T-1138

NUCLEAR REGULATORY COMMISSION

ORIGINAL

In the Matter of: ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

CLINCH RIVER BREEDER REACTOR WORKING
GROUP ON SYSTEMS INTEGRATION

DATE: September 30, 1982 PAGES: 1 - 242

AT: Washington, D. C.

TR04
ADD LPDR ( )

ALDERSON REPORTING

400 Virginia Ave., S.W. Washington, D. C. 20024

Telephone: (202) 554-2345

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
- - -
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
- - -
CLINCH RIVER BREEDER REACTOR
WORKING GROUP ON SYSTEMS INTEGRATION
- - -

Room 1167
1717 H Street, N.W.
Washington, D.C.
September 30, 1982

The meeting was convened, pursuant to notice, at 1:00 p.m., William Kerr (Chairman of the Subcommittee) presiding.

PRESENT:

ACRS MEMBERS:

WILLIAM KERR
MAX W. CARBON
JEREMIAH J. RAY
JESSE C. EBERSOLE
DAVID WARD

ACRS CONSULTANT:

W. LIPINSKI

DESIGNATED FEDERAL EMPLOYEE:

R. SAVIO

ACRS STAFF:

P. BOEHNERT

ALSO PRESENT:

R. STARK
P. GROSS
P. DICKSON
P. CHECK
G. SMITH
R. E. LAWRENCE
B. MORRIS
G. MORRISON
E. ROSSI
MR. ROSECKY
G. MAUCK
MR. MORAN
G. MACREA
D. DONCALS

PROCEEDINGS

MR. KERR: I am trying to remember the comments on common mode failures to which I could refer you. On page SVV-10, "We find that the potential for common mode failures will be identified by a detailed common mode failure analysis, together with rigorous failure mode and effects analysis and fault tree analysis." It doesn't say "maybe" or that they'll be "looked for." It says that "the potential will be identified."

MR. LIPINSKI: There was another table of common modes in the same document. Seismic was not in the review.

MR. KERR: So you would wonder what happened to seismic.

MR. LIPINSKI: Right.

MR. KERR: And particularly seismic events that might have potential for more damage than the SSE?

MR. LIPINSKI: Well, one of the numbers we got on one plant was a number like 1.1×10^{-4}, and the margin would be exceeded. I just wonder what the appropriate number is for CRBR.

MR. KERR: Any other comments?

(No response.)

MR. KERR: Some of the things that occurred to me as I read some of the information made available was a way in which human errors are handled in the analysis. Human errors are alluded to. It was not clear to me how they are going to be treated. I refer not just to human errors in the design and in operation, but other possibilities that may exist in maintenance, testing, and so on.

I bring this up because everything that has been said about TMI-2 almost, and subsequent studies, has indicated that human error contribution may be a bigger contribution than one might have thought prior to TMI-2. I did not see in the limited amount of material at which I looked a recognition of this, if it is indeed a fact, and a proposal to treat it. It probably is there somewhere and you can refer me to it.

Also, does one anticipate that the contribution of human errors will be about that which one has seen or expects to see in lightwater reactors? Or is there some potential for operation which makes the CRBR perhaps less susceptible, or maybe more susceptible to human error?

I also would be interested in some comments on the approach to reliability and safety as it has been influenced by TMI-2. Has there been another look? Have those things that might have been learned at least in the water reactor field been used to make whatever modifications may be appropriate to the approach being taken for CRBR? And in connection with that, I guess it would be helpful to me to have some additional elaboration of any differences in approach.

The impression I get is that this system is being treated insofar as it is feasible as if it were an LWR system, but maybe it is being -- at least the reliability goals perhaps are equal to, or maybe a little better than the LWR system. If I am mistaken, I would welcome some comments on that.

It would also be helpful, and I recognize that we have a limited amount of time today, for me to have some better information than I have about differences that may exist in philosophy between us and the French approach to fast reactor control, or the German approach to fast reactor control, if they are available. And if there are significant differences, why are we taking the particular position that we are taking?

It is also not clear to me, but perhaps it will be clearer as we go on, what the basic philosophy is back of the safety and control system design. I recognize that a lot of adherence is likely to be required to all the regulations and Reg Guides and IEEE standards, but from this I don't have a feel for any coherent approach to determining the appropriate performance, or trying to determine the appropriate performance of the system.

I must say, it appears to me that a great deal of importance is being attached to the reliability goals and to the faith that one will have the ability to achieve them. When the goals are something like one in a million failure per demand, I guess it stretches my credibility to assume that one is going to be able to make a convincing case that this has been achieved.

I am willing to be convinced, and it may be ignorance on my part at this stage; so that if in the course of your presentation you can point out other areas in which people have achieved this sort of reliability, that would help me some in my ability to understand what appears to me to be a rather basic cornerstone of the approach.

This ends the executive session and brings us to Mr. Richard Stark of the NRC Staff, who I believe has the responsibility for getting things started. Mr. Stark.

MR. STARK: Good afternoon. Richard Stark from the NRC Staff.

The two items that show up next 2A and 2B, I guess I would like to handle kind of together and propose that we handle them in a similar fashion to what we did in the last working meeting. The two items concern the status of our review and the schedule for completion of our review.

I guess the status is that we are in the middle of our review. The SER will be issued early in March, March 4th, 1983. I would like to point out that today in the audience here we have two NRC review groups present and they are probably in pretty good shape to cover most of the items that will be covered today.

As we did in the last MEV meeting, the Staff members today will, along with their consultants today, will make a presentation. They will define the criteria that they are using for their review. They will give you some details of their review. Also, they will give examples of active areas that they are currently -- that the current review finds today.

I guess with that in mind what I propose is, we have a half an hour session for this and a half an hour for the later session. I think that we have enough information that we can fill the latter part of today. That will be two presentations by two groups within the NRC.

Questions?

MR. RAY: Mr. Stark, in the documents that we had, and I'm not clear as to how many of these inserts and appendices came directly from the published material, but the dates and the objectives calendar-wise that are listed here are way out of context. They mention '75 and '76 and so on. And it was suggested, if we haven't already done it, that the documents be brought up to date.

MR. STARK: Which documents are you referring to?

MR. SAVIO: All of the documents came out of the PSAR. I think the primary one is Appendix C, reliability program.

MR. STARK: That appendix has been withdrawn from the application by the Applicant.

MR. GROSS: It was recently --

MR. KERR: Would you identify yourself?

MR. GROSS: Peter Gross from the Department of Energy.

Appendix C was recently updated. I don't know whether the ACRS Committee has what is from that last amendment.

MR. KERR: The xerox copy I have does not bear a date, although it does say here "Assessment No. 7, first quarter 1980." Would that be the updated version?

MR. GROSS: No. It was provided in 1982.

MR. RAY: Well, it's an example of the type of thing that I ran across, and I did make notations, because I presumed there was some kind of a program to update all of these dates. But under "features to accommodate primary pipe rupture," under Section 1.1.23, "parallel design" on SVA page 12 --

MR. GROSS: That is the parallel design. That's been withdrawn.

MR. STARK: All this has been withdrawn from the application. What we have before us is, the Applicant is up to revision or amendment 70-something, and a lot of that earlier information has been deleted. The core has been changed.

MR. RAY: So the update is in progress?

MR. STARK: Yes. I think what you will get today, you will get from the Applicant a description of what their current design looks like. I think they can also describe, or we can later, the reliability plan and goals that now exist.

And what the Staff is going to refer to is what we have done since last October and where we stand relative to our review in producing an SER.

MR. RAY: This raises an even broader question in my mind, Mr. Chairman, in that if this is -- if these documents then are so completely out of date, one questions how much of the philosophy of design involving reliability of control and other things that are delineated in these pages is current.

MR. STARK: Well, I don't know how to answer other than in a general fashion. There are a lot of amendments to the PSAR that bring it up to date. The Applicant has changed. They no longer have two designs, parallel and a reference design. That was abandoned before the current staff even started its review again.

MR. RAY: This is my position, that these documents --

MR. KERR: Jerry, I think we're afflicted with information that's out of date and we need to wash our minds of previous misconceptions and start from scratch.

MR. EBERSOLE: I think they represent vintage of about 1973.

MR. RAY: There are features in here involving a parallel design that I thought were superb, and I thought they were learning some lessons. And now you say they've abandoned it and now we have to invent the wheel all over again.

MR. KERR: The information will get to the ACRS in due course.

MR. CARBON: Why do we have this rather than the update?

MR. SAVIO: It is from our reference PSAR. I believe that it was the design that was current.

MR. EBERSOLE: Well, it says stuff will be done in 1975, et cetera, et cetera.

MR. KERR: Let's give Mr. Stark a chance.

MR. STARK: That essentially ends my discussion. As I indicated, we have a rather lengthy summary that I will be prepared to present at the end. And with that, I can turn it over to the Applicant and perhaps they can describe the big picture, and then the status of our review might be more meaningful.

Thank you.

MR. DICKSON: My name is Paul Dickson and I work for Westinghouse.

MR. KERR: Can you hear Mr. Dickson?

THE REPORTER: Yes.

MR. DICKSON: As I heard the comments in some of your executive session, some of the things you wanted to hear, we will do our best to touch on them. It was not exactly what we had planned to do in many cases.

For example, you referred to, did we respond to TMI-2, and we did. We did a system of what we call key system design reviews. We had a pitch prepared on that, but it's not here today. If you would like to hear those and other reliability goal stories, we would be glad to do it.

MR. KERR: I would like to hear this at some point, Mr. Dickson, but I would defer to you as to the most expeditious way of getting information to us. I don't think this is going to be our last meeting, and --

MR. DICKSON: We assumed that.

What we had intended to cover is given in this agenda, which only covers the Applicant's portion of it. I'm going to give an introduction, more than an introduction, a little bit on some of the inherent characteristics. Then Dick Doncals will do reactivity control. Then G. Smith and R. Lawrence will do reactor control mechanism, and then George Macrae, plant protection systems, and then finally Garry Morrison, the full protection system interaction.

MR. LIPINSKI: May I ask a question? On the subject of reliability, that in itself I think will assume a lot of time, for a comprehensive discussion.

MR. DICKSON: Yes, sir.

MR. LIPINSKI: Would it be more appropriate to consider that for a future meeting, rather than trying to resolve the questions that came about in reading this material that is not up to date?

MR. RAY: Well, for one it would help me more than to ask questions based on this, because I may have the idea that you're not pursuing it any more, and that is an obvious risk and I think that --

MR. KERR: Let me suggest that we give Mr. Dickson and his colleagues about 15 or 20 minutes, and then we will be in a better position to ask questions. I would suggest that you proceed on the basis of your plan, to define it a little bit more clearly.

(Slide.)

MR. DICKSON: If you look at the control systems in Clinch River, you have generally these four plus the control of auxiliary systems and their respective instrumentation. These four then are controlled by a supervisory control system. Our focus today is going to be primarily in this reactor control area.

Of course, in doing this you have to refer to some of the functions of the supervisory control and some of its interactions. Primarily, we will focus on reactor control because we feel this is the time that is needed to get that picture across. And again, maybe I am overemphasizing now, but we got lost in a dry run and decided we ought to show you these blocks.

(Slide.)

These people will be strictly on the mechanical portion of the reactor control mechanism, and these three are going to be covering the electronics and electrical equipment.

Confirmatory testing, there is a large program there. It's in a dotted block in that it is not really on the agenda. There will be some mention of it in the secondary control rod system because it's significantly different from what you are seeing in light water reactors. So we will mention the confirmatory testing there, but the rest of the testing is unique for Clinch River, and being as far along as it is for a CP stage is a whole other subject in and of itself.

MR. BOEHNERT: Do you have copies of the slides, Paul?

MR. DICKSON: One subject that has come up is, how do we differ in speed, for example, with the light water reactor, the typical LWR. I use this word "typical" advisedly. I don't know much about LWR's. The typical LWR I'm talking about is a Westinghouse PWR as told to me by the designer.

Our specifications are that we will have a primary trip at 115 percent of power. The delay time is two-tenths of a second and the time to insert a dollar negative reactivity is 1.031 seconds, which is a little faster than the typical light water reactor, which is a half a second and 1.4 seconds. That's the specification. I'm told we do better than that. But that's what the design requirement is.

We do ours like this.

MR. CARBON: Have you shot for that speed deliberately?

MR. DICKSON: Yes, sir.

MR. CARBON: What's the basis for that?

MR. DICKSON: That is what I'm going to get into.

I note that this is within the state of the art. Our core is a much smaller core and this travel motion is not anywhere near as much. This is not an advanced state of the art. But I want to make it clear that it really doesn't have anything to do with the fact that this is a fast reactor.

If you look at the reactor period versus the reactivity insertion in dollars, a light water reactor will tend to have a fast neutron lifetime of about 10^{-5} seconds. Our reactor is on the order of 10^{-7}. They're virtually identical if both are fueled with 239 Pu, and out there you don't see any effect whatsoever.

Our control is back here.

MR. KERR: You said nine dollars?

MR. DICKSON: I'm sorry, nine-tenths of a dollar.

It is of course this different behavior out here that brings up some of the intense interest, along with the void coefficient.

(Slide.)

That is cheating a little bit, because the isotopic result of fission of U-235 is a little different from that of U-239, and the resultant delay time for the neutrons is a little longer in the uranium thermal fission than it is in the plutonium fast reactor.

There is a log scale here, but this also happens to be part of the 10^{-3} lifetime. In a PWR, it would actually drop down more like this (Indicating). Be that as it may, you see here a slight difference or, if I change it this way, a slight difference in period for a given input of reactivity. But it is only very slight.

(Slide.)

Now, if you look at this you will see that supposedly ten cents of excess reactivity puts you in a ten-second period. If you do an analysis just looking at the fuel alone and only the doppler feedback from the fuel, no other doppler, no other axial expansion, no other doppler blanket, ten-cent step, you will get the broad jump and then it equalize thermally and it levels out pretty rapidly to about 116, 117 percent of its initial power output.

(Slide.)

Our reactor will trip well beyond this in the first place. But this was an analysis done just to determine response in a real case. Where the blankets begin coming in, when you get this prompt jump, the blankets will turn a little more slowly. They have a 15-second thermal time constant and it will level out at about 15 percent.

A light water reactor, on the other hand, would have both the doppler feedback, which is a little less than ours, and then the water reaction feedback, which varies. Probably most of its life it would settle out at something lower than ours, at three percent, but pretty close to the same kind of general reaction neutronically.

(Slide.)

Well then, why do we have a different speed? I will talk about three different events. This is -- these are typical events and this is a typical limit, and that was picked for like a scoping study as part of the large plant design work.

A typical event, call it the Van Nuys, is over in about 300 seconds. It has not tripped any scrams. Actual facts appear later that there are rod blocks here to stop it. But this is assumed for analysis. We call this the upset category of anticipated event.

The typical limit is 1500 degree cladding temperature. This is like a screening rule, like you do if you have a plastic analysis. You don't have to go inelastic. This is also not a safety matter, either. It has to do with the safety lifetime, because you anticipate a large number of these events in the light water core.

The second, then, is the loss of all AC power, coastdown to natural circulation. That is once in a lifetime. It's an emergency event. The typical limit would be 1600 degrees F.

Then a faulted event would be a seismically --

MR. WARD: Let's see. Does 1600 degrees represent some sort of core or cladding damage?

MR. DICKSON: Again, what you do when you analyze this, what we do on Clinch River is we go through all the events, lay on a number of these. I don't recall the number. I believe it's 15 times in the life of the core. Lay on its normal life. Then at the end of its life, one of the -- the requirement is that the strength not exceed one-tenth of a percent of the extreme of the cladding and the cumulative damage function that it's taken by all of these events.

MR. RAY: What would it mean in terms of the reliability level if a loss of all AC power occurred more than once in a lifetime?

MR. DICKSON: This is the life of the plant.

MR. RAY: I didn't integrate your thought. Thank you.

MR. DICKSON: In our plant, natural circulation is a very general transient to all the rest of the components. They don't even know it happens. It's only the core that takes a little bit higher temperature and gets a little damage.

MR. EBERSOLE: May I ask a question? In this core, I take it that power swings are reflected in pretty broad swings in temperature, unlike the water reactor. So I'll ask you, all these trips are driven by chambers. By what process do you keep these properly callibrated so you know in fact if they represent something?

MR. DICKSON: You're going to hear more on that later, but I believe you are assuming that our temperature swings are greater because our delta T is greater. But unlike a water reactor, we have a variable speed pump, and when we, as you'll find out later, we bring the pump up to 40 percent power, then bring the reactor up through critical, up to 40 percent power, so the power to flow ratio is unity. It's above 40, is our operating range.

MR. EBERSOLE: Do you have variable speed pumps?

MR. DICKSON: Yes, sir. They track together, the pump and the power, so the power flow unity --

MR. EBERSOLE: I'm sure we'll be asking you about how reliable those things are and how fast can they go to full low speed. Well, that's less than a tripout.

MR. DICKSON: Yes.

And the last event: seismically-induced loss of power. You lose power, you get a 60-cent step insertion. This is the maximum total stackup you can conceive of getting by virtue of taking all the tolerances in the fuel assemblies, so they are at their least active configuration, they are held apart with gaps, and they are compressed instantaneously. And the most you get is 60 cents.

Then you get the retarded control assembly scram. The typical limit is no sodium boiling, but the true limit is you don't want to melt the cladding.

MR. LIPINSKI: What is the corresonding temperature?

MR. DICKSON: Of no sodium boiling? They trip at over 1800, and then at the top of the core it gets down to about 1720 by the time you're down to boiling water flow loss.

MR. RAY: Let me reveal my ignorance. Why do you say "seismically induced loss of power"? Does any loss of power not insert a reactivity?

MR. DICKSON: No, sir. This loss of power doesn't insert any reactivity. The pumps trip and as soon as the flow to flux mismatch is sensed, the control rods go in, and there is no insertion of reactivity.

MR. KERR: Excuse me. I think his question is, why does the loss of AC power introduce reactivity, and the answer is it doesn't.

MR. DICKSON: I'm sorry. It does not. These are seismically induced loss of power, number one; number two, 60 cent step insertion; and number three, retarded control assembly scram.

MR. RAY: I misread that. I'm sorry.

MR. CARBON: But the 60 cents does come from the seismic?

MR. DICKSON: Yes. But in the real world it would be less than 60 cents, in bits and pieces with each vibration.

(Slide.)

MR. DICKSON: I was holding on two vugraphs, but let me hold that out. I've told you that electronically the dollar is different.

MR. CARBON: Excuse me. For a 60-cent step insertion, how high do you reach?

MR. DICKSON: I think we have it in the table. It's about 2.4 times normal.

The inherent characteristics of the breeder, if the low CB coolant's going to be low we'll have a large core delta T, as I mentioned, and a different size blanket and fuel rods. I've been trying to tell our customer, if he'd let us take that blanket out there I'd have an easier time designing that core, but he is pretty adamant about breeding. But you do get a different response.

This is a plot. Note that I've gone to Centigrade here. This is not a Clinch River value. These are numbers in part of the story that I mentioned before for the large core design.

But for the same event you raise the reactor to 100 percent power and then you trip it. This assumes the coastdown speed will go from full power, full flow, to ten percent flow in 30 seconds. The trip is identical to the Clinch River trip.

On that basis, you see the completely different response of these two rods. The one starts to come down as the power comes out, but the flow is coasting down so fast that the sensible heat comes back in and heats the cladding back up again. This one comes right on down until the pump is pretty nearly off or down to pony motor speed before it comes back up.

Now, this particular down transient, if done too many times, will damage the upper internal structure. The upper internal structure can take a sizeable jolt a few times, but if you're going to do this a lot of times in the life of the plant you clearly have to have a very fast stopping pump.

You don't want it to have, like the light water reactor, a flywheel to keep it going, because if the pump doesn't slow down fast enough the shock goes down faster and deeper, and the faster it is and the deeper it is the worse it is for the steel and the upper internals.

So if you wanted to knock this down, one way to do it would be to keep the pump flow up, and that would pull more heat out and you go follow this curve. But if you did that when you had the small rods, you would tend to shock the upper internals.

So the other way to keep this from going too high is to trip it very rapidly, and that has to do with thermal hydraulics and the fact that you are always going to play with two different size rods. There is a period in the life of the plant when there is very little power in the blanket rods, which are very large, that the plant drop -- at the beginning of life, the drop in temperature at the beginning of the core when the plant trips is very rapid.

Later on in life, as you get more power in the blankets, the trip is not quite so significant.

(Slide.)

I am not going to go through events A, B and C. I touched on A, but just to give you an idea of the net result of all of this, one way of approaching it is to say, well, if I have certain temperature limits for these different events and I know that the temperature I get to is a function of rod size, what limit do I have to have in steady state so that when I go through that transient I do not exceed it?

