provides some good balance.

MR. RAY: If I can talk in favor of motherhood and apple pie, there is no question but that there is a hell of a lot of good talentthat could make major contributions, and the more you employ it cooperatively, the better.

MR. PANCIERA: I was very pleased with the efforts put forward by this group of people. I thought they were highly professional people, and did a very good job, and I want to give them credit for it, and that's one of the reasons why I felt their criteria, as far as I was concerned was sacred, and I would not even think of violating what they had put down. I think they did a very good job. No question in my mind. I think maybe it's a way of going in the future, to solicit better advice.

MR. RAY: I would stop short of saying it's as holy as apparently you think it is, but that's something else.

MR. KERR: The diversity requirement you mentioned is not part of the criteria. That's somewhere else.

MR. PANCERIA: It's in the SER under the criteria that addresses redundancy of instrumentation, but it is as a separate Staff position.

MR. KERR: And it's not one of the criteria?

MR. PANCIERA: No, sir.

MR. KERR: That seems a bit strange to me.

MR. PANCIERA: Well, it was an additional Staff position.

MR. KERR: The criteria you gave us were not Staff criteria?

MR. PANCIERA: They were owners' group criteria, but we endorsed them in the SER with this one exception.

Okay.

MR. LIPINSKI: Do all the BWRs have recirc pump trips installed right now?

MR. PANCIERA: I think there might be one exception. Right, Bill?

MR. MILLS: I think Big Rock Point doesn't have it installed.

MR. PANCIERA: That's the only exception.

MR. LIPINSKI: This would have been an interesting event on Browns Ferry without the recirc pump trip, a full power trip without a recirc pump trip.

MR. PANCIERA: Now, as I mentioned in the chronology of Staff actions, we had gotten input from the Probabilistic Assessments Staff. We also further solicited the Probabilistic -- solicited help from the Probabilistic Assessment Staff, and coming up they are reviewing the two basic BWR designs, the single instrumented volume, and the dual instrumented volume, with an eye toward what additional improvements can be made in future plants.

Jim Pittman from the Staff is here to address that.

#22

MR. PITTMAN: I'm going to try to cut this very, very short, so I'm not even going to talk about some of the slides I've got on here, but I just want to reiterate again that as we discussed here several times, and what we saw in our analysis was that one thing that was common to all the problems was either this extremely long length of two inch piping here, or the fact that it was two inch.

(Slide.)

And that, and all the problem modes with all the existing configuration, that problem entered into it.

(Slide.)

What we found basically supported the AEOD's findings and other findings that have already been discussed. We looked then further and we chose this, that was in the

Safety Evaluation Report, as being a system in which to evaluate for the new configuration.

Essentially what this does for us, as has been described --

(Slide.)

--- it provides the instrumented volume attached directly to the headers, the scram discharge headers. So we have eliminated the hydraulic coupling between the headers and the instrumented volumes themselves. So we end up with two instrumented volumes attached to each other and to the instrumentation that is tied onto it.

What we saw was something like this. Let me quickly go through our findings, and we will stop there.

(Slide.)

One thing that we found -- and we just used this as a base line because we thought this will tell us some things we ought to take a look at -- one thing we saw here was don't trust yourself to two sensors on each instrumented volume for scram sensors. We need four, again, in which we would have two for the A channel and two for the B on each one.

We still have a single drain line here that drains from this side, if we would get a flow into this one, for two sensors on each side only. We could disable one of these and we would not get a scram.

So we need to have four sensors. If we are going to have four, the optimum consideration should look something like this, we feel.

(Slide.)

In which each sensor is at a separate tap in a different line, so that we have the optimum redundancy in each one. A minimum acceptable system would look something like this, in which it's typical to what we presently have.

(Slide.)

In which we have only two taps, two at the top and two at the bottom, and we have a pair of sensors coming out each one. If you're going to do that, I think you should be sure that in your testing -- you test these sensors, that you can go back and sense also at the same time the relays that they are attached to, because you defeated yourself even some way -- and Lord knows, it's possible -- but let's suppose here in the B sensor somewhere the wiring got crossed, and we had the C sensor tied in here. If we block this, we block half of our screen, and we can't get one out of two. We can only get one out of one, and that's enough to give us a scram.

MR. KERR: Are you now measuring the level in one volume?

MR. PITTMAN: We are measuring the level in both volumes. I am saying that for each volume, we should have four sensors so that gives us a one out of two taken twice for each instrument volume. That's how a scram configuration is set up for a BWR. They are in pairs. You have to have an A or a C and a B or a D.