That is where this curve came from. This doesn't apply to Clinch River. There are a few minor differences, but we have the same general type of curve.

Your seismic event is limiting to the little rods, because just as they drop down rapidly because they have a very small mass, when you get a reactivity insertion of 60 cents they insert quite rapidly. In other words, if I can go back to this one just a second --

(Slide.)

If I had done the opposite and put in a very large amount of reactivity, this one would shoot up like this (Indicating), this one would still not go up very fast. It wouldn't go down, but it wouldn't go up very fast.

Therein lies the real difference as to why, if you have to trip the pumps rapidly, you also want to trip the control system very rapidly.

So this event is a limiting one for the little rods. Then you have a little bit larger and then finally this is your steady state limit and this becomes the limit on the other side.

Now if you made the reactor trip system slower, these two curves would move down in this direction (indicating). If you made the pump slower -- slow down less rapidly, this would move up. So you can play around with moving that and play around with rod diameter.

To put it in perspective, Clinch River's fuel rod is not quite .6, limited by that type of event. A blanket rod is a little over 1.25, denoted by that event. But the point is that both of those, that curve is a definable quantity. It can be varied. Your rods can be varied in size and the temperature you operate at can be varied.

So you set them all to match.

(Slide.)

So, in summary, we want the pump close down to be fairly rapid to avoid thermal shock of the upper internals, but it is design dependent. The control rod insertion rate requirement is even more design-dependent, but is a fairly rapid one for Clinch River, and that is where we get our requirements. If we had larger rods, they would probably not be as fast, but they are within the state-of-the-art. There is no problem in doing it.

(Slide.)

As a kind of a final slide, let us put that one back up again. They have a little faster trip. There is no problem. And, of course, it is a smaller core. That is particularly no problem.

Any questions?

MR. KERR: Questions?

(No response.)

MR. KERR: Mr. Dickson, it appears to me that what you have done is what I would have expected you to do -- tell us how one controls the reactor. You control it, for example, to avoid clad damage. It is not clear to me in your design whether you call this a control system or protection system so that will occur.

Now that is not any different from a lightwater reactor. In a sense, you control the lightwater reactor so you do not damage the core. But I think one also needs, and I think somebody is going to give us this, I expect, whether you have concluded that the reliability that is required in this operation is about the same as you require for the LWR, a lot better, a lot worse.

What you have said is based on the assumption that the thing is going to work and the LWR design is based on the assumption that the thing is going to work. Do you get in more trouble if this one does not work, or is it about the same as the LWR? How have you gone at the design of the system with the idea that it better work?

MR. DICKSON: Okay. You are going to hear a lot more about that, but let me just try a little philosophy, because I am not sure how much of it has to do with the fact that you are in any more trouble if it does not work and how much of it has to do with the fact that we are more conservative because of a first-of-a-kind type of thing, or whatever the cause may be.

But we have gone and taken the attitude that we want two completely independent systems, which is not different from the lightwater, redundant, which is not different, but diverse as much as possible, and we have tried to get that diversity not only in the electronics and the trip signal, in the mechanical, the way they operate, we have gone through to have our two completely separate, redundant, independent control systems working independent of one another.

So the net result is we end up with a much higher reliability than the lightwater reactors. On the other hand, we have no boron injection system, obviously. We have both burnup control, as well as our power swings and our safety function, with our control systems.

Part of the control system secondary has only a safety function and one-third of the primary system has only a safety function. Two-thirds of the primary system have both a burnup and a power change function, as well as safety.

MR. LIPINSKI: You pointed out you were trying to avoid thermal shock. Right now, all you achieve are fast scrams. Are there benefits to having a rapid rod runback rather than scram in order to mitigate some of these thermal shocks?

MR. DICKSON: There are a lot of approaches. If you look at it from a philosophical standpoint, one could have a fast-acting variable orifice on each assembly. That is a very good solution to the problem. You never have thermal shock. You always have nice power output, and that would be the best. It is difficult to achieve reliably, and I think no one here would be listening to us very long if we offered that solution.

The second possibility is to tailor the rod runin with the pump speed, as you said, which is the second way out. You can do that ideally if the rods are only the same diameter. You will still have the mismatch in diameter between the two, but it will probably be more important than that.

The best way to put the rods in most reliably is to disconnect them and let them go.

MR. LIPINSKI: But you still control the speeds, and if I do not maintain the transient you go through the rapid shutdown mode as a resort.

MR. DICKSON: I think it is in a sense, in normal shutdown we run the rods in. We do not scram it. You are probably right that we would not have to scram it as much as we do. On the other hand, we can do it without damaging the core and without degrading its lifetime excessively. So we can accept that.

I might note, for example, where you talked about how we compare with the French. The French take the same events we do, except they do no lay on an emergency event at the end of plant life. When they talk about a two-year life of the core, a three-year life of the core -- whatever they are achieving -- that does not account for that event. They are willing to take a certain amount of fuel failure at that point, which is another adequate philosophy.

I am not disagreeing with it. We take the more conservative position that a worst fuel pin -- and, mind you, when we talk about these this is always the hottest spot under the worst pin in the worst assembly -- will not get a CDF greater than 1.6. It is conservative opinion.

MR. EBERSOLE: Could you comment on what unusual steps you might have taken to reduce the challenge rate? I notice you worked pretty hard in getting down to a very few per year.

MR. KERR: Is that going to be covered in a subsequent presentation, Mr. Dickson?

MR. DICKSON: I think there will be some mention of it, but I do not think we have really worked hard to get the challenge rate down. What we have assumed for the analyses of all these events is significantly greater than what we actually expect -- like, for example, loss of all AC power every two years.

MR. EBERSOLE: As a case in point, what percent bypass do you have of the turbine? You know, one way not to have a challenge is just to bypass.

MR. DICKSON: There is some, but I do not know what it is.

MR. ROSECKY: Down near 80 percent.

MR. KERR: Would you identify yourself?

MR. ROSECKY: Bob Rosecky, Clinch River.

MR. EBERSOLE: So when you have a plant trip you do not have to scram.

MR. DICKSON: We do, though.

MR. EBERSOLE: But you do not have to. What do you do, have fast run-in via bypass? Do you do something to try to prevent the scram?

MR. DICKSON: No, we do not. We scram.

MR. KERR: This is a question here.

MR. CARBON: Will someone be talking later about how different the two protection systems are, to what length we have gone?

MR. DICKSON: Yes, both philosophically and electronically, so far as we use transistor logic in one system and relays in another kind of thing. That will be covered.

MR. WARD: Getting to the question of what reliability are you requiring, what is needed here, just briefly could you tell me what are the implications, the concern about shock, thermal shock to the upper internals? What is the implication of that? What is the spectrum of thermal shocking?

MR. DICKSON: We have coupons in there to monitor to be sure that we have not reached any damage limit, but if we shock them much more than we anticipated with greater transients than we anticipated or greater frequency, I guess one possible consequence might be that we have to change them out.

But I cannot conceive of that because our analyses are exceedingly conservative in both the rate and the range and the frequency and we have plenty of margins. So I cannot conceive of the problem. But we do have a rather rapid pump rundown, as do the lightwater reactors.

MR. KERR: Thank you, sir.

MR. DONCALS: My name is Dick Doncals of Westinghouse. In this part of the presentation I will highlight the physics features relevant to the CRBRP control and protection systems.

The outline for this part of the presentation is as follows:

(Slide.)

Initially what I would like to discuss is the control assembly locations, in other words show you the different control systems that we have in the reactor, show you where they are located, and also give you a very brief discussion of their operating history -- in other words, during the ascent to power the actual movement of the control rods.

This will be followed by a very brief discussion of the design basis and criteria used in the nuclear design of the control assemblies. Now I will very briefly cover and show you the control assembly works that we predict for CRBRP. First we will show you we satisfy the design basis and criteria. Then I will discuss the control rod withdrawal, reactivity insertion rates, so you see the worth coming out of this reactor.

I will also show you the shutdown worth. As you will see later in the discussions, these values that I will present here are used in the following subsequent two discussions, showing how they meet their reactivity insertion rates for both the primary and the secondary control systems.

(Slide.)

The first subject I would like to discuss is the control assembly locations and their operating history.

(Slide.)

Prior to doing that, what I would like to do very briefly, I am sure many of you are aware of the Clinch River heterogeneous design, but I thought it would be worthwhile just to show it to orient us all here.

The CRBRP core has 156 fuel assemblies and 76 interblanket assemblies. They are interspersed here in radial rings inside the core region. As you can see, we start with a small island of interblankets here. Then we proceed radially with rings of fuel blankets, fuel blankets, et cetera. This whole reactor inside we call the heterogeneous core.

This core is then, in turn, surrounded by 126 radial blanket assemblies, so we have our heterogeneous core mixture fuel assemblies, interblankets. Then this is surrounded by radial blankets. In turn, this reactor is surrounded by 312 radial shields. The reactor core height is 36 inches and on the top and bottom of the core we have 14 inches of axial blankets. That is for the orientation purpose.

Now what I would like to do is show you the location of the control systems that we have. As most of you are aware, we have two control systems. They are identified as the primary control systems and the secondary control systems. I would like first to discuss the secondary control system in a very general nature.

You can see they are located here at these positions, and they are called at the Row 7 flat position, mainly because we are at the hexagonal configuration.

MR. KERR: Are you going to tell us why you chose two control systems rather than one or three?

MR. DONCALS: I will show you the requirements for each of those and show you that we meet --

MR. KERR: I am not interested in the requirements. I am interested in why you went about it this way. I would like to understand why you do some of the things you do.

MR. DONCALS: I will attempt to try that in my discussion. I will show you the general design criteria we used, but we will also show you why we have both control systems. I think a little later in the discussions when you will see the requirements of reactivity insertions and why they are in certain reactivity amounts, you will get a better feel for that.

MR. KERR: Okay. I will be patient.

MR. WARD: What sort of peaking do you have in the fuel assemblies that are next to the internal blankets, inner blankets?

MR. DONCALS: We have radial peaking factors like 1.2, on that order, at Clinch River. We have done an extensive study in laying that core out in which we have analyzed at least 50 different core configurations, coming up with this arrangement. In that study we also varied the locations of the different primary and secondary control systems to see their effect on the power distribution.

In the secondary control assemblies there are six of these. They are withdrawn prior to the ascent to power. They are withdrawn in part at the top of the core.

MR. CARBON: Could you straighten me out? I am missing something. You have arrows to three apparently identical --

MR. DONCALS: There are 15 control assemblies in CRBRP. They are broken down into two subsets. We call them the primary control assemblies --

MR. CARBON: Secondary, you mean.

MR. DONCALS: I am sorry, secondary, and we have nine primary control assemblies.

MR. CARBON: Yes, but your symbols are all alike.

MR. DONCALS: Yes, I will show you. Here, here, here and here in this location are the secondary control assemblies. There are six of them. We should have made them --

MR. CARBON: Do that again, please.

MR. DONCALS: At this location here, here, here, here and here. We call that the Row 7 flat position in the reactor at this position.

MR. CARBON: Then the remaining ones are the primary?

MR. DONCALS: The remaining nine rods are the primary control system. They are in two sets -- one called the startup rods. You can see them at this location here, here, and here. There are three of those. These rods also prior to ascension to power, they are removed from the bottom of the reactor and parked at the top of the axial core.

Now the remaining six rods in the primary control system, you can see them here, we call these the corner rods, at these locations here. They are the rods that we normally operate for control reactivity for fuel burnup and depletion. Now they also have the capability of shutting the reactor down to the hot standby condition.

The nine rods at hot full power condition, anytime in our lifetime, will shut the reactor down to hot standby condition, and I will show that a little later. These six control assemblies will shut the reactor down to refueling conditions from any operating conditions. So both of these sets are able to insert enough reactivity separately to shut the reactor down.

In addition, the primary system is able to control reactivity or provide necessary reactivity for burnup and depletion, so in effect we have two systems that can shut the system down.

MR. KERR: Let me see if I understand. With all of the primary control systems out --

MR. DONCALS: No, with the primary control system out or only here.

MR. KERR: Let me finish my question. With all of those assemblies out, the secondary assembly will shut the system down?

MR. DONCALS: No, sir.

MR. KERR: Okay, then I misunderstood you. I thought you said two separate systems, each of which would shut the reactor down.

MR. DONCALS: From the normal operating position of the primary system.

MR. KERR: I am not trying to be critical. I am just trying to understand.

MR. DONCALS: The position you are talking about would imply that the primary bank has withdrawn completely from the reactor.

MR. KERR: It sure would.

MR. DONCALS: This system will not do that.

MR. KERR: But with the secondary completely out, insertion of all of the primary will bring it to hot standby, is that correct?

MR. DONCALS: That is correct.

MR. RAY: If they were in reverse, what would be the state of the reactor with all the primary out and the secondary in?

MR. DONCALS: That normally would not occur as you scrammed.

MR. CHECK: It would be on its way to somewhere.

MR. EBERSOLE: Are the channels within which the rods go down protected by a cylindrical shell or something?

MR. DONCALS: I think a subsequent speaker will be able to tell you that much better than I.

(Slide.)

Just to give you some more insight on where the rods are operating in a given startup, if you recall --

MR. KERR: Excuse me. Just one detail. The primary will bring it to hot standby with one most reactive rod stuck out?

MR. DONCALS: That is correct, and I will show you that in one of my vugraphs. I wanted to get it across that we are designing into those type of criteria.

MR. KERR: Thank you.

MR. DONCALS: The last one in this section that I would like to show you is to give you some feel for where the control rods are actually operating within the reactor. The 36 inches of the active height of the reactor at hot operating conditions, we had six secondary assemblies fully withdrawn and those three primary rods fully withdrawn.

At this point of start of life, the plot here is the position of the rods relative to the bottom of the reactor at hot, full-power conditions as a function of lifetime. I have shown this here for what we call cycles 3 and 4 and as a function of full power days of operation. I have plotted here two curves -- the nominal condition we expect of the control rods and also what we call the 3 sigma or the furthest end position that we would expect.

I would like to point out on the nominal condition at time zero we are at 100 percent full power. At that time our rods are 16 to 17 inches from the bottom of the reactor. As fuel is depleted in the reactor, we have built up our fission products and they are built out to about 28 inches to give us the necessary reactivity.

At that point, at the end of cycle 3, we would shutdown, refuel the reactor and bring the reactor then back up. And you see you start again at about the same place and the rods will move out in the subsequent cycle about the same amount.

MR. WARD: Do you build in -- there is not any ability to independently shape the actual power profile?

MR. DONCALS: That is correct.

MR. WARD: What sort of peak average power ratio do you have?

MR. DONCALS: The axial is anywhere from 1.3 to 1.4, and the radials are 1.2. So you have the multiples of those two values.

MR. WARD: Do you build in plutonium in the blanket in some sort of an axial profile, then, and burn up the fuel?

MR. DONCALS: You burn up the fuel in the middle of the reactor and we do detailed calculations to account for that.

(Slide.)

Now the second subject I would like to address, and we get a little more into some of the criteria we use, is the design basis and criteria.

(Slide.)

And there is a spelling wrong here, but we show the reactivity control and protection system requirements that we are using. We are using Appendix A to Title 10, Part 50 of the Code of Federal Regulations. We had this interpreted. You can see it in section 3.1 of the PSAR actually how we are doing it.

We use the two criterion -- criterion 23, which is the protection system requirements for reactivity control malfunctions, and 24, reactivity control system redundancy and capability. These are somewhat general criteria, but we have made them very specific for CRBRP based on these criteria, and that is listed here.

(Slide.)

We feel that we do meet every intent of those criterion and we are very pessimistic in the way we assume certain things. As you can see, in the primary control system --

MR. KERR: Excuse me. Do you think those are good criterion?

MR. DONCALS: Yes, sir. I have worked on these for about three or four years.

MR. KERR: The GDC 23 and 24 to which you refer?

MR. DONCALS: I do, but they do give you some latitude to make certain approximations. When they say a stuck rod, we assume that our stuck rod is in the completely run out position. The criteria does not pinpoint you there. It gives you two temperatures that you can come down to. We define those here. So it gives you latitude. That is why I say they are general, but we made them very specific here for Clinch River.

As you can see, under the primary control system the first function is to shut the reactor down from hot, full-power conditions to hot standby temperature. In addition, it must compensate for any excess reactivity requirements that you need during the cycle.

Here is the main point that you were making, that we have to have allowance for the maximum reactivity fault associated with any anticipated occurrence. We have postulated this to occur upon the accidental withdrawal of the highest worth control rod inserted in the reactor. That is the primary system.

If you are operating at full primary condition, your primary bank is in, we assume that one of those rods run up and we use that reactivity as the maximum reactivity fault.

In addition, we assume that that single rod is stuck out where it ran. So we could have assumed that the rod would have been stuck at the operating position, but we put it on what we felt was a more conservative assumption by having that individual rod run out to the top of the axial core and then stick there. That is this rod we stick.

MR. CARBON: This one we are speaking of was part-way in?

MR. DONCALS: That is in our operating control system.

MR. CARBON: So it runs the rest of the way in and then all the way out?

MR. DONCALS: At 17 inches, roughly, the beginning of life, the furthest in, it will run. The amount of reactivity we insert is taking it from 17 inches to 36 inches. That is the rod run-out that we call the fault.

We stick one at that position. That is the stuck rod. Then we assume the other rods in the bank will come in and shut -- we do not assume it. We make the other rods come in to shut it down at the hot standby temperature.

MR. CARBON: There is no matter of timing or anything in the worst case?

MR. DONCALS: You will see in the subsequent discussions that they worry about rates of insertion, giving ramp insertion rates, plus these are static-type insertions.

MR. WARD: The assumption that the maximum reactivity fault is the single rod drive now? I guess that must be based on some reason from the design of the rods that you cannot have more than one drive out from a common fault. Is that correct?

MR. DONCALS: That is the basis of this, but the criteria says it is a maximum reactivity fault. We have looked in our system to see what kind of reactivity we could get from, say, the core voiding and all the different conditions. We feel that this is the highest worth that is possible.

It is certainly in a faulted condition. I do not want to give this as a normal occurrence. I will show you a little later the magnitude of these. These are very large values.

MR. WARD: So you are protecting against that, but my question is, is there a mechanism by which two rods could fault?

MR. DICKSON: You are really jumping ahead. If you would bear with us a little bit --

MR. DONCALS: We will be showing you some of that.

MR. KERR: Mr. Ward, I can answer that

question. The answer is yes.

MR. EBERSOLE: Your primary system reminds me of a PWR, except they use boron. What do you do when your primary control system -- well, how do you get it below zero power, down to zero power at the refueling temperature? Do you use the secondary controls?

MR. DONCALS: We actually bring both of the control systems in as we come down to refuel.

MR. EBERSOLE: It takes both of them?

MR. DONCALS: No, sir. We can do it with one or the other. The secondary control system will bring us all the way down. The way we have it designed today, to the refueling condition, this one will bring it down to the hot standby condition.

MR. EBERSOLE: You have failure of the secondary?

MR. DONCALS: All these under this postulated --

MR. EBERSOLE: Then what do you do?

MR. DONCALS: One would have to first attempt to -- well, we have these operating specs that we have in our PSAR, but one would have to see what was the problem. We could maintain -- when I say "hot standby", that says 600-degree conditions, so you are really fully shutdown. It is not producing power.

MR. CARBON: The primary control system is all nine rods?

MR. DONCALS: That is right, all nine rods.

MR. CARBON: If one of the three cocked ones did not move, that would not be a worst scenario?

MR. DONCALS: No, sir. We looked at that to make sure that this is the highest one.

In effect, the way we do this analysis with this reactivity fault, assuming it stuck in a full-out position, we actually lose two rods out of the primary system because we have what we call an interaction effect that is very large. If the rod moves up there, there is a build-up of flux, so its worth is much larger.

MR. EBERSOLE: If I stick a rod, that is an accident and then I attempt to shut down. Do you have then a criteria that you shut down with no further rod sticking?

MR. DONCALS: Yes, sir.

MR. EBERSOLE: In other words, the first stuck rod is the only stuck rod?

MR. DONCALS: Yes, sir. That is correct.

(Slide.)

I will give you an idea for the magnitude of these various values of stuck rods and faults. This is shown herein this control assembly worth versus requirements section.

(Slide.)

I will not go into a lot of detail in our talk here, but I did want to get across to you some of the magnitude of the reactivity values that were controlling these two different systems.

For the CRBRP I have four vu-graphs, two relative to the secondary control system and two relative to the primary system. We have done this analysis for different times in life. This is the beginning of cycle 1, end of cycle 1, and so on to the beginning of cycle 5.

Listed here are the requirements for the secondary system, and listed here are calculated 3 sigma worths. So the magnitude of the secondary coming down to refueling condition is about one percent delta k. The reactivity fault you can see is very large. It is .72. That's the rod running out from its full inserted position to the all out position.

This is our requirement for some of those, too, and here are our worths. You can see that's a very high value for a stuck rod if you just divide it. This rod worth is very high, so we take that off, and this is our requirement to compare it with this, and that is what we call our worth minus requirement value, .85k. And our insert need is 0.46 on that value. We attempt always to have the worth minus requirement in excess of the value of the 3 sigma value. That is merely to show you how we meet the intent of the requirements that we have developed for Clinch River.

I won't go into much more detail on this, but

I would just like to point out that the limiting value for the secondary control system is in the third cycle at the beginning of cycle 3 and the beginning of 5. You can see where the worth minus requirement is approximately equal to the 3 sigma value. We satisfy all our requirements and we meet what we call a 3 sigma. We have enough margin to satisfy the 3 sigma uncertainty.

MR. WARD: What contributes to the sigma uncertainty?

MR. DONCALS: Well, here it is, in the cold to hot. In going to hot full power condition we have uncertainty in that. We have a fault uncertainty; also from the criticals. We recently, about three or four months ago, completed all of the criticals on CRBRP where we measured worths, compared them with our predictions, got biases and uncertainties. So that is where we get our 3 sigma values.

MR. CARBON: What sort of uncertainty do you have after you get through with critical tests?

MR. DONCALS: In the insertion of the criticals it's about 2 percent 1 sigma or 6 percent. If you measure the rod worth, we predicted on a 3 sigma basis we can come within 6 percent. We used 12 percent in our design.

MR. CARBON: I would like to go back to a moment ago, Mr. Ebersole's question. If the operating rod sticks, then you assume no further ones sticking, but that is in the primary system, is that correct?

MR. DONCALS: That's correct.

MR. CARBON: If one did stick --

MR. KERR: Excuse me. But you do assume it sticks full out.

MR. DONCALS: That's right. We assume that that rod -- it doesn't stick at the operating bank position. We assume it's the faulted condition where the rod runs fully out and sticks in the out position, even though the other rods are operating in a much better in position. So we have two rods that we're paying a penalty for rather than one when we do it this way.

We have come up with this because we wanted to get what we felt was the largest fault condition.

MR. CARBON: I got lost somewhere.

MR. DONCALS: We operated at hot-cold power with the six primary rods about 16 to 17 inches from the bottom of the reactors.

MR. CARBON: Suppose one of those sticks?

MR. DONCALS: We don't assume it sticks there.

MR. DICKSON: Answer his question. He says suppose it sticks.

MR. DONCALS: We can shut the reactor down very easy. I can take of those like that if I don't have another fault.

MR. CARBON: With the primary system?

MR. DONCALS: That's correct.

MR. CARBON: I guess what you were going to say before Mr. Dickson diverted you was -- go ahead and tell me that.

MR. DONCALS: What I was trying to say is the way we design it is we assume that that individual rod runs out. That is our fault reactivity that we use in all of this. Then it is stuck out there. It's not stuck at the operating position of 16; it's stuck at 36 inches. That is why we effectively lose two rods the way we do this.

We could have, if we interpreted the criteria, assume like you said that --

MR. CARBON: You couldn't assume any more stuck.

MR. DONCALS: I can take another one.

MR. CARBON: A cocked one?

MR. DONCALS: I can't take another fault of the magnitude of this value out here because it is fully out, but I can take two stuck rods under the condition you're talking about and fully shut the reactor down.

MR. CARBON: Even if one of the cocked primary rods did stick and one of the operating stuck in, you'd still have the secondary system.

MR. DONCALS: Oh, yes. We have two systems. I personally feel we have more shutdown than a PWR normally has. I've looked at that in our own system, and we effectively have two systems of about the same magnitude, about $7 or $8 to bring in. They only have one.

MR. WARD: The assumption of the rod that drives out stick and sticks does not seem to be all that wildly conservative to me. Whatever the fault is, it drives out. It's probably not too unreasonable to assume that the same fault would prevent it --

MR. DONCALS: I've talked to my friends in the PWR position. If they have a bankout, they assume it comes back in. We're assuming that rod stays out there. It's a much easier condition if you let me bring that back in. I followed their logic the way they did it.

MR. KERR: I don't think we need to start a trend of being wildly conservative, because there is something anomalous about being wildly conservative. But please continue.

(Laughter.)

MR. DONCALS: We normally operate our six primary at an operating bank position. They are all together within plus or minus an inch and a half.

MR. CARBON: Is there anything that one comes out in the common mode sort of thing that would take them all out?

MR. DONCALS: I believe in a subsequent discussion they will be able to tell you that. Carvel already answered that, Max. The answer is yes.

MR. CARBON: Okay. I'm glad to hear that.

MR. DONCALS: The next part of this, I'd like to very briefly show you the same type of requirements and control rod worths for the primary systems. Again, we've done this type of analysis for the different times in life. You can see the requirements and control rod worths. The differences in cold to hot is slightly less, and that's because we're coming down to the hot standby position.

We have reactivity of about 3 percent delta k. This is for lifetime considerations, fuel depletion and burnup. Again, we have the reactivity fault in the system. That is our total requirement. In our control rod worths we have our six, and our other three rods giving us again a stuck rod. Then we have the difference of worth minus requirements, and you can see we have considerable margin in our rod worths.

MR. EBERSOLE: May I ask? I think somebody mentioned this, but what is your argument that you cannot have gang withdrawal?

MR. DONCALS: I really think that is going to be discussed by George Smith after my presentation.

MR. EBERSOLE: Is the gist of your position that you cannot have that?

MR. DONCALS: I think I'd rather let those gentlemen talk about that.

MR. KERR: He doesn't have a position on that, Jesse.

MR. DONCALS: I, some people say, am the nuclear physicist.

(Slide.)

The other thing I would like to very briefly cover with you is to just show you some magnitudes of rod withdrawal reactivity insertion rates in the LMBFR CRBRP.

(Slide.)

Shown is the single rod withdrawal reactivity insertion rates in CRBRP. You can see I plotted shown here the rod withdrawal speed versus the reactivity insertion rate. The maximum operational speed of an individual rod is 9 inches per minute. The amount of reactivity insertion per second if you have an individual rod moving out at that speed is something like 2.3 cents per second.

Now, if there is a control failure and there is a problem that it is supplying that we're having what we call a maximum mechanical design limit where you have this control failure and the rod is rapidly moving out, the maximum speed that it could move is about 73 inches per minute, and then the rollers open up and the control rod cannot move any further. At that position you have something like 18.5 cents per second insertion from this individual rod.

Now, they have performed prototypical tests that indicate the speed for this condition here is only about 45 inches per minute. At that position the rod cannot further move out because the roller nuts move up, and the rod cannot move.

MR. KERR: I don't understand the significance of the 73 in one case and the 45 in another.

MR. DONCALS: This was actually occurring.

MR. DICKSON: Seventy-three is the design spec. It was the maximum in the E spec, and the 45 was what they achieved in the design.

MR. KERR: Should I feel good about those numbers in the righthand column, or should I feel bad?

MR. DONCALS: I was going to say in a PWR their value is --

MR. KERR: That doesn't comfort me at all.

MR. DONCALS: These values are used in the transients.

MR. KERR: Why should I feel good about those numbers?

MR. DONCALS: With these type of transients here --

MR. KERR: I'm looking at the 18.5.

MR. DONCALS: The 18.5 -- and I'm not the expert in this area, but I would like to say that I talked with our experts prior to this meeting, and this is not the limiting condition, a 60 cent reinsertion.

MR. KERR: I should feel good because some expert looked at it, and he feels good about it?

MR. DONCALS: He's shown through analysis that the 60 cent per second is more damaging than this fuel condition.

MR. KERR: And you've convinced yourself that that is the largest withdrawal that is physically possible?

MR. DONCALS: Yes, for that.

MR. EBERSOLE: That's just one rod.

MR. DONCALS: That's on rod.

MR. WARD: That's the rate. So I guess some time response of the roller nuts would get some number of seconds at 18 1/2 cents per second?

MR. DONCALS: That's correct, and I don't have that.

MR. WARD: I guess we'll hear about that later.

MR. DONCALS: I would like to say that I know in PWRs their value is on the order of 10 cents per second.

(Slide.)

The next subject I'd like to briefly cover, because this is the basis that in a subsequent two discussions will be used, is the primary and secondary worths from hot full power conditions. Shown is the primary and secondary scram shutdown worths from hot full power conditions. These are the minimum shutdown conditions in percent delta k. They're given for 3 sigma maximum excess reactivity and minimum control rod worth; so we feel these are the minimum reactivity insertions we will have.

I have shown this table here as a function of time for the different times in the lifetime of the reactor up to this cycle (Indicating). There are two separate groupings -- the primary system here and the secondary control system here (Indicating).

Now, very briefly, because this is much easier to describe, the secondary control system, the values listed here are with the row 7 or one of the shutdown worth with one of the rods stuck full out. So with one of the six secondaries stuck in their full out position they are able to insert this type of reactivity.

As you can see, the minimum values are like 2.73 or 2.79, and this corresponds to something like $7 or $8 worth of reactivity. So that is the amount we're ready to put into a reactor on a scram.

In the primary control system it's a little more difficult to get that value. One must examine in detail if the row 4 rod is stuck out or the partly in rods are stuck at that position. So we go through all that type of analysis, and you can see we calculate the worths of the six rods here and these three rods for those different conditions.

Again, the limiting condition at the beginning of cycle 3, beginning of cycle 5, you add this value here, 15 versus .8. It's 2.3. So we again have $6 or $7 worth of activity at the hot full power condition ready to be slammed in the reactor.

MR. KERR: Let me see. The heading says R 7 F shutdown worth. What is R 7 F?

MR. DONCALS: A row 7 flat position.

MR. KERR: Those are the secondary rods with one rod stuck full out. Does that mean a primary rod or a secondary rod?

MR. DONCALS: That is the secondary. That is its own rod stuck. The remaining five coming in will provide you that reactivity.

MR. CARBON: Are all those five or six about equal, or is there much difference?

MR. DONCALS: They are different because of this interaction effect in a fast reactor. The one left up there is worth more on an average.

MR. CARBON: Is any one particular rod stuck out?

MR. CHECK: They are all equal.

MR. DONCALS: They're all equal in worth, but the one you leave cocked out there is much higher than if you just calculate the average of the six coming in.

MR. CARBON: But it isn't the matter of picking the weakest rod?

MR. DONCALS: No. That's why again in both these systems, the primary and the secondary systems, at hot full power conditions we have something like $7 or $8 worth of reactivity that we can insert as we scram the reactor.

As you will see in subsequent discussions, these values are used with the speed of insertion of rods that they have been designed to to meet what we call our design limit curves for how much reactivity we insert in the reactor as a function of time; in other words, how fast do you get $1 of reactivity in the reactor. That will be discussed in the subsequent discussions.

Now, what I hoped to do here, just in summary, was to show you that the CRBRP primary and secondary control systems are designed to meet the requirements. I feel personally we are using very pessimistic assumptions about the maximum reactivity fault and the stuck rod criteria. In turn, we feel we have conservative values of the resulting shutdown reactivity worths in the evaluation of the primary and secondary control rod scram reactivity insertion requirements.

MR. EBERSOLE: In the course of doing maintenance and testing and so forth when one is drawing rods out for testing purposes, what is the old phenomenon called local rod withdrawal when you accidentally pull two of them out which are continguous?

MR. DONCALS: I don't follow you.

MR. EBERSOLE: You pulled one out, and somebody makes a mistake and pulls the neighboring one out.

MR. DONCALS: It's worth will be less than the first one you pulled out.

MR. EBERSOLE: You don't have a local critical?

MR. DONCALS: No, sir. We don't have anything like that. No, sir. I understand. No, we don't have a local criticality problem in this reactor.

MR. CARBON: How much reactivity do you have tied up in the six primary rods that operate? How much would you gain if the whole bank of six came out?

(Slide.)

MR. DONCALS: These are the reactivity worths that we have. This is the primary control system. Here is the rows -- the six rods we were talking about. They're about six percent, and the three rows are 1.6, so you have about 7, 8 -- you've got about 9 percent delta k.

MR. CARBON: But three of those are cocked out.

MR. DONCALS: Yes. These are the only ones that could come out.

MR. LIPINSKI: But if they come out do they give you that 6.27? His question is if they come out, what do they add?

MR. DONCALS: You would take approximately this value. I have to take the shutdown from it.

MR. DICKSON: 2.95.

MR. DONCALS: Yes. It's the accessory activity here. It's about 003. You're talking about $9, something like that.

MR. CARBON: But 2.95 there in the secondary system is worth 2.73 with one stuck, and three cocked rods plus the secondary system would more than compensate for pulling out all of the six.

MR. DONCALS: It would if you didn't have a faulty condition.

MR. DICKSON: If I could add to that, if you calculate this on a nominal basis, not with the stuck rod and all of that, the secondary alone is enough to shut the reactor down to hot standby if all the primary bank comes out. That's not taking all the uncertainties he uses in his conservative calculation, but just nominally it would.

MR. CARBON: So that is if the three cocked rods weren't counted?

MR. DICKSON: And the other out, and the secondary comes in. You're shutting down the hot standby. Not assuming the stuck rod in the secondary, but all of them coming in and not taking the 3 sigma uncertainty value.

MR. CARBON: So that's reasonable.

MR. DICKSON: Yes, sir.

MR. DONCALS: For reasonable conditions we can.

MR. CARBON: So even if you take the stuck rod in the secondary system and a very conservative assumption, you withdraw the six operating and the six cocked primary ones come in and the five secondary ones.

MR. DICKSON: You'd still shut down, yes, sir, even with conservative assumptions.

Dick gets so used to these requirements with the 3 sigma --

MR. DONCALS: We have to design it that way. We looked at that very briefly in your logic, and we can't do it under these 3 sigma limits in a so-called faulted condition.

MR. KERR: Does that conclude your presentation?

MR. DONCALS: Yes, it does.

MR. KERR: Are there questions?

MR. CARBON: Yes, one question. I know very little about your system, of course, but I can hypothesize that if something caused one operating rod to withdraw, maybe it's conceivable that there's something that would cause all six of them to withdraw.

Can there be something? Have you looked?

MR. DICKSON: Yes. We've worried about that in significant length, and you're going to later hear about all the rod blocks we have in there to make that an extremely low probability event because we don't want that to occur, and we don't believe it can.

MR. KERR: Other questions?

(No response.)

MR. KERR: I don't know whether this is a question of Mr. Doncals or not, but I see reliability criteria, half of which has been withdrawn, I gather, and I see the single failure criterion stated or implied, and I hear about a multiple failure study.

At some point again it would be helpful to me to know how you guys, not the NRC but how you guys decided on what reliability standards you used. Is it a mixture of all of these -- reliability part of the time, single failure?

I'm not trying to be critical. I'm just trying to understand what it is that you used to say this is the way we are going to design this thing. We will operate the way we think it should.

MR. DICKSON: Let us caucus during the break, and we'll try to get the rest of the staff to bring it up.

MR. KERR: Do you understand my question? I may not be expressing it very well.

MR. DICKSON: I think I do.

MR. EBERSOLE: Is what you're now doing going to be analyzed against reliability criteria, all these safety features?

MR. DONCALS: These safety features --

MR. EBERSOLE: It's the chicken or the egg problem.

MR. DONCALS: To be honest with you, we used the criteria laid down by 10 CFR, okay, in our various criteria. You see, we are doing static-type calculations here which do not get into the reliability of a rod coming in or not. They are assuming certain things occurring.

MR. DICKSON: Dick does the nuclear analyses and the nuclear analyses only. He was told by others assume these things happen; see to it that we have enough control to do such and such, and that's all he can do. When it comes to the probability of those other things happening, we have the rest of the crew here, and I would just as soon Dick get off reliability.

MR. CARBON: There is a question that I think should be addressed to you. You have gone from a homogeneous to a heterogenous core, and there have been some benefits to it, but there surely are some disadvantages as well.

I know that the French, the Germans and others have looked and said gee, we don't see any benefits of a heterogeneous core. I think they have concluded that there are rod snattering effects that come in and so on. My question then is have you identified any deleterious effects as far as control is concerned in changing from a homogeneous to a heterogeneous core?

MR. DICKSON: No. In fact, everything we looked at at Westinghouse in the heterogeneous configuration -- we pushed it very hard in the CDS large core design studies, and it's been accepted as the accepted concept here in the United States at a very large core.

We feel very strongly that the advantage of it is primarily, which I see in the sodium void area, it cuts those values in half.

We feel that would be one of the big licensing issues, if you tried to license the homogeneous core. Paul Dickson has done some --

MR. DICKSON: Just a comment. The French continuously publish papers saying that the heterogeneous cores have advantages. A fairly recent one I got said the heterogeneous core would give you a lower time, but we don't need to go to it yet. The French and the Russians published a paper saying they planned to go to a heterogeneous core when we get to the large core, where it becomes significant, because now you're talking about flow-through numbers of plutonium where it makes a difference.

Most people seem to regard -- when you're making one little demonstration plant, why do you worry about breeding ratios? They take that attitude, why buy all that extra analysis in criticals, which costs a lot to achieve what appears to them to be a very small end goal that you can always do later.

MR. CARBON: Some people will argue, at least, that there's more to it than that. For example, I think the doppler coefficient is cut in half or something.

MR. DONCALS: That's true.

MR. CARBON: So there are advantages and disadvantages. It might be better to have an operating system where you have a higher doppler.

MR. DICKSON: We've done transient studies. I think Paul is going to show you that the effective doppler on ours was only about a 10 or 15 -- what was it, a 5 or 6 degree increase in temperature?

(Slide.)

MR. DICKSON: This is a terminated overpower transient. Here is our heterogeneous core. Here is the delta T increase. It's like 240 degrees. It's not a major impact.

MR. CARBON: That's the change in cladding temperature for this fault, this seismic fault?

MR. DONCALS: That's right. So it really doesn't amount to much. It is true that it is changed by the factor of almost two or more than two, but if you add in now the blanket dopper as well you actually have more in the heterogeneous core. So for slow transients you get a better effect.

MR. CARBON: Is there any other place that you would have a much more likely sort of problem, where you would like to have a bigger doppler than what you gain in this relatively rare condition?

MR. DICKSON: In the doppler range you're talking about, I don't think it's of great significance. This is a terminated transient. I don't really think it is of much significance.

The most negative effect of a heterogeneous core is in the handling of thermal stripe. A lot of hot and cold fluids mix.

MR. KERR: Other questions?

(No response.)

MR. KERR: I declare a ten-minute break. We will start again at ten of.

(Recess.)

MR. KERR: Who's on first? My agenda says G. Smith. Is that correct?

MR. LAWRENCE: I'm Bob Lawrence from Westinghouse. I'm going to address the question about the reliability program for just a few minutes, to try and get us all in the same base, if I could. I really believe that any detailed discussion [illegible] the reliability program should be the subject of another meeting, but it has become fairly clear that you gentlemen have looked at some relatively old and out of date information, and I would like to kind of give you a feel for how we've deployed our reliability program.

The updated Appendix C has laid out a plan since about 1976 or '7, I would guess, that says in effect reliability is one of the many tools a designer uses. It is used as a means of obtaining the final end product, just as we use stress analysis, thermal hydraulic analysis, and all the other tools of design. We do not have a specific quantitative reliability goal we are trying to demonstrate. Somebody mentioned 10^{-6} earlier. We do not say we are going to demonstrate the secondary shutdown system to 10^{-6} or 10^{-5} or some other number.

What we have done is perform on systems important to safety qualitative reliability analyses, such as failure modes and effects analyses, common cause failure analyses and so forth, to try and use reliability kind of techniques to improve our design.

MR. RAY: You use reliability quantitatively -- let me see if I understand it -- as a tool, but you haven't decided when you are going to be satisfied yet. You haven't yet decided as to when you're going to be satisfied that you have sufficient reliability.

In the old philosophy, apparently, if someone decided on 10^{-6} and you are going to be satisfied if you could meet that, you had gone that far. Is that the difference?

MR. LAWRENCE: I don't believe I followed all of that. Let me try and explain in a little more detail how the designer uses the reliability program. For example, on the secondary shutdown system there are lots of different analyses performed. Reliability is one of them. Failure modes and effects analysis in particular is one of them.

Now, if there is a failure mode identified in that analysis the designer has to make a conscious decision, what he wants to do with that failure mode. Does he want to change the design in such a way that he designs that failure mode away? That is one possibility.

Another possibility is that he looks at all of the things it takes to have that failure occur and he decides that in his own judgment, that that is so unlikely that he is not going to change the design.

MR. EBERSOLE: But does he do that numerically?

MR. LAWRENCE: Not necessarily numerically. He may have some numerics developed, but it is not a fixed number that he has to use as a go-no go test.

MR. EBERSOLE: It's judgmental.