MR. KERR: I know this is true of some systems. I didn't realize you were requiring four sensors for each parameter.

MR. PITTMAN: Well, the parameter for the instrument volume is the water level that's on that volume.

MR. KERR: I understand that, and you are requiring that be measured by four separate sensors.

MR. PITTMAN: That's correct.

MR. KERR: Does each one have to be different, or can two of them be alike?

MR. PITTMAN: This is a personal opinion: I would say two of them could be alike. I would say the A and the B could be the same, and the C and the D could be the same.

MR. KERR: But two is not enough?

MR. PITTMAN: Two is not enough. Well, the reason why, if we have a one out of two taken twice system, and we have only an A and a B in there, let's delete the top two, if I disable one of these, I cannot get a scram.

MR. KERR: I don't have to connect them the way you have them connected. I thought from what I was hearing earlier that you required the satisfaction of the single failure criterion and you can do that with two sensors.

MR. PITTMAN: Oh, no, you can't.

MR. KERR: You can't?

MR. PITTMAN: No. If I have a one out of two taken twice --

MR. KERR: I don't have to use that. I'm talking now about measuring the level in the sensor. The one out of two taken twice thing is not just for reliability.

MR. PITTMAN: That's the instrument configuration in a boiling water reactor.

MR. KERR: But it is not just for decreasing the probability of scram. It's also for decreasing the probability of false scram.

MR. PITTMAN: That's correct.

MR. KERR: And the one out of two taken twice is not a requirement at the NRC, as far as I know.

MR. PITTMAN: I would agree with you, but I'm saying that to obtain the optimum, one for safety and one for operability, they have chosen that configuration, and that's the configuration we are operating in with the BWR.

MR. KERR: That's now being used?

MR. PITTMAN: That is now the configuration, yes, for all of the scram instrumentation. Every parameter is measured by four sensors.

(Slide.)

Going back to this one, then, also now by dividing here one blocked sensor line, these will probably be again one or two inch lines, or smaller. These lines, since one of the criteria was that we can have a static block and a line less than two inches would disable our scram function here -- down here, this is unacceptable. The sensor line tied in at the drain line below the IV.

There is another problem, if we could go -- it doesn't make any difference which one we look at --

(Slide)

If we tie our instrumentation in at this point, if we have a welder's glove or some accumulated crud that comes in here at this point, not only have we blocked our IV, we have blocked our instrumentation, and that's another good reason for having those taps directly tied into the IV.

(Slide.)

I think the only other point that comes out in our analysis was the fact that we can see the essentialness of cleanliness in this system, and we made the recommendation to the operating group that maybe in the inspection and enforcement function of construction, there should be a stop point in assembly of this before the end caps are welded on and the system is closed up, that this would be a good time to have an inspection to make sure that all the gloves and coveralls and miscellaneous items used in construction have been removed.

And I know -- I worked for an aerospace company for several years, and much to our dismay one time -- the first time the Air Force got into a fuel tank of ours, they found a pair of coveralls with the company's name on the back of them.

And unless there are any questions, that's the end of my discussion.

MR. MATHIS: Any questions?

Thank you.

Stu.

(Slide.)

MR. RUBIN: The serious and fundamental nature of AEOD, Browns Ferry 3 investigation findings of deficiency made it appear that perhaps a less than adequate systems design review and regulatory safety review had been made for the SDV system design when it was originally developed and proposed.

Because of this perception, AEOD made the decision to extend its initial analysis and evaluation of the Browns Ferry 3 scram system by performing a more thorough safety assessment of the reactor coolant boundary and primary containment functions of the system.

Since our Browns Ferry 3 case study report, we have extended our initial review to include a more thorough study of the safety concerns associated with single passive failures. That is pipe breaks in the SDV system.

It is postulated that attendant to a reactor scram, a break occurs in the SDV piping downstream of the scram outlet valves and upstream of the SDV sys' m vent and drain valves.

For this break location, automatic closure of the redundant vent and drain line isolation valves will not terminate the RCS blowdown, since these valves are located downstream of the break location.

In such an event, group closure of the outlet valves would be the only option available to prevent an uncontrolled reactor coolant system blowdown outside primary containment.

Break isolation problems. This action requires the ability to manually reset the RPS, which requires RPS power and the lack of trip conditions, and the availiability of a control air supply.

However, group closure of the scram outlet valves has not heretofore been defined as a required safety function. Accordingly, the systems upon which operation of the scram outlet valves is dependent have not been designed to assure reliable closure of these valves.

This isolation in the reactor coolant boundary cannot presently be assured to the degree inherent to reactor coolant boundary pipes, incorporating qualified isolation valve design arrangements.