MR. LIPINSKI: Let's discuss the ion chamber rate through to comparative. How do you know your system's comparative if you don't have the numerical evaluation of the chain?

MR. LAWRENCE: In some cases --

MR. MACRAE: We'll talk to that.

MR. KERR: If they're really going to discuss it, let's see what they come up with.

MR. LAWRENCE: In general, we have not set some of the goals. Some of the components do use numerical analyses as part of their design, and we have not prohibited that, plus there is no overall number set for the project as a whole.

MR. LIPINSKI: How do you address the ATWS issue? What's the probability you're going to have an ATWS, 10^{-3} per year?

MR. LAWRENCE: Our position there is that we have, as you've heard today and will hear more, a completely separate second shutdown system.

MR. LIPINSKI: But I still don't know how good it is. It may have a common mode where it's not of any value.

MR. KERR: What I hear you saying is you have not used the probability of an ATWS, the numerical probability, as a decisionmaking tool.

MR. LAWRENCE: That's correct.

MR. RAY: But you measured one design possibility against another by a reliability calculation for each.

MR. LAWRENCE: Could you expand on that a little?

MR. RAY: That's the question. I'm still not clear on what you do with the quantitative reliability calculation, how you use it, if you use it and how.

MR. LAWRENCE: For example, we have done a quantitative analysis of shutdown heat removal systems. We have done an extensive modeling of the whole shutdown heat removal system, and we have quantified failure rates and so on. And then we have run sensitivity studies.

We have looked to see where the overall shutdown heat removal process was most sensitive to a failure. Then we have concentrated our efforts there. So rather than trying to make a recirc pump more reliable, maybe we try to make the steam generator more reliable because we found that failure of the recirc pump really didn't do much for the overall reliability, but the failure of the steam generator did.

MR. LIPINSKI: That's a basic change in philosophy, because Appendix C gave original portions that you have abandoned.

MR. LAWRENCE: That's correct. That's why I want to try and clarify that we are not aiming at a particular numerical goal.

MR. LIPINSKI: What was the reason for abandoning the original approach?

MR. LAWRENCE: I think in some cases that has already been expressed by Mr. Kerr, that it is a little difficult to convince anybody that if you have a number, that you have in fact satisfied that.

MR. LIPINSKI: But having no number, you have no appreciation for how well you've done.

MR. KERR: That is a statement, not a question.

(Laughter.)

MR. LAWRENCE: I don't agree with the question.

MR. DICKSON: He didn't say, I believe, that we never look at a number and use it as a judgment. What we do not want to do is propose a number proves anything in a licensing arena sense from the standpoint that once you get in the realm of 10^{-6}, 10^{-7}, you are really on thin ice.

The second thing is, those reliability numbers are very difficult to quantify, taking into account common cause and human factor error. Your reliability numbers tend to be in single failures to a train. Yes, those can be used to find out, where is the weak point, where do we want to put in a duplication, a change of design, or whatever, and they are used by the designers.

But we would not want to present them and try to defend them against common cause and human factors.

MR. LIPINSKI: But if your numbers without common cause are very low -- and take again 10^{-3} for atmosphere, that's a common cause and it's a system that's unacceptable to start with.

MR. DICKSON: And we would not design it that way.

MR. LIPINSKI: But we don't know how well you've designed it.

MR. RAY: I am still in left field, in a sense. You say you do quantify reliability in your analysis, and then you perform a sensitivity study to determine where the most influential deficiency can develop, as it were. And you do this by changing your design and improving the reliability of that one component or element.

How do you know when to stop? When will you be satisfied?

MR. LAWRENCE: That comes back into the engineering judgment of how credible do we believe the failure is or how extensive are the results of that failure.

MR. RAY: So then, having modified the most sensitive element, you will have another calculation of reliability overall with that incorporated in the design and then make the decision as to whether you've proved it or not on a judgmental basis; is that what you're saying?

MR. LAWRENCE: Generally, yes.

MR. RAY: So in general what you're saying is that no figure is holy, in the sense that you have reached heaven, as it were, when you've reached that figure, and that's what you wanted to avoid.

MR. LAWRENCE: We have tried not to design to a figure. We have used the quantitative approach to look at what might be the weak links in the chain and then how significant are these weak links.

MR. RAY: And modifications of them.

MR. LAWRENCE: That's right.

But just like to some extent a stress analysis comes out to be a judgment call as to were your assumptions conservative enough, this will be dependent upon judgment.

MR. RAY: But in stresses, you have a quantitative measure as to what materials or electronic performances -- what variations there are in those things that are reliable.

MR. LAWRENCE: There are still going to be assumptions made in the analysis.

MR. KERR: May I suggest we haven't had our introductory comment. We're going to hear about the reliability in some detail later on. I think we recognize that it is not being used as an absolute criterion.

MR. RAY: I yield.

MR. WARD: Could I just make one point? I think this is going to keep coming up. It just seems to me that you have used a rather traditional design approach, based on engineering judgment, rather than moving into the world of quantitative reliability design on a PRA basis.

And there was an indication in the earlier PSAR that the design was going to be based on the more explicit use of quantitative assessment of reliability. I think I can understand why you have not done that, but you must have had some reasons why you backed off from that approach. Maybe that is what everyone is wanting to hear.

Do you believe that the state of the art of quantitative reliability analysis in design is not advanced enough, the human error things predominates? Are those the reasons?

MR. LAWRENCE: Those are the types of reasons, yes.

MR. KERR: If I had to guess, I would guess that someone wrote Appendix C without consulting the design people. Well, they found out about it.

(Laughter.)

MR. LAWRENCE: I hope that puts us into a better context of how we are using the reliability.

MR. RAY: It helps me. Thank you.

MR. SMITH: My name is George Smith from Westinghouse. I would like to talk about the mechanical design of the primary control rod system.

(Slide.)

I think we know now that we have two control rod systems.

(Laughter.)

MR. KERR: Just wait. We'll have three in a little while.

MR. WARD: Two is more reliable than one. Twice as reliable?

MR. SMITH: I'm not going to get into those numbers.

(Laughter.)

MR. SMITH: The primary control rod system has two functions: It has a control function and a shutdown function, or a negative reactivity function. It is different than the second system, which is principally a shutdown system. I think Roger pointed that out, but I wanted to emphasize it again.

I would like to go into the two functions in the design of the primary system. Before we do that, I would like to show you how they fit in the core.

(Slide.)

MR. KERR: Is there some way that we could eliminate some of the light? I hate to miss the beauty of this color. Ah!

MR. SMITH: I have shown here the two control rod systems schematically. To give you an orientation in the plant, this is the primary system and the secondary system (Indicating).

To give you some figures, the primary system mounts on the head. It extends 11-1/2 feet above the head. I use the top of the head as a reference because that's our reference point on elevations. The sodium level is about 7-1/2 feet below the top of the head. The center of the core, the active portion of the core, is about 36 feet below the top of the head. The total length of the primary system from the bottom to the top is 55 feet.

The maximum radial dimension is about 10 inches. We've got a very long-in system.

(Slide.)

Here again is a schematic drawing. I would like to just point out some of the components in the primary system. I think we will talk about the secondary later.

We start with the head. The primary system is a basic roller nut design. It's a conventional design that was developed for the light water long ago. It is being used today in FFTF and it's only very slightly modified for the CRBR. So it's a conventional roller nut design which you probably are familiar with.

It has stators. It has a stator segment, arms, roller nuts, it has a scram spring, bellows, a drive line that comes down and connects to a control assembly.

MR. EBERSOLE: Would you comment on the motor characteristics?

MR. SMITH: I'll do that next.

MR. LIPINSKI: Before you take that off, on the collapsible rotor nuts, are there springs that drive them apart?

MR. SMITH: They pivot and are driven apart by springs.

MR. LIPINSKI: There are springs that drive them apart?

MR. SMITH: Yes.

(Slide.)

This is a very simple description of how that works. Out here is the stator, which produces the magnetic field, which brings the segment arms apart. You pivot at this point and force the roller nuts in against the lead screw. When the magnetic force is removed, if the scram breakers are open and the power to the mechanism is terminated, the segment arm springs here force the segment arms apart here.

The roller nuts come out, release the lead screw, and the nut comes in. The motor really has four functions. It has to latch, it has to hold, it has to run, and it has to scram. Let's review those four functions.

The latch. The power on the stator, the segment arms move out and at the same time we sequence the power in the stator such that the segment arms and the roller nuts rotate. Since the segment arms are held in place by bearings, the roller nuts are being rotated around the lead screw. This will cause the lead screw to either go down or up.

In the latch mode, we are applying force to the segment arms, latching the roller nuts and driving them down. It's possible for the roller nuts to come in land on land, but the down motion slips the roller nuts into the threads of the lead screw and they latch. You then reverse the direction of sequencing of the motor and the rod is driven out.

At any point we can stop the sequencing action and the rotation of the segment arms and it holds. The sequencing function or the application of the six-pull, four-phase motor. The application, the sequential application of the magnetic field around the motor is independent of the actual power to the stator. They are two separate functions and we'll talk about that later.

The point I'm making is that when we stop this sequencing we still have power to the stator and we still hold the roller nuts in against the lead screw.

MR. EBERSOLE: May I ask a question? What is the maximum possible hold force? Suppose you get excessive magnetic forces due to a loss of control over whatever field forces you have, and you jam the roller nuts together with whatever the maximum voltage tension.

Is there any possibility of deformation and common sticking of all of these?

MR. SMITH: The maximum voltage -- well, if we had a series of failures in the MG sets in the controller, the maximum possible voltage available is 250 volts. The normal application is 175 plus or minus

5 volts.

MR. EBERSOLE: That's the unregulated maximum, is that right?

MR. SMITH: The 175 is our regulated.

MR. EBERSOLE: Unregulated maximum is?

MR. SMITH: If a very unusual sequence of failures occurred, the maximum postulated voltage available is 252 volts.

MR. EBERSOLE: You designed to that?

MR. SMITH: Yes.

So this is how the mechanism operates.

MR. EBERSOLE: You said four-phase motor?

MR. SMITH: Six-phase.

MR. EBERSOLE: What voltage?

MR. SMITH: 175.

MR. EBERSOLE: What frequency?

MR. SMITH: It's DC.

MR. EBERSOLE: DC?

MR. SMITH: Yes.

MR. KERR: You never heard of a DC induction motor, have you, Jesse?

MR. EBERSOLE: No. You beat me there.

Is there any potential for phase reversal and having a common reversal of all of them?

MR. SMITH: Well, the DC power to the stator just holds it in. That reverses it and it goes out. The sequencing function just means that we apply sequential power.

MR. EBERSOLE: It's a stepping motor.

MR. SMITH: That's .at it is, a stepping motor.

MR. EBERSOLE: It's not an AC induction.

MR. SMITH: No.

MR. LIPINSKI: If you have a force at right angles to your pivot points, sinusoidal, what the frequency of that spring mass?

MR. SMITH: I don't have that number with me today.

MR. LIPINSKI: I assume when we heard about the scram with seismic it assumes these roller nuts are not disengaging, but they're slamming back and forth?

MR. SMITH: No, it assumes that the rod coming in is rattling in the chamber.

MR. LIPINSKI: It has nothing to do with the latches?

MR. SMITH: It has nothing to do with the latch function. We synchronize the bearing at the top, which is connected to the top of -- we actually have four -- two segment arms and four roller nuts. There's a synchronized bearing at the top of the segment arms which requires both segment arms to work together. You can't slam one out and one in at the same time, either through a seismic event or any other. So if one is in the other is in, and if the other is out the other is out.

MR. EBERSOLE: Is this a bone-dry system? No lubricants?

MR. SMITH: No lubricants. It has an argon atmosphere.

MR. SMITH: This is another look at that system which is not so diagrammatical, this will just give you a little feel for what it really looks like. It describes again the lead screw coming down through the segment arms and the four roller nuts being engaged to lead screw. The segment arms collapse. The roller nuts come out. The lead screw come in.

MR. EBERSOLE: Is there an individual stepping signal for each unit?

MR. SMITH: Yes.

MR. EBERSOLE: No commonality?

MR. SMITH: Each individual motor has its own control.

(Slide.)

The bottom of the drive line of the system is the primary control assembly. This is the drive line coming down from the control rod drive mechanism. It latches here and latches here. This is just the shaft. This is an outer duct.

I think the question came up earlier. We have a duct which is identical -- virtually identical -- to the fuel ducts -- the same pitch, same dimensions. The whole system rides inside that duct. The sodium comes in through here, goes up through orifice plates, up through a shield block to protect the lower internals from radiation and on up into a series of 37 pins. This is the absorbing elements in the primary control assembly.

We have a rotational joint here which, like a universal joint, which does not allow torque to be applied to the control assembly as it slides in the duct. We have a second inner duct which slides inside the outer duct on wear paths. Its principal function is to channel sodium flow up through the pins.

MR. KERR: What is the significance of the breakaway joint, or are you going to get into that?

MR. SMITH: That is used in case the control assembly sticks. It is a section there that is designed to break at a particular load. I think it is around 18,000 psi. If the control assembly duct sticks in the outer duct for maintenance or removal system, we could apply force to this drive line and break the control assembly at this point.

The control assembly will still be stuck in the duct. We can then withdraw the drive line and disconnect it from the stuck rod and shut the plant down and go in and so some maintenance on it. But the breakaway joint is a maintenance function.

(Slide.)

MR. SMITH: I said originally that we had two functions -- the control function and the shutdown function. I would like to go over some of the parts of each and I would now like to talk about the control function.

The primary control rod system is a category 1, safety class 1 system. It has two independent position indication systems -- the absolute position system of atmosphere, plus or minus .5, and the relative system, .15.

The absolute system maintains its position after scram and is measured by a wire which comes down inside the lead screw. It is a long positioning rod that goes all the way down to the top of the PCA. There is positive control on the actual controlling element. You do not lose that identification during scram.

The relative system is a magnetic counter which counts revolution of the segment arms as they rotate. When we scram, we lose that system. We have to re-zero it when we latch it in. We have to have selectable rod motions between 0.36 to 9.0 inches, and we move it at 0.025 inches steps.

The question came up about withdrawal speeds. If you remember -- I will put it back on. We ran a little test where we actually had to override the controller system and put in a sequencer that we could run to any speed we wanted, assuming the controller was out of business.

We applied successively higher rotating speeds to the segment arms. We find that they fly apart at precisely 43.5 inches per minute. The 73 inches that Mr. Doncals was talking about is used for design analysis and was a requirement on the mechanism. But the tests have shown we cannot exceed 43.5 inches per minute on withdrawal.

MR. EBERSOLE: Do they toggle out and clear, or do they just sit there and chew?

MR. SMITH: It is hard to tell. We have two things. One is pull-slip and the other is roll-out. The other is when the segment arms actually separate from the lead screw far enough to lose the lead screw and drop.

We have done a series of tests on what the minimum voltage is for roll-out. We have not found any significant wear or damage to lead screws subsequent to those tests. You can hear it chattering down, so that is the best I can tell you.

(Slide.)

The lifetime requirements on the primary system, the mechanism is 30 years, which assumes 732 scrams and 17,000 feet of travel. The drive line comes down into the sodium section of the plant, has a design life of ten years. The control assembly, one year. So right now the proposal is to change out the control assemblies after each 275 days.

We also have a requirement that the torque and moment on the mechanism be such that we can insert a 1,000 pound force to free a stuck control assembly.

MR. KERR: What does it mean to say that the mechanism is designed to last 30 years?

MR. SMITH: That is basically an economic limit.

MR. KERR: I am not asking why but what does the statement mean? It certainly does not mean it will last 30 years and the day after that it breaks down. How do you design for a 30-year life?

MR. SMITH: We design a certain lifetime. We assume that in the plant operation we will move the rods over a certain pattern. In 30 years it will have traveled 17,000 feet. If the very conservative criteria on scram and transient vent occurs, we will have had 732 scrams.

MR. KERR: What you are saying is that you do not design it so on the 733rd on it fails. So what does it mean to design it for 732 scrams? What do you design for?

MR. SMITH: You design for wear.

MR. KERR: For example, do you design it so you think it would really take twice that many scrams or 1.1 that many?

MR. SMITH: We designed it conservatively on the basis that we felt that the wear characteristics, the embrittlement effects, the sodium effects -- all of the effects -- the mechanism does not have any sodium effects, but we have actually found by tests that it will last twice as long as that. It will go to twice as many scrams and 35,000 feet of travel and show no wear characteristics. So our tests will show that it exceeds double that requirement.

MR. EBERSOLE: When you tested it, did you test it in a sodium vapor atmosphere and no inert gas and doing all the nasty things?

MR. SMITH: Yes, sir. We had a complete sodium system with sodium flowing at the design flow rate and the design temperature. We exceeded the flow rate and temperature in our test program. We have it -- I did not point it out -- we have a bellows system which maintains sodium atmosphere below the level.

We deliberately ruptured the bellows and found no diverse affects after one year of operation. So the answer to your question is yes, we designed it in prototypic conditions.

(Slide.)

The second function of the system is the scram function or the shutdown function. We have the primary shutdown systems. It has got to be fast enough coming in to not impact damage severity limits independent of the secondary system. I think Mr. Doncals went into that to some degree this morning.

MR. EBERSOLE: That gets back to the fastest reactivity transient and whether there is gang withdrawal.

MR. SMITH: From the mechanical point of view, each mechanism in the primary system is identical to every other mechanism. The system shall function during and after an operational basis earthquake. It shall function during an SSE.

MR. EBERSOLE: Is there a marginal capacity? Can I define a mechanical margin for the SSE just above some number that is in the book?

MR. SMITH: We think we have margin.

MR. EBERSOLE: This is a standard question.

MR. SMITH: Yes. We think we have margin. I do not have a number in my head. On the basis of -- one of the criteria here, what we are really talking about, is the control assembly itself.

MR. EBERSOLE: I guess we would ask you where is the break point for that item? What is the keystone?

MR. SMITH: Where do we fail first?

MR. EBERSOLE: Right.

MR. SMITH: Well, our basis of analysis is the pin cladding for the control assembly. It has to do with clad temperatures and pin clad failing. We have to be able to show that even after that transient the system will continue to hold, maintain its position, and keep the reactivity in the core.

MR. EBERSOLE: I thought we were talking about mechanical shock.

MR. SMITH: No, we are not talking about mechanical shock.

MR. EBERSOLE: I am talking about greater than SSE, which we do not know how accurate that number is.

MR. SMITH: We do not find any significance in our seismic analysis of this system. I think the worst place we might fail is in the fingers which hold the drive line to the PCA.

As an example, in an OBE, those fingers must not fail because we have to be able to take it back up to power during an SSE. Those fingers which latch on to the rod which holds the primary control assembly would be allowed to fail.

MR. EBERSOLE: Well, that is a fail-safe failure.

MR. SMITH: Well, it is different than the OPE because we could bring it back up again. That kind of failure is the thing that would limit us.

MR. KERR: One can imagine, without giving it a high probability, that there could occur an earthquake which would distort the core and distort the channeling that the control rod operates, so that they could not be moved in. That, of course, is not going to happen with the SSE.

Your design is a reasonable design, but there are designers -- not in the U.S. -- who have at least imagined that and I think have put in flexible control rods which will insert even after some core distortion. Why did you decide not to do that?

MR. SMITH: I am not sure, but I believe it was the belief that we had a conservative enough system to meet the kind of motion we were designing for and that our duct which encloses the system will adequately maintain it. I do not know what level of earthquake we are talking about.

MR. KERR: Well, the SSE at Clinch River is what?

MR. SMITH: But it is designed to maintain its integrity.

MR. KERR: The SSE for Clinch River is not very big compared to the one you use for California. Suppose you had a California-type earthquake at Oak Ridge? I do not know what would happen, and I do not think you do either if what you tell me is the case.

Now my question is why did you decide to just design the SSE or not take into account some probability of a large earthquake?

MR. DICKSON: If I can add just a few comments to that, we designed to the SSE. This is designed and tested to the SSE. On top of that, we have a so-called margin study on earthquakes. I cannot recall the figures this came out with, but we looked at the margins we had in a variety of systems.

I would note that our core has the limited free-bow concept where in its operating condition it is well restrained at the top of the core to hold its configuration. Coupling that restraint with the amount of error band allowable for the positioning of these devices, you could go significantly above an SSE before you would get significant core distortion.

In addition to that, as you will hear when you hear about the secondary control system, it decouples inside the core, so that it adds an extra degree of margin. There is some margin over an SSE, but I cannot tell you what it is right now.

MR. KERR: Did you discuss with or try to find out why I think it is the French design that uses the flexible control rod -- my question is, seismic activity in France is certainly not greater than Oak Ridge. I am just curious. I am not trying to defend one viewpoint or the other. I am just trying to understand why.

MR. DICKSON: They actually design to a lower SSE. They do not call it an SSE. In fact, they changed it upward when there was that earthquake in Italy in, what was it, 1978 or so. But they have a completely different core restraint concept. They allow -- the flowering concept, I believe they call it, so that during a seismic excitation there is more room for their assemblies to move as compared to our limited free-bow.

Does that first slide show the core restraint system?

MR. CARBON: Let me interject here. I believe it is the German SNR-300 that has the flexible, and do they have the flowering core?

MR. KERR: My impression is that both do, Max. Is it just the German?

MR. CARBON: I believe so.

MR. KERR: I heard Tom Ghee give a talk on that once, but maybe this has changed.

MR. CARBON: Let us broaden the question. Perhaps both the French and the Germans have the flexible rods. Do they both have the flowering core that you speak of?

MR. DICKSON: I do not know. They both call them that. One has the leaning post concept in which they have a series of posts that comprise the core definition charcteristics. We have never really analyzed in depth those cores, but we have looked at that type of core as compared with our limited free-bow core.

We like our system better, partly because it gives you a greater degree of definition as to where all the assemblies are at any one point in time in normal bowing effects, radiation growth or seismic events. So we are coming at it from two different positions. Ours is a very rigid core as compared to some other cores that might be held in a different manner.

MR. KERR: Thank you.

(Slide.)

MR. SMITH: I had something to say about our last requirement on scram, and that was simply to satisfy our operational and scram requirements for the maximum misaligned design conditions. We do have a system that allows us to misalign.

MR. CARBON: Let me go back to an earlier comment. You said you had looked at studies on how much margin you had for exceeding the SSE. Could you tell us about that sometime?

As you are aware, I am pretty sure, and certainly the Staff people are, we have had consultants say that the chances of exceeding the SSE or return frequency of 10^{-3}, 10^{-4} -- something like that -- some number well greater than 10^{-6}. We have asked the Staff this question in a general sort of way two or three times.

MR. DICKSON: We could do that. I will note that the margin study was done some years back. It would not apply to all components today, but I believe it would still be applicable to the control systems because they have not changed that much and to much of the plant. We could do that if you wanted.

MR. CARBON: I would welcome hearing it sometime with respect to the control system.

MR. EBERSOLE: Was the test under maximum misalignment done at full hot?

MR. SMITH: Yes, full hot conditions, full flow.

(Slide.)

Now the basic function of the shutdown system is to get reactivity into the core. We have an expected bank height -- now I am talking about the six primary rods that move in the core and the three primary rods that sit at the top -- but when I say expected bank and minimum bank, I am talking about six of the nine at either 17 inches or somewhat less than that, depending.

Our analysis shows that using the worst that Mr. Doncals has presented and the requirement -- this is developed from the fuel damage limits, that we have to get so much reactivity in to shut the core down. I think Mr. Dickson mentioned .3 of a second we have to get our first dollar in.

This is what we will actually do in the worst time in life. I think it was cycle 5 which for speed and reactivity insertion was the most limiting case. The bottom line here is that we far exceed either for our expected bank or our minimum bank height the requirement on reactivity insertion.

MR. KERR: I do not want to disagree with you, but I cannot see how if you have to get in a dollar at .3 seconds that you exceed that. It seems to me you may not even be there, but perhaps that is the artist's rendition.

MR. SMITH: Here I have two dollars at the minimum bank height.

MR. KERR: I am sorry. I am looking at the requirement. Okay.

MR. SMITH: And the expected I am looking at roughly four dollar.

MR. KERR: Okay.

(Slide.)

MR. WARD: It is pretty close to that other curve.

MR. SMITH: What I would like to leave you with, then, is the statement that on the basis of extensive analysis and testing the primary control rod system satisfies all its functional requirements and provides a reliable means for the operational reactivity control and shutdown for the CRBR.

Any questions?

MR. KERR: Well, I guess, except we have only an engineering judgment analysis of its reliability, I am not against reliability, but, as Harold Etherington says, the difference is between knowledge and judgment, which sometimes is rare.

(Laughter.)

MR. SMITH: I would now like to introduce Lawrence, who will give you the other system, the secondary system.

MR. LAWRENCE: I am Bob Lawrence, and I am going to speak to the secondary shutdown system.

MR. KERR: Is this part of the independence of the two systems? You don't let the group who is working on one talk to the group who is working on the other?

(General laughter.)

MR. LAWRENCE: That is not quite true, but it is a point of fact that we have had completely separate design organizations as well as fabrication organizations. We do encourage them to talk to each other in many instances, but the design is done by a different organization.

(Slide.)

MR. LAWRENCE: Just as an overview, I am going to speak a little bit to why we have a second system. You have heard from Mr. Smith that we have got a perfectly good primary shutdown system, so I am going to touch on why we have gone the extra mile and had a second one. We will go through some of the design requirements, give you a functional description of the scram function. I am not going to bother with non-scram items. I will lead you through the diversity of the scram function between the two systems to show you how we have made things as different at each step of the way as we could. I will summarize the function of the secondaries during plant operation and then conclude.

(Slide.)

MR. LAWRENCE: We touched earlier on the general design criteria. In fact, Mr. Doncals mentioned Criterion Number 24. The requirements in there break down in terms of the mechanical shutdown systems into two basic things. One is, we have to have a system that controls reactivity during normal operation. It takes into account fuel burnup and that sort of thing, and planned normal power changes.

The primary system does that. In addition, we are required to have a system that shall use control rods, preferably includes a positive means for insertion, and is capable of controlling reactivity changes to assure that we do not exceed acceptable fuel damage limits. That is not just for a normal operation, but for anticipated operational occurrences.

Now, that is really what brings us to the secondary system. Although I will note that the proposed systems respond to that requirement --

MR. EBERSOLE: When you control reactivity changes, there are two ways you can do it. You can measure progressive changes in level using level trips, or do period measurements. Do you do one or both or what do you have? Do both systems do the same thing?

MR. LAWRENCE: This is for measuring.

MR. EBERSOLE: Reactivity changes?

MR. MACRAE: Did we discuss that earlier?

MR. LAWRENCE: Mr. Macrea in the plant protection systems will get into where they come from.

MR. WARD: By the last item do you mean that the two systems meet the core together?

MR. LAWRENCE: Yes, each by itself. I could have just put SCRS here.

MR. WARD: But the other does it independently?

MR. LAWRENCE: Yes. They do have a positive means for insertion. In fact, the first time through I left this off and I confused everybody, so I put it on.

MR. WARD: But it is not the two of them together.

MR. LAWRENCE: It is each one individually.

MR. CARBON: What is the definition of positive? Does that mean by force or gravity positive?

MR. LAWRENCE: Something in addition to gravity.

MR. KERR: What is the something?

MR. LAWRENCE: I will get to that. In the case of the primaries, it is a spring. In the case of the secondaries, we have what we call a hydraulic assist.

MR. KERR: You show me criteria which are general design criteria which were developed for water reactors. Do you still think that is a good criteria for fast reactors?

MR. LAWRENCE: This was the Clinch River general design criterion.

MR. KERR: That is not much different from GDC 24.

MR. LAWRENCE: I am not sure whether the numbers stay the same, but yes, it is quite similar to the one with the light/water reactors, and we believe it is quite appropriate here. In this case, we have used two fast-acting systems rather than a single fast-acting system, and say a boron injection like a pressurized water plant uses, but we feel it is good.

MR. KERR: But you did not just blindly follow the general design criterion that was developed for light/water reactors?

MR. LAWRENCE: No.

MR. STARK: By the way, that is going to be the subject of one of our next meetings in October. We met in March on it, for a day and a half on general design for this plant, and we are going to give it one more try on the 27th.

MR. KERR: I am trying to get some feel for the Westinghouse design criteria as well as the NRC design criteria, because I don't think they necessarily have to be the same, but I am interested in what you said. Thank you.

MR. LAWRENCE: Now, for the design requirements in terms of scram insertion, we have broken down Mr. Doncal's requirements into a time for the protection system which Mr. McCrea will address, a time for mechanism to actually respond, and then the mechanical motion of the control rod. I will show you a curve in a minute that lays out this requirement.

In addition, the mechanism has to respond in less than a tenth of a second. Our testing has shown that we can do that in about half that time. Also, as in the primary system, we do impose maximum misalignment conditions that are expected and require that the rods make it in under those adverse conditions.

For the duty cycle, again, we have broken the life requirements into one for the drive mechanism, one for the drive line, one for the control assembly, and the years are comparable, and I think the questions Mr. Kerr asked earlier would have the same connotation here.

MR. WARD: What does no contact mean?

MR. LAWRENCE: That means if the duct that the control assembly goes in is bowed or if the control assembly moves the rod moves. We somehow have to get this through the channel without touching at three places. You might touch at the top and the bottom, but as long as you are not touching the middle some place, the restrictive forces do not become terribly severe. Once you get to the three point contact, it becomes very difficult to assure yourself that the rod is going to get in, so we have gone through extensive clearance analyses to make sure we stay away from three-point contact.

MR. EBERSOLE: What accounts for the shorter life of the control assembly compared to the other one?

MR. LAWRENCE: It is essentially the pressure retaining capability of the Pita clad.

(Slide.)

MR. LAWRENCE: This is the curve that we have generated out of Mr. Doncal's reactivity requirements. As I will explain in a little bit, the speed of response of this system is directly related to the primary coolant flow. That is why you will see that we respond more quickly at 100 percent flow than we do at 40 percent flow, but this is the kind of requirement that has been laid on the secondary shutdown system for speed of response.

(Slide.)

MR. LAWRENCE: The mechanical and structural requirements are comparable to what was described earlier for the primary. We do use the ASME Code Section 3 Class 1 for the pressure boundary, seismic Category 1, Safety Class 1. The control assembly requirements are comparable to the primary control assembly. That is one of the areas where we have required the designers to speak to each other to make sure that each is applying the same rigorous standards.

(Slide.)

MR. LAWRENCE: I brought along a photograph to give you an idea. This is just the drive mechanism. It does not show the control assembly, which would be another 14 feet. We have got about 44 feet of hardware right here. Again, the maximum diameter is about ten inches. So, as in the case of the primary, we have a very long, slender piece of equipment.

(Slide.)

MR. EBERSOLE: Does that three-point requirement occur in a safe shutdown earthquake?

MR. LAWRENCE: We have to meet that in the safe shutdown earthquake. Yes, sir. Now, to accomplish a scram, there are four main items that come into play, and I will describe each of them for you. One is latch, one is pneumatic valve cylinder arrangement that controls the latch. Then there is the tension rod that connects these two together, and then the motion is initiated by this hydraulic scram assist.

(Slide.)

MR. LAWRENCE: In a very simplified version, this is what we have. Up in the mechanism housing itself, which is up above the top of the reactor head, we have really a cylinder controlled by some valve that applies pressure on the underside of a piston. Coming down here is the tension rod I mentioned, and then the latch.

Now, this latching function is in the control assembly stationary duct down in the core region, whereas in the case of the primary the segment arms and lead screw mechanism is up above in the housing, above the top of the head. We make our connection down inside the core, down inside the ducts that are comparable to the fuel assembly ducts, so we are some 30 feet below the top of the head, and 20 some feet below the sodium surface.

MR. CARBON: Is the minimum clearance between the rod there over that 30 some foot distance a few inches? How big is the channel in which the --

MR. LAWRENCE: What we really have in this area is a solid rod a half-inch diameter that is inside a cylinder, which is inside another cylinder. The clearances are on the order of about a quarter of an inch, I would say, but the fact of the matter is that this thing is like a 30-foot piece of spaghetti, so there is really a lot of allowance for misalignment in this area.

This tension rod could still perform its function. Now, when we scram we vent the pressure from under this piston. The piston drops, the tension rod drops down enough that these grippers -- there are five of them -- move outward. A control assembly head falls out, and the control rod moves down. And we only require a quarter-inch downward motion of this tension rod to accomplish this unlatching.

MR. LIPINSKI: Is there a hydraulic force present on the left diagram before the rod starts to go in?

MR. LAWRENCE: Yes.

MR. LIPINSKI: So it engages the piston down effectively.

MR. LAWRENCE: This latch is having to work against --

MR. LIPINSKI: The weight of the rod?

MR. LAWRENCE: -- the buoyant weight of the control rod plus the hydraulic force acting on the control.

MR. LIPINSKI: What is the differential in forces between what is on the under side of the piston with normal pressure versus the hydraulic force acting on the rod?

MR. LAWRENCE: About 200 pounds.

MR. LIPINSKI: That is the differential. Now, if I take the pneumatic force off, what is the hydraulic force?

MR. LAWRENCE: The hydraulic force is about 200 pounds.

MR. LIPINSKI: What is pounding the piston up? It has to be greater than pounding down.

MR. LAWRENCE: Two hundred pound nominal.

MR. LIPINSKI: So you have a 20-pound differential.

MR. LAWRENCE: Right.

MR. LIPINSKI: Forgetting about the weight of the rod.

MR. LAWRENCE: Right.

MR. KERR: I don't understand how these forces can be different. It seems like if they were different it would accelerate it out of the top of the vessel.

MR. LIPINSKI: No, it has to raise the rod.

MR. LAWRENCE: The 220 pounds holding this piston up, we have got hydraulic force pushed down here of about 200 pounds.

MR. KERR: So the rod weighs something.

MR. LAWRENCE: The buoyant weight of this is about 300 pounds.

MR. EBERSOLE: Those are individual or operated by solinoid valves or something?

MR. LAWRENCE: There is a separate one for each rod.

MR. EBERSOLE: What is the diameter?

MR. LAWRENCE: I don't know.

MR. EBERSOLE: I am an enthusiastic painter. I see a rack of these things that need to be painted with thick gray paint. What is to stop them from coming over and painting your orifice?

MR. LAWRENCE: This is all inside the control rod mechanism.

MR. EBERSOLE: Don't I have to have a connection to atmosphere some place through that vent?

MR. LAWRENCE: This vents to the interior of the mechanism housing.

MR. EBERSOLE: I can't get to it and mess it up?

MR. LAWRENCE: That is correct.

MR. LIPINSKI: There is something wrong with your number. If you say the force down is 200 to the hydraulic and the rod weighs 300, that is 520 down. My piston is the only thing that is holding that whole assembly up. That has got to be at least 520.

MR. LAWRENCE: I have got 220 pounds holding this piston up.

MR. KERR: Why don't you do the arithmetic during the break and get back to Mr. Lipinski?

MR. WARD: You are pushing on that piece of spaghetti, though.

MR. LAWRENCE: I am sorry?

MR. WARD: You called that long tension rod a piece of spaghetti. You end up pushing on that, right?

MR. LAWRENCE: I am holding this end up with 225 pounds --

MR. RAY: That is pressure. I am sorry. I just realized that. There are 220 pounds per square inch on the bottom of the piston, and I am not sure what the effect of air is.

MR. KERR: Go ahead and proceed.

(Slide.)

MR. KERR: According to my schedule, you have minus five minutes. Is that about right?

MR. LAWRENCE: Well, I started --

MR. KERR: That doesn't count.

(General laughter.)

MR. LAWRENCE: You are going to make me pay for all their sins.

I thought I would briefly show where the scram assist force comes from, since it was mentioned earlier that we have flow up through the reactor. In this case we bring the flow in through the side, come up in an annulus, and then this piston is at this point with a labyrinth kind of seal and flow out to a low pressure point, so in effect we are running off the DP between the core inlet and outlet.

(Slide.)

MR. LAWRENCE: Now, in terms of the diversity between the two systems, the first thing we need for scram is for the sensor and logic to do their jobs. That will be described by a later speaker. What we do first is have diversity in the logic as well as the sensors. We get two out of three PPS inputs. In the case of the secondaries, there are two solenoid actually in the mechanism housing that have the PPS signal routed to them. Those solenoids control the valve that vents the cylinder we talked about, so the scram signal comes to the solenoids, and when two of them, two out of three indicate scram, the solenoid energizes, and the valves move to vent the cylinder.

The comparable thing for the primaries is, we de-energize the trip coils and the scram breakers pop open. Once we do that, we then remove power from the mechanism of some sort, some kind of power to cause the trip. In the secondary we vent the schematic cylinder whereas in the primaries we collapse the magnetic field. So here is a real strong case for diversity. We have gone with a pneumatic vent compared to a collapsing pneumatic field.

The next thing we have to do is release the force holding the control rod. In the case of the secondaries, the tension rod drops down a quarter of an inch, which disconnects the latch, and the latch, as we pointed out, is in the top of the control assembly down in the core region. In the primaries, the segment arms move out to disengage the lead screw, and that happens up in the mechanism housing at the top of the vessel head, so we have a different kind of action in two greatly differing positions.

MR. LIPINSKI: Back to the scram solenoid valve, you said there were three of those in the mechanism?

MR. LAWRENCE: Yes.

MR. LIPINSKI: If I open one valve, what action does it take for the pressure?

MR. LAWRENCE: It takes two valves.

MR. LIPINSKI: Scram rods?

MR. LAWRENCE: It takes two solenoids to de-energize to cause the scram.

MR. LIPINSKI: I want to know how three pneumatic valves are arranged.

MR. LAWRENCE: There are five valves.

MR. LIPINSKI: Five valves?

MR. LAWRENCE: Three solenoids controlling five valves. It takes two of the solenoids to move enough of the valves to get a vent flow.

MR. LIPINSKI: So you have effectively a flow path that looks like the breaker path for electrical connections.

MR. LAWRENCE: That is correct. There is a very strong parallel.

(Slide.)

MR. LAWRENCE: If you recall, the general design criterion said we should have a positive insertion force on one of the systems besides gravity. We have that in both systems. In the secondary we have this hydraulic scram assist functioning at the bottom of the moveable rod, so that is again well down into the control assembly.

In the primary we use a scram spring on the drive line and that is up above the top of the reactor vessel head again. Then, the actual insertion of the negative reactivity comes from the boron carbide pins moving down into the active core region. For the secondaries we are moving just a 36-inch pin bundle downward and all the motion, if you overlook the quarter inch of the tension rod, all the motion takes place between the fixed control assembly duct.

In the primary case, we have to move the drive line control assembly and that comes down through the upper internal structure.

One other item of diversity, Mr. Smith explained that he had a hexagonal outer duct with a hexagonal wrapper coming down on the pins and a universal joint. In the case of the secondaries, we have a circular duct moving within a circular -- excuse me. We have a circular bundle within a circular duct which is then inside the outer hexagonal duct. All the ducts are hexagonal.

On the outside here we have relative motion between two cylinders just to try and rule out any common mode failure that could come from failure of that universal joint.

MR. EBERSOLE: That spring you have is just a ticker to get it started.

MR. LAWRENCE: That is correct. You mean on the primary?

MR. EBERSOLE: Yes.

MR. LAWRENCE: It works on the first 27 out of the --

MR. EBERSOLE: I think that is a positive interpretation of the positive force to get it down. It is certainly not like the other one, which goes all the way.

MR. LAWRENCE: Once the flow starts and the control assembly moves at the rate of flowing sodium, there is no net force there either. If anything tries to retard the control rod movement, then you move the control rod up again so that there is some degree of commonality.

MR. EBERSOLE: You can relatch and force it down anyway with the screws on the primary system.

MR. LAWRENCE: And with the secondary system we could drive the carriage down and shove the thing in.

MR. LIPINSKI: How do you get the low pressure at the bottom end of the piston? Is that vented to the upper plenum?

MR. LAWRENCE: It goes through a channel between the core barrel and the reactor vessel.

(Slide.)

During operation I think it is impoortant to note that the secondaries are withdrawn to the fully withdrawn position completely out of the reactive core region before any of the primaries are open so they are immediately available for scram to call upon. They stay in that parked position throughout the power operation. We have been through the scram signals.

Then, for shutdown, they are brought in after the primaries have been inserted, so we have that secondary bank out when the primaries are out.

MR. WARD: The first one I guess I did not understand. The lifetime on the active element in both cases is a year. You said that was related to what?

MR. KERR: Pressure buildup.

MR. LAWRENCE: Pressure buildup inside the pin.

MR. WARD: You get that even though they are out of the core?

MR. LAWRENCE: Right. There is some absorption, particularly in the bottom few pellets, which are just above the top of the core.

MR. WARD: I am surprised that the lifetime of the pins in the secondary system is a year, the same as those in the primary system.

MR. LAWRENCE: We are in fact looking at a two-year life. If you noted on the vugraph where I showed the lifetime, I gave the --

MR. DICKSON: If I could interject, your point is well taken. The primary reason you get about the same is there was a requirement -- there was less room. Once you get a circular duct inside a circular duct, inside a hex, you had less room. So they had less room in which to maneuver to achieve their greater lifetime.

MR. KERR: It strikes me that if they make those things just a little bit leaky they would not have the problem.

(Laughter.)

MR. LAWRENCE: We are looking at a two-year life. Mechanically it is no problem at all.

(Slide.)