That is, there are numerous disabling events in a pipe break, as well as the numerous disabling failures in the control air systems which could temporarily, indefinitely, or permanently prevent successful reclosure of the scram outlet valves following a scram.

Furthermore, the scram outlet valves do not incorporate an automatic closure feature. Lack of auto-closure is clearly necessitated by the need for a reliable scram function which must not be automatically overridden under any circumstances.

The net effect is that the scram valve group closure is a manual operation which must be remotely actuated by the operator for one of the control room panels. That is, the isolation system for a postulated break in the SDV system piping can be characterized as a man-machine system.

A review of the man side of the man-machine SDV break isolation system also indicates that less than adequate human factor preparations have been provided.

The operability and calibration of the radiation monitors located in the control rod hydraulic control unit areas, which provide indication of a break in that area, are not required by technical specifications, and so the assured reliability and operability of those detection elements in the man-machine break isolation system are not assured.

Furthermore, we believe that the operator has not been provided with adequate emergency operating procedures to quickly and appropriately respond to a break in the SDV piping system.

A local manual isolation valve in series with each remote air operated scram outlet valve is provided on each hydraulic control unit.

However, dispatching an auxiliary operator to manually close these valves would be extremely unlikely, given the harsh environmental conditions, probable loss of lighting in the part of the reactor building where the postulated break is located.

Therefore, for both equipment and procedural-related reasons, isolation of a break in the SDV system cannot reliably be assured.

I anticipate a question. No?

MR. KERR: I was just going to suggest that if we are going to look at these problems in this much detail, we really need more time. I had assumed we were going to get some very quick overview.

MR. RUBIN: If you want it more condensed than that, I can just read my slide.

MR. KERR: No, I don't mean to say that the problem doesn't deserve consideration, but if you have a number of these, and you have looked at them in this much detail, we probably need to take more time to look at them.

MR. MATHIS: That's right, I don't think there is any question of that.

Why don't you just highlight the types of things you are looking at, Stuart?

MR. RUBIN: The other one is this one. Okay? There aren't any more. It's the break in the SDV system. The break discharge conditions, examining the blowdown rates that one could anticipate from each drive.

We could get up to numbers like say 550 to 900 gpm out of the break, just by looking at seal leak rates. The seals would probably degrade over continued blowdown as a result of the heat-up of the seals, much like the recirculation pump seal degradation on a loss of seal injection flow.

So we are talking about 550 to 900 gpm and up. The consequences to the core for this kind of postulated break would be equivalent to the break in the bottom of the reactor vessel, because we are talking about the discharged flow being released through the drives which hit the bottom of the vessel.

And, furthermore, the break would be piped outside primary containment, so the inventory lost would be lost from not only the reactor, but also from the primary containment pool, which is the normally presumed reservoir of water for long-term cooling purposes for LOCAs.

So we would be in a depleting-the-inventory situation.

MR. KERR: The bottom of the reactor vessel is not in containment?

MR. RUBIN: It is, but the fluid being lost is being piped by the scram exhaust which goes out of primary containment for the SDV system which is in the reactor building.

Another way of looking at it is that the jet pump diffusers would not provide any protection against a rapid drop in core coverage upon a loss of makeup supply, since the break is at the bottom of the core.

So we have those problems. The consequences to the mitigation system. The break is in the reactor building, which is where your emergency systems are located. One floor below the postulated break location are all the low pressure coolant injection pumps, HPCI and RCI pumps, and the control rod drive pumps, so the adverse environmental conditions created by blowdown of that sort would raise questions as to the continued availability of these systems for an unisolated break because of the limitations of the sump pump capacity flooding of the reactor building basement would be an impending problem with the potential flooding of all these pumps in the building.

So the consequences to the mitigation system for this is that the break threatens those systems.

Next the SDV system mechanical design integrity basis. We looked somewhat at the design of the SDV system from the mechanical point of view, the stress analyses that were performed on some of the earlier systems, to try to get a handle on what confidence we had that these pipes are going to stay intact.

We found that many of the plants have their SDV systems built to a V-31.1 which did not require things like the fatigue analyses, did not require certain kinds of fabrication inspections which are required of the newer codes. As far as in-service inspection requirements on the system, it's not clear to us at this time that they ever have to perform an in-service inspection on any of the vent or drain lines.

In fact, the code permits them to never inspect, in-service inspect pipes which are four inches or less. So pipes which have four inch SDV headers may never get the headers inspected.