I just wanted to briefly touch on the test program since this is something of a more unique system than the primaries that have been used in FFTF as well as some of the PWRs. At this time we have tested five prototypes. We have performed over 3,600 scrams with zero failures to scram. In each case the scrams were within the required insertion time, and we have run an additional 1,260 scrams on the valve cylinder in a component test to ensure ourselves that we have a reliable component there.

These tests all involve both expected operating conditions as well as overstress conditions, increased flow, increased temperature and so forth.

MR. CARBON: These will not be under true prototypic conditions, so what conclusions do you draw from that?

MR. LAWRENCE: The only thing we are missing from the prototypic conditions are the radiation environment and the main pass forcing treatment for the pumps. Other than that, we have got the right flow rates, the right temperatures, all the right modes.

MR. CARBON: Well, they will not sit there for nine months or something.

MR. LAWRENCE: For example, one of those five prototypes we actually drilled holes in the bellows and ran some scrams and then -- well, we operated that unit for a year with failed bellows.

MR. CARBON: So you had one test, but that is not like 3,600.

MR. LAWRENCE: We did not run 3,600 scrams on that particular unit, but we have one unit to over the design life of scrams.

MR. LIPINSKI: The question really involved crud buildup, because ideally if you did not have any scrams you would run your rods in a fixed position for one year and then attempt to scram. The question is what crud builds up in all of the gaps and spaces.

MR. LAWRENCE: We have not found any. One thing to remember is the sodium system is on a constant cleanup.

MR. LIPINSKI: What happens in the corners where you do not have flow paths?

MR. LAWRENCE: One of the things we have to do as designers is minimize those corners. We found no indications of that kind of problem. Your point is well made, but we have run a fixed number of units.

MR. LIPINSKI: What about seismic testing? Have you done anything to seismically-qualify it?

MR. LAWRENCE: We have run seismic tests of the scram valve and cylinder. We will also qualify that to the requirements of 1E, which will involve more seismic testing.

MR. LIPINSKI: What about this long, slender tension rod? Are there standing wave conditions at a frequency that will shorten its length by an inch?

MR. LAWRENCE: We have not found that to be the case. The only problem that we found that we get into under seismic conditions is ensuring that we do not drop the control assembly.

MR. LIPINSKI: What is the diameter of the space that the tension rods move into in terms of the clearances?

MR. LAWRENCE: I do not remember for sure. I think it is a quarter of an inch.

MR. LIPINSKI: The tension rod is how long?

MR. LAWRENCE: Roughly 30 feet.

MR. LIPINSKI: Can I distort that tension rod within a 30-foot length and shorten its overall length by a quarter of an inch with the spaces available?

MR. KERR: We will accept "I do not know" as an answer.

MR. LAWRENCE: Our analysis has not shown that to be a problem.

MR. LIPINSKI: I do not know. I have not seen your analysis, so I do not know if you have analyzed the question.

MR. EBERSOLE: Your 3.9 contact is really just an ideal that you will not obtain in a seismic? It is going to see a three-point contact, is it not? When you shake it laterally you just do not know it. What is going to stop it?

MR. LAWRENCE: Our requirement has been to design in clearances so that we do not.

MR. EBERSOLE: You cannot verify that that is true though, can you?

MR. KERR: Do you understand the question?

MR. LAWRENCE: I think what he is asking for is a measurement.

MR. EBERSOLE: I am saying, Bill, that in an earthquake you will probably get three-point contact and never know it because it is only an analytical --

MR. KERR: But it will be a momentary --

MR. EBERSOLE: Sure.

MR. KERR: That is not what he is analyzing for.

MR. LAWRENCE: We ran tests where we bowed the guide tube, something like 150 percent of the worst stackup of manufacturing and irradiation-induced deformation and achieve scram insertion within the required time up to, I believe it was, 130 percent.

MR. EBERSOLE: Have you effected the long tube, so, therefore, the maximum earthquake you will have a drag indicative of three-point contact?

MR. LAWRENCE: That is in the control assembly, not in the tension rod.

MR. EBERSOLE: It is not in the tension rod?

MR. LAWRENCE: No. It is in the control assembly.

MR. EBERSOLE: I was referring to the control assembly. You will get three-point contact in a long rod.

MR. LAWRENCE: Probably would, but that is not seen as a problem.

MR. WARD: I guess maybe to Walt's point, as I understood it, the gripper has to move a quarter of an inch travel to release the rod?

MR. LAWRENCE: Right.

MR. WARD: How far can the piston -- it probably can move more than that, right?

MR. LAWRENCE: Yes. There is a total allowed motion of -- well, the bottom can only move a quarter of an inch. It is restrained to that. But the top end can move in excess of that, and I do not remember the number.

MR. CARBON: Along that line, you said that your analyses had not shown this was a problem. Have you actually carried out analyses to see what that sort of seismic motion would cause waves in this tension rod that might give you an effective quarter of an inch shortening?

MR. LAWRENCE: Well, as Mr. Ward brought out, there is more than a quarter of an inch allowed motion.

MR. CARBON: Sure, but you did not say how much. You seemed to be rather vague on that. Are you saying it is really four or five inches?

MR. LAWRENCE: My recollection is it is on the order of a couple of inches.

MR. CARBON: Well, if that is so, it would probably take care of it.

MR. LAWRENCE: We have not seen --

MR. CARBON: I would not be much concerned if it truly can move a couple of inches. If it is three-eighths of an inch --

MR. LAWRENCE: My recollection is it is on the order of a couple of inches.

MR. WARD: Maybe we could hear back on that point.

MR. LIPINSKI: I think that is important whether it is a couple of inches or whether it is three-eighths of an inch.

MR. LAWRENCE: So our conclusion is that we do in fact have a highly reliable, independent, diverse shutdown system.

If there are no other questions --

MR. KERR: Mr. Lawrence, at the end of Mr. Smith's presentation I recall he said something about the primary system being a perfectly adequate shutdown system by itself, I think he said. I hope that the secondary system is not being designed with that philosophy of being too strongly supported.

MR. LAWRENCE: We have designed the secondaries on the assumption --

MR. KERR: That the primary will fail?

MR. LAWRENCE: To shut down the plant.

MR. KERR: It seems to me important that both are reliable and not that one is just there as a requirement, even though you are convinced that the other one is okay.

MR. LAWRENCE: I think that is one benefit of having two different design organizations.

MR. KERR: So your organization does not know that Mr. Smith thinks the primary by itself is enough?

MR. LAWRENCE: Right, we do not let him talk about that sort of thing.

MR. KERR: Are there other questions?

MR. CARBON: Maybe. Is there more discussion of the primary and secondary, Roger?

MR. DICKSON: This ends the mechanical portion of it. Now we will get into the plant control system, which will be the electronics in the system, and then the plant protection.

MR. KERR: Forward, onward.

Excuse me, Mr. Stark, perhaps I should have made the specific comment that if at any point you or your staff or your colleagues want to add anything to this, please feel free to signal or something.

MR. TINDER: I am Bob Tinder of Westinghouse. I want to cover the plant basically reactivity control.

The main objective is to product electricity in my plant and really my design criteria is to keep the plant on line and really not to ever challenge any of the safety systems.

(Slide.)

Just to show you briefly what I will cover, the control areas, the control requirements, just what the plant control system is, specifically in the reactivity control we are going to talk a little bit about electronics that make the control rods move up and down.

(Slide.)

I assume you have seen it before, but that is

Clinch River and that is the control building (indicating).

(Slide.)

Inside of that control building is the control room, the main control panel being in this panel here. There are a lot of back panels. The control area to continuous monitor is in this area right here (indicating).

(Slide.)

Here is a picture of the mockup of the main control panel itself. Reactivity control is done right in this area here (indicating). You end up over here. The turbine breaker, the steam end. It comes all around, reactivity control all in one area.

MR. LIPINSKI: Was it stated earlier that these panels had been reviewed for human factors after TMI-2?

MR. TINDER: Yes. These have been reviewed for human factors before and after TMI. I think somebody mentioned there was going to be a talk on all the key system reviews that we had.

MR. DICKSON: I did not say there was going to be one. I said we could do one.

MR. TINDER: There was one of the key system reviews following Three Mile Island, which was on the control. There were probably about 20 people for six months walking through reviewing everything that the designer and human factors people had done.

MR. LIPINSKI: Where is this located?

MR. TINDER: Oak Ridge, Tennessee.

MR. WARD: Bob, does that review include -- you know there is a NUREG-0700. Has that sort of review been made?

MR. TINDER: We did not have 0700 when we were doing this. Since then we have compared 0700 with what we have done and been under discussion with NRC on the comparisons of the two. We had our checklist developed by human factors people, very similar to the list that is in 0700.

MR. WARD: Does the Staff think that this control room meets what will be required in SECY-82-111, let us say, whatever those requirements are negotiated to be? Are they going to go through the same process?

MR. STARK: We have an assessment that we will have in the safety evaluation report and there is no one here from the human factors group to speak to it. We have had a lot of discussions and I guess I really do not know what the details are.

MR. TINDER: There is lots more to go through. 0700 almost talks about an operating plant, so we are a long way away from having the operator simulators.

MR. WARD: Is there going to be a training simulator?

MR. TINDER: Yes, sir.

We will have integrated control in the main control room, so I don't have controls throughout the entire plant requiring a lot of people. Automatic control on the primary control rod drive mechanisms only, and that ends up to be only six out of the nine. The three that would pull all the way out at power are not going to be automatic, but the six that are controlling the plant in power operation is a automatic system, but it can be manually controlled.

The automatic control ranges from 40 to 100 percent power. Basically, the design is for three percent per minute ramp or a ten percent step. We actually look much farther than that, but that's the average requirement.

MR. KERR: How did you choose the 40 as the lower limit of the controlled range?

MR. TINDER: I don't know if I can answer, but probably because of our pumps. When we bring our pumps on to automatic control, the speed they are brought on, I believe they are a little above 30 percent. So at that point we then have continuous control over flow.

MR. KERR: Thank you.

MR. TINDER: We regulate the plant variables over a part-load profile, which I have a few vugraphs, which I do not hold hot leg temperature at some constant value, at 40 to 100 percent. We have ramp values for hot legs, cold legs, primary and intermediate flows; and operation with a minimum number of staffing requirements, again, to make sure we evaluate, what can people do better than machines, machines do better than people.

We want it to be automatic. We think that is the best for power operation. So really, the plant will run with nobody between 40 and 100.

(Slide.)

This vugraph is in Paul Dickson's handout. It's not in mine. I thought I would review the way we do run Clinch River.

The first thing you do is pull each of the secondary control rods out individually, all the way out. You park them. You pull each of the three primary rods out and park them. Then you go critical on the six primary rods.

We have interlocks that prevent any primary rod from moving until the secondaries are all the way out. You cannot move the six primaries until the three primaries are all the way out. We don't want to rely on the operator for the interlock. The six primary rods, remaining six rods.

The pumps are basically on pony motors

somewhere around 7 to 10 percent speed all the time. That's just when the plant's down. You would bring the plant onto automatic flow control, which brings them up to about 30 or 40 percent power. Then you would start pulling the rods.

You do not pull rods until your pumps are up to where you have speed control over them.

MR. LIPINSKI: I'd like to back up to your comment you don't want to rely on the operator. Is any of this withdrawing of control rods done automatically, or is it done manually?

MR. TINDER: It's done manually until you are critical and at 40 percent. Then we can switch everything over to an automatic supervisory control.

MR. LIPINSKI: I'm not critical of 40 percent.

MR. TINDER: You can do that manually with the six primary control rods.

MR. LIPINSKI: Then what happens when you're critical? You go up on the control profile to 40 percent?

MR. TINDER: Yes.

MR. LIPINSKI: Automatically?

MR. TINDER: No.

MR. LIPINSKI: When do you switch to automatic operation?

MR. TINDER: 40 percent.

MR. LIPINSKI: At 40 percent power?

MR. EBERSOLE: There's a third bullet there. Would you mention how you control those six rods? Are these individually controlled, manually or automatically? Is there a gang motion of these? If it's a gang, how do you keep it running out as a gang withdrawal, et cetera? Or is somebody else going to do it?

MR. SMITH: I'll do it.

(Laughter.)

MR. EBERSOLE: Are we going to talk about fires and all those sorts of nasty things?

MR. TINDER: I have some backup vugraphs. Let me go through what I have. Don't let me get away without doing that. And I'll try to explain it.

MR. KERR: Also keep in mind that we're a little bit behind schedule, so skip every other word.

(Laughter.)

MR. TINDER: Here's the plant at 40 percent power. I do have a supervisory control. That supervisory control tells the reactor controller what to do. It also tells the primary flow what to do, it tells the intermediate flow what to do, and it tells the turbine throttle what to do.

Since I'm controlling things on a part-load profile, not holding fixed values all the time, I need something to know at what steam load I am at, telling the flow in the reactor what to do. That's what supervisory control does.

Nothing elaborate; commercial control equipment, very similar to water reactors; and it has no problem from control analysis.

MR. EBERSOLE: Suppose it fails, since it's a simple complex, and it's in its worst configuration. Is the system then competent to pull out from that circumstance?

MR. TINDER: No. And we'll see it in a couple more vugraphs.

One of my conclusions -- one of our objectives is to never challenge the protective system. There are a number of things in the control system so that we cannot challenge the protective control. Part-load profile, what I mean, percentile. We actually control the hot leg temperature on a sliding scale. The same with intermediate, hot leg, and the steam throttle temperature. We basically hold that constant, but it does drop off a little bit, as you can see, as you come back into power.

MR. LIPINSKI: What is happening with the primary inlet?

MR. TINDER: The primary inlet also has a shape of this type (Indicating). I don't know if I have the inlet curve.

MR. KERR: You don't want to see that.

MR. TINDER: The delta T out here is about 250. It gets smaller and smaller as I come back into power. It does climb with power.

(Slide.)

Flow, the same kind of profile. I have 100 percent flow at 100 percent, and basically 40 percent flow at 40 percent power. Not exactly. We do have slight curves to them because my objective for them is to keep steam pressure and temperature where they belong. I do that by matching up the rest of the plant parameters.

(Slide.)

Reactor control. I have a few subloops here. I won't stay too long on those, but we actually are controlling on the outlet temperature of the core using a large number of thermocouples that are right at the outlet of the core. It's really the hot leg temperature, but the thermocouple on the outlet of the core responds a little faster than waiting to get around to volume.

We compare that to what supervisory says I ought to be, taking the difference and going into a simple servocontrol system. I can come in here manual at different points. I can control flux by manually controlling flux or I can manually control temperature, but in normal automatic it is controlled from the supervisory.

The output of the control system going over to the rod control electronics, there is a signal that tells the primary rods, I want you to go up or I want you to go down. And it also tells it how fast it wants them to go. If it's small I want to take little teeny steps and move real slow.

MR. WARD: It doesn't give them a demand condition; it gives them a rate?

MR. TINDER: Right, it gives them a rate.

Now, in this part of the circuit I have a lot of blocks here, so that if something has gone wrong I will stop. I have a high flux compared to the goals to stock my rods. I'm also comparing flux and flow in the primary and intermediate load.

Basically, we are trying to hold a one to one. If the power gets much more above that, I also stop the rods, again, just so I have something to prevent a failure in some of the electronics from taking rods out when they're not supposed to go out.

(Slide.)

Flow control load is just a closed loop servosystem. I give it demand of what flow I want and I measure the flow three times in a loop, taking the middle one, comparing them with where I want it to be, and amplifying it down to the pump to tell the pump to increase or decrease in flow.

(Slide.)

Here is one that I'll spend a little time on. The rod control electronics is actually moving the rod -- that is busy, I know. You don't have to remember much. But basically, we're receiving signals from that reactor control loop saying, go in or go out, and what speed you want to go.

I do have circuits back there, rod withdrawal stop. If flux is too high or my power in the flow is too high, it tells it to stop. From there I tell each rod to move separately and individually. We only move one of those six rods at any one time. I tell rod one, take one step out. It moves .025 inches.

MR. WARD: That's one pulse on the stepping motor?

MR. TINDER: That's right, one step on the stepper motor rotates 15 degrees, which on the lead screw and its pitch moves out .025.

Then I tell rod number two, move out same amount, then three, four, five, six, one. And we move one rod at a time, very small steps, because as far as the operator is concerned that's a vacuum; he can't read the difference.

I also mentioned that there are two rod position systems on the primary control rods. The physics analysis, he wants me to keep those rods in a bank. I take each one of those systems separate, and if any one of the six rods is out of alignment from the bank it comes in also and stops rod movement.

MR. LIPINSKI: At the bottom of the block you have "rod select" from the manual control panel?

MR. TINDER: That's from the main control panel, because I do have the ability to move one rod at a time in manual if I want to. He selects that in the control room at the main control panel. Because see, initially on startup I am in manual. He does have the ability -- or if rods get out of line for some reason, he can select one rod, move it back in a little bit to get it back in bank, and then switch back to his group bank control.

MR. LIPINSKI: Is there a line missing that says there's a rod select going from that auto interface to the manual interface? I see six pulses going through, but how do you determine which drive is going to move at the particular instant in time?

MR. TINDER: This auto signal coming across calls some of the circuit down, if it's supposed to be listening to commands from the auto unit. What we have -- we're almost there, to answer your question. When you're in bank control, zero to four inches a minute is about all the rods I need to control the plant safely in automatic.

That is controlled by a clock. A clock back here is pulsing these things in a sequence that would give me no more than four inches a minute. It can be much smaller if my reactor control is not calling for very much movement. So that clock is here.

If I have one rod and I want to move one rod by itself, that clock is way out here for each rod. It has its own clock and that one will move about eight or nine inches a minute by moving one rod. Each rod has its own clock.

MR. LIPINSKI: How does the auto controller direct which rod is to move? I have six rods and I have to decide what it's going to be.

MR. TINDER: There is a tremendous amount of electronics in here that is keeping track of which phase -- of six phases on each one of these stepper motors. It's keeping track of which two or three phases are energized in the stepping sequence, because I want to step it in opposite from where it came out, so it always stays in phase. The electronics here keeps track of where all those things are.

All this says is, rod one, take a step out, two, three, it stops. If I want rods to go in, this thing says, rod three, step in a step, rod two in, it goes back the other way. This one keeps track of which one is told to move out, which one in; downstream keeps track of which stages have been energized in the mechanism.

MR. LIPINSKI: So these pulse lines are being pulsed sequentially, one through six?

MR. TINDER: Yes, sir. And there are a number of steps in there that monitor the sequence of pulses -- if the sequence is wrong it stops it -- monitoring the output. If this thing says, you should go in, and something out here says out, things stop. If voltages are wrong, it also stops.

MR. KERR: Would your experience convince you that such a system could be made to operate reliably?

MR. TINDER: This is basically what has been running at FFTF for three years or so.

MR. KERR: Does it operate reliably?

MR. TINDER: Yes, sir. I was there, so I'm not just talking off the top of my head.

(Slide.)

That's what the rod control equipment looks like.

(Slide.)

Just some of the characteristics. An insertion command also takes priority over an out command. There are a couple of overspeed circuits that are in there monitoring the pulse rate to make sure it's not too fast.

We also have interlocks coming in from rod positions and stuff to stop it. That's the two misalignments from the broad position indicator circuit, the overpower and power to flow block that I have.

This is just some quick conclusions. It provides an integrated control for the reactor and the turbine, and the primary control rods only are involved. It provides a number of features to not challenge the control system. These are similar to commercial systems.

The rod control is already built. The dynamic control loops are being bought from the same people as water reactors, people like Foxboro, Standard Control Systems.

Just to hit one slide here, it sort of shows a picture of the electrical part of the mechanism. This will be the last one.

(Slide.)

The mechanism has six windings. It has poles on the collapsible rotors. We energize two of them and that pulls the arm apart, puts the magnetic in there to pull them apart, but gives it no rotational force. We energize the third one and you get a 15-degree shift in the magnetic field. You de-energize the first one, you get another 15-degree shift. You energize the fourth one and another, turn that one off, and the next one on, that one off, and the next one on.

And you have circuits in here, logic circuits that keep track of where they are, so that you always do them correctly. In other words, if you got down to only one energized the rod is liable to scram and not have enough magnetic force to hold the arms.

We control all of that by controlling silicon control rectifiers coming from a three to six-phase transformer. Six-phase, your ripple is extremely small. When you put it into a big L, you get DC current going down. Scram breakers turn off all the power to the mechanism. Power coming from two parallel MG sets.

There's a lot of logic there in sequences that keep track of everything for you. So if rods are on the bottom all the way, I can't continue to push them down. If they're all the way out, I can't continue to pull them out.

MR. KERR: In certain other reactors, certain Westinghouse reactors, power supplies and things like that have been known to fail in the control system. This doesn't happen in this kind of a control system?

MR. TINDER: Oh, no, my power supply can fail any time.

MR. KERR: It doesn't make any difference?

MR. TINDER: If my power supply fails, say my rod stops and sits still.

MR. KERR: That's if it fails in a nice way which doesn't upset anything.

MR. TINDER: All right, let's do it the other way.

MR. KERR: Have you looked at this?

MR. TINDER: We have looked at that and put blocks in and things to monitor those things. But you're right, if I can build it you can fail it.

MR. KERR: How many control systems do you have operating at one time? You don't have two control systems each of which is capable of doing the same thing?

MR. TINDER: No, we do not. But again, you know, if it fails and the rod starts moving out -- rods normally move out. The first thing that would happen, I would get to one of my stops and say, hey, your power's a little too high. That'll stop it even if the system has failed calling for it.

MR. KERR: We both agreed, we don't want to challenge the protection system.

MR. TINDER: Never challenge the protection. That's somebody else's problem. I'm not going to touch it.

MR. LIPINSKI: Have you done a failure modes and effects analysis of the whole system?

MR. TINDER: Yes.

MR. LIPINSKI: Does it take multiple failures to get into trouble?

MR. TINDER: Multiple failures, as the safety guide asks that question, you need probably about six.

MR. LIPINSKI: So if I want to get six drives to go out I need six failures?

MR. TINDER: Half-assed. Not normal speed, because I do that every day. Half-assed is enough to cause a problem.

MR. LIPINSKI: Enough to cause a problem full-blast?

MR. TINDER: My clocks go bad and it quadruples the speed.

MR. LIPINSKI: How many clocks do you have? You said you had a clock on each output?

MR. TINDER: One of those clocks can fail.

MR. LIPINSKI: But if I want six --

MR. TINDER: If I have a monitor to monitor, if the pulses are faster than nine inches a minute you can shut it down. You can say that failed. Yeah, that'll fail. So I can end up somewhere along the line with one rod moving out. On another failure -- I've got something that's watching the relative position of all six. If one of them gets out of that six-bank, that's going to stop you.

I do that twice with the two separate position indicators. You can go on and on. I think the primary control guy would say, hey, the worst thing I could do would be to try to move the thing out 70-some inches a minute. Physically, it can do that.

MR. LIPINSKI: Yes, with the roller nuts open.

MR. TINDER: There are a number of steps, but you can still ask the question. Does that explain sort of how the mechanism works?

MR. EBERSOLE: I can't see any way I can get them all moving at once.

MR. TINDER: I say we do and I think my engineer came up with six, and everybody reviews this in all of my design reviews. You can go in there and start turning wires together and shorting things out and getting that master clock tied in with all of those other six clocks out there. Sooner or later you can -- if you look for enough failures --

MR. EBERSOLE: But it looks like it would almost have to be intelligent delivery.

MR. TINDER: That's true.

MR. EBERSOLE: Have you found any possible hot short configuration that would bring two rods out together?

MR. TINDER: I can't answer positive, but I'm quite sure the answer is no. That rackup of equipment, the reason it gets so big, each rod sort of has its own clocks and its own monitoring circuits, and all of that was just intentional design, not for reactor safety, but I want to generate electricity.

MR. EBERSOLE: Are there any maintenance activities that could result in the two rods coming out at once?

MR. TINDER: No. I do have maintenance activities where I could actually take a rod out onto a hold bus and hold it stationery, cannot rotate it. We have that ability for maintenance, because I can actually go in and replace a lot of the electronic hardware and just put the rod out on a static DC.

MR. KERR: I want to warn you, you convinced Mr. Ebersole and you better stop.

MR. TINDER: I want to go home tonight, too.

(Laughter.)

MR. CARBON: I would like to ask a question along the same lines. I'm not sure whether I heard what I think I did.

You have looked at this system from the standpoint of design errors, construction errors, maintenance errors, all of these sorts of errors like that, and common cause failures, and you don't see any way that more than one rod could be withdrawn simultaneously? You've looked at all the design errors, maintenance errors?

MR. TINDER: When you say "all", we have tried to look at all those and have found no reasonably probable thing that could ever occur. If you ask me for a number -- and some of the others don't want one -- I can say my numbers came out at 10^{-7}. Everybody'd say, oh, goodness sakes, that's impossible. That's why I don't like to get to the numbers.

MR. CARBON: But you've gone at it in a systematic effort to evaluate all the different possibilities?

MR. TINDER: That's true. And in our operation that is done not by the designer. We have a separate organization that goes in and digs on top of the designer. The designer can get --

MR. WARD: In love with it.

MR. CARBON: But you looked at specifically this type of thing, any possible way, any mistake?

MR. TINDER: Yes, yes.

MR. LIPINSKI: Is that documented?

MR. TINDER: It's documented at ARD, yes.

MR. LIPINSKI: Your initial analysis? Did you produce a document to support your conclusions?

MR. TINDER: Yes, because I have to present that in my design reviews. That's one of my internal requirements, to present that document.

MR. KERR: Does that complete your presentation?

MR. TINDER: Yes, sir.

MR. KERR: Further questions?

(No response.)

MR. KERR: I'm going to declare a ten-minute break, even though it's not scheduled. We've been sitting here for two hours. We'll get started again at five of.

(Recess.)

MR. KERR: Let's get started again, please.

MR. MC CREA: My name is George McCrea. I am with Westinghouse, and I am going to talk to the electrical shutdown systems. We have already had a discussion on the mechanical systems. I am really going to talk now to the actuators, the logic, and instrumentation.

(Slide.)

MR. MACRAE: The topics I cover will be, first of all, the design basis of the system, a functional description of how we selected the various trip functions. I will give an overview of the instrumentation, what I believe is significant there, and I will discuss any other features you choose to get into.

(Slide.)

MR. MACRAE: Okay, this is my first vu-graph. It is a pretty bland one, so I will use it to talk to some of the issues that were discussed which were not in my formal presentation. There was quite a discussion about the design process and reliability. I would just like to tell you how we went about it.

We have two independent diverse systems. They are based on a new design. We started that design eight years ago. Designers have worked on it which were the same ones that worked on the FFTF. We first went to the vendor and we got him to do a report for us on what his experience with the equipment had been, what he thought he could do to improve its performance or its reliability. We then did a reliability analysis of the system itself. We had an allocation. We wrote that up for the different components of the system. We wrote that into a specification, and we went out to the vendor.

What the vendor had to do was, first of all, he got the contract. He had to first of all realize that he had to build two equipments, one which would go into the plant, and one which we would test at Walts Mill. He also had to look at our reliability allocations and do a mill handbook analysis to show us how he would achieve those where mill spec components were necessary, and they usually were.

We then built prototypes. We approved the prototypes. He built the test equipment, the prototypes, rather. He built it. We had a major prototype unit seismically tested. We had all -- I call them reliability units, but it was really an extended operation test program unit delivered to Walts Mill. These were about 50 units of each type. It was probably about 800 or 900 units. We set them up there in the test program.

The function of this test program was to verify that we had in fact gotten the reliability that we thought it was in the first place. We did many other things as well as that. It really was a program aimed at proving our design to ourselves, whether we got things right, whether the equipment was maintainable, whether we could calibrate it, various other features associated with the logic which we wanted to find out, because it was not a completely new system.

We have had a lot of talk about diversity and people going to different vendors for diverse equipment. In our case, we came to the conclusion that the best way to get diversity in electrical equipment was to go to the same vendor. If you go to two different vendors, the chance is you will find that they both do things the same way. They have preferred ways of doing things, and you will get what the industry believes to be right at that point in time.

By going to the same vendor, however, we are able to make an issue out of diversity with them, and discuss what he was doing, and get changes and differences factored in.

MR. EBERSOLE: While you are on these general lines, one of the guidelines that we all use, as you know, is IEEE 279, the single failure criteria for "the protection system," which is defined as being bounded by the beginning of a trip signal and the end point is the generation of the trip signal, which is a very narrow area. There are another pair of documents that extend failure rationale and logic into the whole physical world. Do you all use all three of these documents in your basic logic evolution?

MR. MACRAE: We certainly use the first one.

MR. EBERSOLE: I am asking about the second, because the first one is that narrow domain between a trip generation and a trip set point, and that is a very, very small piece of the whole world of safety. I am asking about the other two, because they extend some of that and improve on it, N-18A and 4.1.

MR. MACRAE: Those areas elsewhere we covered really by testing and by our design verification performance.

MR. EBERSOLE: It is the principle in those elements, for instance, the coincidence of failures and accidents, and the non-privilege you have of considering the first failure being of non-random character. There is quite a bit in the other two. I am merely asking to what extent do you use industrial documents and those three in particular?

MR. MACRAE: As far as I am concerned, the answer is no.

MR. MORRISON: My name is Gary Morrison. We use IEE 279. The other document you mentioned we don't use.

MR. EBERSOLE: And you don't use them why?

MR. MORRISON: I think they were generated after our design was complete.

MR. EBERSOLE: I would like to know and find out for the record where you do not comply with the content of those other two documents, okay?

MR. MACRAE: Okay. So I have tried to give you an overview of how we in fact did have -- it was really a conventional development program for this equipment. It involved testing. It involved prototype work. It involved reliability analysis, and really that is my response to your earlier concerns about to what extent did we try to quantify our design and find out what we got. I think we did.

Okay, my next issue here is maintaining the parameters within acceptable limits. I will discuss the selection of the design basis events later. The design is based on the LMFBR or NRC general design criteria and other regulatory positions. I think that will be discussed elsewhere, and we will be judged on that. Conformance with industry standards is where you have picked me up. I was confident of this one. I am not so confident of it now. Utilization of FFTF technology and experience as well as test program results. Well, as mentioned, the design that we developed really is the development of an FFTF logic design, many instrumentation systems, as you will see later.

The story we are trying to present here is, if you will look at our equipment, you will find that three-quarters of instrumentation is really conventional. The other quarter, LMFBR type instrumentaton, we usually point to FFTF to indicate that is where we see it cooking.

(Slide.)

MR. MACRAE: You have seen several of these diversity type vu-graphs. This is yet another one. Again, we did have a reliability analysis which we aimed at showing freedom from random failures. Of course, common mode failure is a continual problem. We try to promote it in a number of areas. We have already discussed the control rod release mechanism. The previous speaker mentioned that we do have two different kinds of logic in the protection system. We also have different isolation features, different types of circuitry in the two systems. We use integrated circuits in one, discrete components in the other, separation.

We try to use as much of the facilities in the building as we could to separate the cabling. For instance, the upper cable spreading room in the one and the lower for the other. In the case of instrumentation, again, we looked for different types of instruments wherever we could. There is obviously a limit to the extent that you can do that. For one example, the flux chamber used ion chambers and fission chambers in the other. We have to measure speed in the primary system. We used pressure and speed in the first system. In the other we used pneumatic flow. I will get into this again, but I was trying to paint a picture that there was a conscious effort made at every stage when we designed the equipment with the vendors and we selected functions, we tried to introduce diversity.

MR. EBERSOLE: The next to the last line there suggests a substantial effort. The main cable spread termination, that suggests you are now coming to the usual question of the integrity of the cable spreading room or the control room. Over the last ten or twelve years or so, it has now become recognized as a need to have an auxiliary control room, invoking the thesis that something horrible has happened in the main control room, not just the fact that you had to go out because it smelled bad or something, but there was large-scale damage in it.

Does your design now incorporate an auxiliary control room with sufficient but austere equipment?

MR. MACRAE: There are facilities outside the control room for shutting down the plant.

MR. EBERSOLE: Are they independently provided with source information and terminal actuation such as you don't depend on any cables or elements in the control room?

MR. TINDER: I believe all of the actuation type things have no dependence on the control room. Some of the monitoring instruments that are at the remote shutdown location, the electronics for those instruments are in the control room, like flux monitoring.

MR. EBERSOLE: What happens when those are burned out by a control room fire of some sort?

MR. TINDER: Then I would not use flux to indicate that my plant is down.

MR. EBERSOLE: You don't need it then. What I mean is, is there any critical --

MR. TINDER: No, there are no critical ones.

MR. EBERSOLE: Let me put it this way. I bring a 50-gallon drum of something into the control room and I burn it out. Can we shut the plant down?

MR. TINDER: Yes. Yes.

MR. WARD: That means both the primary and the secondary systems can be operated from the auxiliary shutdown?

MR. TINDER: The scram part of them. I can't use automatic stuff.

MR. EBERSOLE: There is a good circuit then anyway.

(Slide.)

MR. MACRAE: This diagram indicates the different logics in the systems. In the primary, we have a local sequence logic. In measuring flux, we have three chambers. We compare them on a two out of three basis. We de-energize three channels, which again would be used to de-energize breakers, which Bob showed you previously are located between the MG sets and his electrical control equipment. So in this situation any two flux, whatever the parameter is for the signals would shut down the plant and they would do it by means of signal in the control building.

The intervening cabling, of course, would be inert to the control room reactor. Now, we had general logic in the secondary. In this case, we have parameters feeding into each of the three channels directly, so in this situation the flux here, and let's say the pressure here, could in fact cause a trip in the plant as opposed to fluxing, but you now have a different principle in this area.

MR. EBERSOLE: Somewhat more reliable but more troublesome.

MR. MACRAE: A lot more troublesome. This restricts the size of the system in this type of configuration. In this case, we, as was noted before, the pneumatic solenoids are located in the actual mechanism, so we are now disconnecting or carrying out the tripping action right at the mechanism as compared with the previous case where we carried it out separately in the control building.

MR. EBERSOLE: Isn't it true that the ultimate weak point for the first system over here is the common mode failure potential for the two breakers? That is, the two train breakers? That is where the unreliability is probably localized?

MR. MACRAE: Yes.

MR. EBERSOLE: Aren't there a variety of ways to improve that, like upsetting excitation or going into a diverse way of interrupting the magnet circuits?

MR. MACRAE: Well, the breakers we have used are the type of breaker we have had a lot of experience with. We looked around until we found one.

MR. EBERSOLE: I was thinking about the old kind with an undervoltage trip, which is analogous to a mousetrap that runs a rattrap. I am asking, why do you not have internal diversity in the circuitry of the system on the left to get the power off the rods?

MR. MACRAE: Because we believe the performance of that system was adequate such as it is.

MR. EBERSOLE: I guess that means that you went to some numbers.

MR. MACRAE: Oh, yes. As I pointed out, this whole design really started off with an allocation which we gave to the components. Then we tested to see if we had it.

MR. EBERSOLE: Some of the light/water reactors are going to diverse ways of interrupting the signal rather than a common way through an undervoltage relay. I would have thought you all would have gone whole hog to diversify that method of de-energizing the rods.

MR. MACRAE: I think we thought about doing it twice. There was the thought if you went to diversifying things there is a limit.

MR. KERR: And the prime objective is really reliability, not diversity.

MR. MACRAE: Exactly.

MR. EBERSOLE: How true.

(Slide.)

MR. MACRAE: My next point, I have really given you an overview of the equipment. Now I will discuss how we actually selected the trip functions for these two PPS systems. Design basis events were identified and categorized in three frequency classes. These are the ones which Paul discussed earlier on, the upset emergency and things. Damage was categorized, as we pointed out, the more likely the event, the less the allowable damage. The allowable damage levels for the secondary shutdown alone, the system responds at one level.

MR. LIPINSKI: How do you quantify that last one?

MR. MACRAE: By analysis.

MR. LIPINSKI: In terms of fuel temperatures. Are the damage limits defined in terms of a fuel temperature here? Effectively you are saying you will take an upset on the primary and an emergency on the secondary?

MR. DICKSON: No, let me clarify that a little bit, if I could. In every upset event, both the primary and the secondary should scram. Now, you design the primary so that if it alone scrams and the secondary doesn't, it will hold it to the temperature limit specified for the upset event.

MR. LIPINSKI: At 1,500 degrees Fahrenheit clad?

MR. DICKSON: Yes. If the primary fails, the rationale is that the probability of both that upset event which is anticipated and will occur once and a while and the failure of the primary is sufficiently low probability that it will allow you to go to the next set of limits, the emergency limits of, in that case, say, 1,600 is a typical example, the rationale being that that would occur so infrequently that your fuel will be able to take that, so that is what we have done, allowed the limits to go higher. So you may have noticed on the curves at .31 seconds to get the dollar in applied to the primary. There was a little longer time applied for the secondary.

(Slide.)

MR. MACRAE: This is a table taken from the PSAR. It lists the anticipated faults in terms of the reactivity disturbances and the flow disturbances. We have an effort to provide different functional protection in the two systems. For instance, in the startup system we have a flux, delayed flux to take initial rampant activity. In the second system we have a modified nuclear rate, and also a startup level trip. At full flow now we have in the primary system a high flux level trip. In the second system, we have a flux total flow trip.

You will see in a number of cases that we used flux two flow trips. This is from what Bob Tinder described to you before, that we will vary flow with power, so flux two flow is a critical parameter. We measure flux two flow in the primary system by comparing flux to temperature drop across the core, and comparing flux with the in flow.

I have got about four pages of these here. I won't go through them all, but you will see the same situation repeated on the steam side. You will see the primary system, we use feed flow to steam flow ratio in the one system as opposed to drum level in the other. An effort is always made to look for an alternate measurement.

The end point in this selection, this is really a conclusion of the previous discussion. You can probably compare more directly here what in fact we have done if a flux, delayed flux that will be the S type term, which will be functionally different. Here again, we have flux to pressure, as mentioned, flux to flow.

We have primary, intermediate speed ratio to determine problems between the two loops, while here we have primary to intermediate flow.

Again, in terms of steam system problems, we use level in one system -- steam to feedwater flow in one system, steam drum level in the other system. To show a lot of heat sink, we use IHX primary outlet temperature and secondary pump or sodium in the secondary.

MR. EBERSOLE: You don't need the trips?

MR. MACRAE: These are rate trips. There is one there and then there is also a delayed trip. That compares the flux at a point in time with a previous point in time.

MR. EBERSOLE: Those will protect them up to a reasonable power level?

MR. MACRAE: Yes.

MR. EBERSOLE: When it starts real low down, it will protect it coming through.

MR. MACRAE: Let me describe the flux system and that may take care of it.

MR. DICKSON: If I just might interject, I think you are thinking of a light/water reactor. We are never quite that far down. We always have a lot of new trains.

MR. EBERSOLE: I was, of course.

MR. DICKSON: I thought that's what you were thinking of. In starting up a light/water reactor, our inherent source is so much larger than the light/water source.

MR. WARD: I think it is more than just the source, though.

MR. DICKSON: That is what will trip you off. The delayed flux. If you start off with no neutrons at all, that is what trips the reactor.

MR. MACRAE: One of the functions -- I am moving on to the instrumentations that we use, to give us those functions. We have indicated instruments here and their location. Again, there has been an effort made to use different types of instruments and instruments in different locations. It is obvious if you are measuring flux you are in the reactor cavity. You don't go inside the reactor. So we are stuck with one location. In other cases, we go to, for instance, speed, and the pump shaft as opposed to flow, flow signal, and a piping cell. Thermocouples again in cells.

We have an instrumentation well distributed around the plant. We anticipate taking the most advantage we can of location.

MR. EBERSOLE: I guess it is not possible to show here, but if I take any one of those horizontal lines like nuclear flux, that is a two out of three logic, isn't it?

MR. MACRAE: Right. They almost all are.

MR. EBERSOLE: I just can't draw a line through that and say it won't work without being in trouble, can I? There are none of those other horizontal lines that will pick me up anywhere.

MR. MACRAE: If you pick that line out, you have that one, right?

MR. EBERSOLE: Okay, you are telling me because of the secondary system I have that. I would not normally have it.

MR. MACRAE: Right.

MR. EBERSOLE: The secondary system gives me that. Of course.

MR. MACRAE: If you look at these instruments. you will find that three-quarters of them are really instruments which have a lot of experience. The ion chamber frequency relays, venturis, thermocouples. The unusual one in this reactor is the Nak transmission pressure sensor, and that is not really that unusual. Those are the ones that are probably peculiar to this reactor. Most of the others you will be familiar with.

You have seen them all before.

(Slide.)

MR. MACRAE: I will go on now to talk to them briefly.

The intent of this vuegraph is to try to show you that the configuration of the flux system is not very different from what you see in the light-water reactor, apart from the fact that we have two systems going up to full power.

That is the reactor vessel. Around the reactor vessel we have three sets of thimbles located, inner blocks which contain source range detectors and outer range detectors.

The wide-range detector uses the camering technique to go up to full power. So these are up to full power. And wide-range systems out here (indicating).

This instrumentation connects back to the control room where we again have two sets of paddles, one containing the primary pump system, the ion chambers in this case; the other containing a wide-range system related to the secondary shutdown system. That is just a display of instrumentation.

There is also a peek provided for refueling so that the operator can observe the rate of the counter while he is refueling.

MR. EBERSOLE: Would you comment on how tight you keep the chamber calibrated against thermal power?