So there is a concern here as to what kind of assurance are we providing ourselves as to the continued mechanical integrity of the systems. So given the lack of the highest quality of assurance that we feel we need for the system, in combination with the potential consequences, we feel that corrective measures would be in order, and we will be making those recommendations in a report in the near future.

MR. MATHIS: I hope you are doing some probabilistic assessment as to what the likelihood of these kinds of things are.

MR. RUBIN: Well, I guess a rule of thumb is that the probability of breaks in small lines is somewhat higher than the breaks in large lines, and we are talking about mostly small lines in the system.

One can argue whether or not this is a high energy system. These are things that the regulators will have to decide, but what we would like to simply do is let everyone understand what the consequences would be, given such an event, and then go about deciding if we are going to have to consider it as a credible event, and if we decide it is not a credible event, we will have to think about what kind of assurance we are providing ourselves that it is not.

MR. KERR: What do you mean by an incredible event?

MR. RUBIN: Well, for example, we don't postulate that the reactor vessel ruptures.

MR. KERR: What would lead you to believe that this event is either credible or not credible?

MR. RUBIN: Well, right now I don't know what the condition of the pipes is.

MR. KERR: What I mean is what information would you need to have in order to decide that this again is either credible or not? I'm just trying to get some idea of how you make your decision.

MR. RUBIN: We would go a long way in arguing it was incredible if you were to lay on the table a very exhaustive and conservative mechanical design analysis, and next to that lay a very complete and ongoing in-service inspection report that the system is continuing to maintain its mechanical integrity; even given those reports, one could argue, well, you have to postulate a break anywhere in the reactor system, and I want to put the break there right in that portion.

MR. KERR: You don't have to postulate a break anywhere in the reactor system unless you have some idea what the probability is. This is a little like saying that if you can drown everybody in Detroit with a three-gallon bucket of water, you have to eliminate all the water. And you don't. Because although in principle you can do that, the probability is low.

MR. RUBIN: I think you are right.

MR. KERR: I don't know whether the probability of this is low or not. What Bill was saying, and I agree with him, is it seems to me somebody needs to have a look and ask is the probability low or high.

MR. RUBIN: Exactly.

MR. KERR: You seem to be saying that's not your job.

MR. RUBIN: Well, no. In a way it may not be much different from ATWS in the sense that I just described. The consequences could be rather severe, in that you have an unisolated blowdown, you are leaking inventory, and you are not going to be able to get it back in because it's going out of primary containment. You lose all your mitigation system. The consequences are high. The probability of the event may be very low. The risk, therefore, may be something not worth addressing from a requirements point of view. But I think the report will at least lay on the table some of the concerns as to the --

MR. KERR: The report is going to be given without any consideration given to the probabilities.

MR. RUBIN: We will characterize the current confidence we have in the integrity of that piping by the current mechanical design.

MR. KERR: If the report comes from the prestigious group, of the kind with which you are associated, and personally it seems to me there is the assumption that you think it's reasonably high risk or you wouldn't be publishing the report --

MR. RUBIN: Well, the risk, as you know, is the probability of the product times the consequence.

MR. KERR: I do know, and it seems to me before you publish such a report, you need to give some thought to the probability.

MR. RUBIN: We will make note of that.

MR. KERR: Don't you think you should?

MR. RUBIN: I think it's appropriate, yes.

MR. MATHIS: Well, I think what we've got here is, shall I say, a tentative "what if" kind of list that you want to take a look at.

MR. KERR: Which I applaud, by the way. I think you are doing precisely the sort of thing you should do, but I think you also have to look at the probabilities.

MR. RUBIN: Okay. I think, though -- I'm not saying we will come up with a precise number, but if we can come up with a reasonable probability, whatever that means, on the likelihood of a break, then when you have that with the unrevised ability of isolation with the current system, you get a fairly high risk, I believe. But you're right, that element in the convolution has to be looked at.

MR. MATHIS: Well, we will be hearing more about that as you continue your investigations; right?

MR. RUBIN: I suspect, yes.

MR. MATHIS: Thank you, sir.

Well, with that, that concludes the items on the agenda, with the exception of what we have down here as executive session.

(Whereupon, at 5:45 p.m., the hearing was adjourned.)

* * * *

end

NUCLEAR REGULATORY COMMISSION

This is to certify that the attached proceedings before the

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in the matter of: ACRS-SUBCOMMITTEE ON REACTOR OPERATIONS

Date of Proceeding: March 10, 1981

Docket Number: ______________

Place of Proceeding: Washington, D.C.

were held as herein appears, and that this is the original transcript thereof for the file of the Commission.

ANN RILEY

Official Reporter (Typed)

Ann Riley

Official Reporter (Signature)