MR. MACRAE: We will calibrate these within 1 percent.

MR. EBERSOLE: How often?

MR. MACRAE: I cannot tell you how often, but I do know that we do have a data handling system that does routine checks. So we get data from that. I could find out.

MR. EBERSOLE: So you will get indication of some abnormal imbalance?

MR. MACRAE: They will tell you on a daily basis if we have a problem between the steam system power and what you observe.

MR. EBERSOLE: Does this run around in full ride out?

MR. MACRAE: Full ride out when you shut down?

MR. EBERSOLE: When you are changing power, do you get much miscalibration due to rod movement?

MR. MACRAE: Because of the movement of rods in the bank, we would expect an extremely small perturbation. That was one of the reasons for going to that scheme with infinitesimal movements. It provides a very even change in reactivity.

MR. CARBON: Do you not have in-core flux monitoring because of practical problems of temperature and so on?

MR. MACRAE: Right. That is, certainly nobody has a detector that will take a thousand degrees, but at the same time, we do feel that we can do all we need to do outside the vessel. These ex-vessel detectors, combined with the monitors in the plant, allow us to do that.

(Slide.)

This is the same topic. It just shows the range of the detectors. The wide-range system in the secondary PTS, there is the primary ion chamber, the wide-range system goes right down to the shutdown level.

This is our shutdown power down here. Basically, this is really a refueling monitor. Although this appears to be separated, in fact, this detector would give about a fifth of a count a second, something like that. You would get knowledge of the core when you were shut down from this wide-range system. It would be slower, but you would have it.

MR. EBERSOLE: Let me make a guess that the plant operation is dependent upon the maintained air flow to keep the core cooled; is that right?

MR. MACRAE: No; the temperature in those thimbles, the thimbles are outside the reactor cavity with a reactor temperature of 120 to 150.

MR. EBERSOLE: What happens when the plant is tripped, the air circulation stops?

MR. MACRAE: There are cooling systems in the cavity.

MR. EBERSOLE: I understand that. But is the plant adequate riding on those cooling systems that are sometimes low-grade systems?

MR. MACRAE: If you lose the system and drop to 250 degrees in the ion chamber, the fission chamber can take that. 250 degrees is the equilibrium temperature.

MR. EBERSOLE: Is that what the temperature stabilizes at?

MR. MACRAE: I believe that is so.

MR. EBERSOLE: You then do not need forced convection to keep things running?

MR. MACRAE: No.

MR. EBERSOLE: That must be pretty far away from that hot sodium.

MR. MACRAE: Bear in mind there is the core, there is the vessel, there is the guard vessel.

MR. EBERSOLE: Oh, you are way out.

MR. MACRAE: Yes.

I must apologize for this vuegraph. It is a rather crude one, but I just want to really talk around this particular instrument, the flow meter, which again is an unusual one.

Basically, we have a magnet on each side of the piping. We have electrodes along the piping. It is an extremely simple instrument. It measures flow. The magnets are, in fact, somewhat more complicated than what this diagram would make you believe.

This just looks like a slab of steel. In fact, the magnets on each side consist of a large number, one or two hundred 8-inch long Inconel 5 magnets which are located horizontally and which are connected by mild steel outer cover to the magnets on the other side.

By virtue of having the small magnets, you can adjust them to linearize the flux, which you cannot easily do with the single magnet. Again, this is a simple robust instrument. It exists on most LMFBR and FFTF and have worked very well and reliably. So that we think this is an excellent diverse backup system, 5 percent instrument.

(Slide.)

MR. KERR: What do you assume about the accuracy with which you can measure the thermal output of the reactor?

MR. MACRAE: Using ASME coded systems, we think about 1 percent.

MR. KERR: On a continuing basis you think you know it to within 1 percent?

MR. MACRAE: I do not know how often they are going to do it that way, whether it is once per year. They expect drift between these measurements. I have no feel for that, but there is a data handling system that does, in fact, continually take measurements from the steam systems to compare them with the flux. I am not the person to tell you exactly what the drift is in that steam signal measurement.

MR. KERR: But there is someone hidden in your organization who knows that?

MR. MACRAE: Right. I could find that out.

MR. LIPINSKI: You use the steam system for the calibration; then you have to estimate your losses from the primary system. Your estimation errors are within 1 percent for your losses?

MR. MACRAE: You find that 1 percent of 900 megawatts is a lot of power. The losses are relatively small compared with that 1 percent. We actually look at the quantities, and you find that they have come right down.

These are the level detectors. These again are a type of inductive probe. They are supplied winding with the kiloHertz constant amplitude signal. The other winding gives you the MF portion of the coupling of the two, which is influenced by the level of the sodium inside the vessel. Again, it is a simple, straightforward instrument.

(Slide.)

Our last vuegraph shows response times and accuracies of instrumentation. What I am trying to get across here is the performance accuracy that we have designed to is not unusual. It is extremely -- this is a variable-type instrumentation. Relays 200 milliseconds. Outlet temperature, this is in the loops. That is 5 seconds. This is in a loop of the transit time of probably a minute and a half for a heat sink type measurement that is a reasonable performance flux. These are reliable systems.

MR. KERR: When one says evaporator outlet sodium temperature plus 2 percent, what is the span?

MR.SCHINTELLE: Ed Schintelle.

The evaporator has a 500-degree range.

MR. KERR: 2 percent is 100 degrees?

MR.SCHINTELLE: 500 degree range. Yes. Span.

MR. MACRAE: 10 degrees, 2 percent.

So again, basically the thought I would like to leave you with on this system is really the control part of it. I know you heard Bob Tinder before me. I must sound like the Maytag man, "with nothing to do with all the work" he is going to take off of me.

But apart from that, the system and the components are really conventional, with very few unusual things in it.

MR. KERR: I was surprised to hear you say that 25 percent of them were not conventional.

MR. MACRAE: Yes. They are instruments on which there is experience: the flow meter, the level detector, the flux temperature, pressure. They are all instrumentation that we have experience with.

That really concludes my presentation unless there are some questions you would like to ask.

MR. KERR: Are there questions?

MR. LIPINSKI: I have one question. You have to withdraw your startup chambers? FFTF cannot leave them in place. You have to withdraw them?

MR. MACRAE: FFTF startup chamber goes inside the vessel or ex-vessel. It goes out of the thimble into the vessel. We have a BF-3 detector at the moment outside the vessel.

MR. LIPINSKI: And they are left there at 100 percent power?

MR. MACRAE: That is the intention. You disconnect the supply, obviously.

MR. KERR: Other questions? Mr. Carbon.

MR. CARBON: I have a question of Mr. Tinder. You said anything could happen in the control room and it would not be critical as far as the auxiliary shutdown system.

In line with my earlier question of had you explored to see if there could be any sort of common-mode difficulties or design failures, is there anything that could go -- if you knocked out the control room, could that not be a matter of needing something or, perhaps, yes, a matter of needing something from there, could anything be knocked out in the control room, knock out being able to shut down from your auxiliary site?

MR. TINDER: Well, I do not believe we are any different than the rest of the plants. There are not people out in the plant standing by all of this equipment waiting. The philosophy would be, you know, if you had a body in the control room, you definitely should hit the scram button before you leave. If not, it is going to take you some minutes to get down to where the scram breakers are and do it at some other remote station.

So I think we do assume you do. The operator scrams the reactor before he leaves the control room. If he did not, the protective system is still monitoring and he will still do it. But all of the procedures and, I think, all of the reg guides and all, you push that button before you leave there.

So then you have to worry about, did the rods do what they were supposed to do, and is my decay heat system taking over and doing what it is supposed to do? That can be controlled totally from outside of the control room, and you do not rely on anything that is in the control room.

MR. CARBON: It would be controlled all right. But is there anything that could go wrong in the control room in one of these accident situations that would prevent the heat removal equipment from working insofar as your secondary?

MR. TINDER: We have studied that, and we think there is none.

MR. KERR: Other questions?

MR. EBERSOLF: Did you invoke the old 10-minute rule that nobody has to do anything for X minutes or 10 minutes or 30 minutes if you have an emergency? What is your criterion for operator response?

MR. TINDER: I do not know right off what our criteria is, but the systems are all automatic. If I did not invoke one right now, it could go for an extremely long time.

MR. EBERSOLE: I am saying, if you look at your full accident field you have got, can I hold my hands for 10 minutes and not do a thing?

MR. TINDER: Yes.

MR. DICKSON: The earliest operator action required is 10 minutes.

MR. KERR: What do you do with the conscientious operator who will not wait 30 minutes?

MR. DICKSON: We did look at that as a part of that key system task force, and there have been some who have facetiously suggested that the first step in every operating procedure is, have a cup of coffee and think it over, because you do not want an operator acting improperly. But we think we have looked at that with diligence and care in our key system task force.

MR. EBERSOLE: In other words, you have an extensive --

MR. KERR: What did you conclude when you looked at it with diligence and care?

MR. DICKSON: That if the operator goes through the procedures, he will do the right thing. We made every effort we could to remove any confusing signals, every effort we could to be certain the operator was not misled and, therefore, would be able to follow the best operating procedure, the correct operating procedure.

It was mentioned 20 men for 6 months. I thought it was more like 8 months and we had outside human consultants we brought in for that very purpose. There is never a guarantee that no operator will ever do anything wrong.

MR. KERR: No. But did you change anything as a result of that study?

MR. DICKSON: 480 items.

MR. KERR: As a result of your assumption that the operator would not be handcuffed during the first 10 minutes? You did not change anything as a result of that?

MR. DICKSON: No, sir. We had originally set a goal, the 10-minute criteria that you mentioned, adopted from light-water reactor practice, and then found that we never even had to come close to that.

MR. KERR: But that is a different criterion, as I understand it. That criterion says the operator does not have to do anything for 10 minutes. There is also a criterion that says unless the operator has been handcuffed, he can do something in the first 10 minutes and what can he do wrong. I thought you said you looked at that.

MR. DICKSON: We did look at that, yes.

MR. KERR: But you did not change anything as a result of that look?

MR. DICKSON: We eliminated some alarms that we thought might be misleading. I do not recall what else we did.

MR. TINDER: No. But we looked at the misleading things we were concerned over. I think that is also where there was a recommendation that supported the project. Training is very important, and we cannot do without training. They highly recommended that we make a commitment to the dedicated simulator, which now is part of Clinch River.

MR. DICKSON: Prior to that, we had not made our mind up as to whether or not we needed the simulator. That was a key decision. Another key decision was a first-alarm indication so that the operator would know what was the first alarm so that he would not lose track.

MR. KERR: Are your operators going to be -- and I realize this is probably premature -- but are they going to be told not to do anything for the first 10 minutes?

MR. TINDER: I personally am scared to tell an operator, "Don't."

MR. KERR: I do not know what the right thing to do is. But on the one hand you have a 10-minute rule that says the operator should not do anything for 10 minutes. Now, are you so convinced that the operator does not need to do anything for 10 minutes and that there is a non-zero chance that he will do something wrong, that you are willing to say to him, do not do anything for the first 10 minutes?

MR. DICKSON: I guess I would rephrase what you said. It is not that the 10-minute rule was the operator should not do anything for 10 minutes; it is that the plant should be designed not to require him to respond any faster than that.

MR. KERR: Agreed. But there is always a non-zero probability that if he does something, he will do something wrong. I do not know what it is, but it is not zero.

MR. DICKSON: That is correct.

MR. KERR: If you really have things designed so he does not have to do anything for the first 10 minutes, do you decrease risk by making sure that he does not? Or do you decrease risk by saying, well, maybe I have missed something and there are some things in there which really will require the operator --

MR. DICKSON: That is what I was going to add. There is also the non-probability that we have done something wrong that would require something. I guess I would not have a strong problem with saying he should not do anything other than scram his reactor in less than 10 minutes.

MR. EBERSOLE: In this area, did you not find in your examination that if he did do something wrong because he was enthusiastic and alert, that what he did was irreversible beyond hope of retrieving?

MR. TINDER: No. We do not know of any irreversible step.

MR. EBERSOLE: In essence, he seals in that he cannot get out. I mean, it is nice to say he did something wrong and now he can see he did something wrong and he can back out.

MR. DICKSON: Yes. One thing that is true about these plants is that the plants tend to develop slowly so you tend to have a recovery capability.

MR. EBERSOLE: If he can back out, I think it would be not smart to tie his hands.

MR. TINDER: I think most human factors people will agree with you. Be careful of tying his hands, because the reason you have the operator is hoping if he has to, he can take some actions where we designers have failed.

MR. EBERSOLE: But along with that, I think he needs a prerogative of backing out.

MR. TINDER: You have to make sure that you give him the indication to tell him he has done something wrong, too.

MR. KERR: We are agreeing too much to get anywhere. Why don't you go ahead, Mr. Morrison?

MR. MORRISON: I am Gary Morrison, Westinghouse advanced reactors division. The subject I will be discussing today is the protection control interface.

Specifically I will speak in the areas where we provide control signals from protection system channels. The applicable criteria in this area is the CRBRP criterion 22. This deals with separation and protection of control systems. This is based on 10 CFR 50 criteria and IEEE 279 dealing with control and protection system interaction.

MR. KERR: Do you think that separation as indicated in criterion 22 is a good idea?

MR. MORRISON: In general, yes, I do. There are some interpretations that I feel are needed in terms of some words in there about minimizing the interaction, the effects of interconnections between the two. I think that needs to be interpreted, but in general I think that is a good criterion.

(Slide.)

In the previous presentation by Mr. MacRae, he showed you a configuration for the primary and secondary shutdown systems. This shows a little more detail as to what the secondary shutdown system looks like.

In the front end of the primary and secondary system the channels are configured pretty much the same, where you have a sensor, a signal condensor feeding some kind of logic train, deciding whether you need a scram or not from that analog channel. The analog output from the signal conditioner, we develop signals to the rest of the plant through buffers which provide an isolation function.

Now these signals that go out to other systems may go to indicators, plant computer recorders and in this particular case I want to discuss there are some signals that go to the plant control systems.

If we are looking at safety criteria in this area, everything you see on here is 1E, with the exception of that point out to the other systems. That area would be a non-1E area. Where these signals are fed to the control systems, we have a configuration that looks like this.

(Slide.)

This is similar to what I just showed on the other vugraph. The sensor transmitter, trip comparator, feeding downstream logic trains. These are the buffers which provide the isolation function.

In terms of how we give those signals to the control system and what configuration it is, all three channels are provided into the control system. The control system then uses a median select to chose the middle signal to use as the control signal being used in the control function.

MR. LIPINSKI: What happens if you lose one channel?

MR. MORRISON: These channels are independent, independent 1E channels. The buffer from this point down is a non-1E function. Let us assume we lose channel A.

MR. LIPINSKI: It goes to zero.

MR. MORRISON: This signal goes to zero, so the median select would then chose the lower of the two signals between B and C.

MR. LIPINSKI: I see.

MR. MORRISON: If channel A fails in the high condition, then it would chose the higher of the two signals betwee B and C, so it depends on what failure mode this channel goes into which signal will be selected between B and C. In a sense, A, B, and C are all measuring the same plant parameter, so you should still have a valid signal into the control room.

The advantages of --

MR. LIPINSKI: Let us continue that with two failures.

MR. MORRISON: Two failures? If you had double failures, then you would have a bad controller. It depends on how that failed. You would have to assume some kind of failure.

MR. KERR: You would also scram the reactor, would you not?

MR. MORRISON: I would be into a transient condition at that point.

MR. LIPINSKI: You would not scram the reactor if you had two channels going to zero unannounced.

MR. MORRISON: We have monitoring capability.

MR. KERR: I though you said they failed, Walt.

MR. LIPINSKI: To zero.

MR. KERR: Unless they are not failed safe, they will scram the reactor.

MR. LIPINSKI: I am assuming these are unsafe failures, undetected into his buffer, so now his control system --

MR. MORRISON: These two channels fail? All right. We do monitor the channels through the buffers and through the plant computer. If the first channel fails, you get a deviation alert through the computer that says one channel has deviated beyond the other two redundant channels.

MR. LIPINSKI: Have you reviewed connecting the protecting system with the control system with the NRC?

MR. MORRISON: We have discussed it with them. They have seen this as a new type of arrangement.

MR. LIPINSKI: It is not new, because in Arkansas 2 that was present and they were not allowed to make that condition. They did, but they broke it.

MR. KERR: They were not trying to do this particular thing, Walt. They were not using it to control. They were using it to record.

MR. LIPINSKI: They were taking the plant protection system panels. The plant computer was making decisions as to whether the channels had failed.

MR. KERR: Yes, but they were not using it for controlling.

MR. LIPINSKI: But the fact that it went to the control system, the buffers were sending the protection system channels to the plant computer.

MR. KERR: I know that. I thought you said they were doing exactly this. I do not think they were doing exactly this.

MR. LIPINSKI: Not with the controller, but they were buffering the protection system information, sending it to the plant computer. The plant computer was analyzing it to see which channel failed.

MR. KERR: Maybe the NRC has learned by now.

MR. ROSSI: This is Ernie Rossi from ICSV. We are still looking at what they are doing here and I guess we are probably going to accept this kind of design. We may ask for them to periodically test the median selector.

Now the median selector here is not part of the protection system, but the median selector is indeed a device that is used to meet the standard IEEE criteria on interaction between protection and control. So we may ask them to have some sort of period test of that when they do the periodic testing of the protection system.

We also have some questions, I guess, on whether they should meet -- whether the primary system by itself should meet all of the IEEE 279 criteria with respect to interaction between the control protection and the secondary system just by itself should meet all the criteria. As things are designed right now, there are some cases when -- I think it is only when they are testing one of the channels, where it is really only the combination of primary and the secondary together that will meet the standard criteria of IEEE 279 on interaction, but that is only a limited period of time during tests and the combined systems, as we understand it from our review to date, will meet IEEE 279.

MR. LIPINSKI: What is the status on Arkansas 2? Have they been allowed to reconnect the plant computer?

MR. ROSSI: I am simply not familiar with Arkansas 2. We have other plants where they take control systems from the protection system and they do indeed use a system similar to this, except they do not use the median selector. In general, what they would do is to control for just one of the channels. Then they would have a fourth channel there and use two out of four logic to meet IEEE 279.

Here they have three channels. They have got the median selector and except when you are in test their argument is that that meets IEEE 279. That up there in itself meets IEEE 279 with respect to control protection.

MR. LIPINSKI: That was not the issue on Arkansas 2. It was to put those buffers onto the plant protection system channels and run those buffered signals into the plant computer.

MR. ROSSI: Well, the buffers, as I understand it, are intended to be isolators. They are intended to be part of the 1E system. The buffers are no different from what is used on the Westinghouse pressurized water reactors, except you would have -- well, the kind of system you would have on a Westinghouse pressurized water reactor might be that you would have several channels, all of which would have buffers just like you have got there and instead of the median selector you would have the switch.

MR. LIPINSKI: Forget about that. The basic principle was to put buffers on the plant protection system channels and to simply run that information on the plant computer.

MR. ROSSI: We have buffers in many places.

MR. KERR: What was your question, Walt?

MR. LIPINSKI: I asked him what the status was in Arkansas 2. The simple principle on Arkansas 2 was that they were not allowed to run the buffered signal to the plant computer from the plant protection system.

MR. KERR: He said he was not familiar with Arkansas 2, so I do not think we are going to get anywhere. I think we probably need to formulate the question. Please continue, Mr. Morrison.

MR. MORRISON: Do you want to continue with two failures?

MR. LIPINSKI: Yes, two failures.

MR. MORRISON: Okay, two failures. Here again it depends on what failure modes a channel will go into what signal you will see out here, but if you say that both signals will fail to zero, median select will give a zero signal out, or near zero, and that will give a bad signal to the control system generating a transient condition in the plant, and it will channel to the safety system.

MR. LIPINSKI: If it goes high, it will accept a high signal?

MR. MORRISON: Yes, whether that is a feedback or however it is being used will generate the opposite transient.

MR. LIPINSKI: Okay.

(Slide.)

MR. MORRISON: The advantages of using the PPS sensors for control is we have redundant control signals so that the signal channel failures we are talking about do not necessarily generate a transient within the plant. It would challenge the safety system. This also tends to reduce the quantity of sensor penetration in the plant and eases the separation burden around the area being monitored.

The shared channels are also subject to the protection system maintenance and test schedules, so we would expect to have a better calibration, better maintenance and testing, or at least greater test and maintenance frequency than would be normal for the control system grade equipment.

MR. KERR: I do not want to push the question too hard, but earlier when I asked you if you agreed with the separation of control and safety system, I thought your answer was yes, that was a pretty good idea. It seems to me here is a situation in which you are defending non-separation.

By the way, I agree with this, but it does not seem to me that it is separation. I personally think it makes the overall safety probably better, but I think it does it by reducing the separation.

MR. MORRISON: Separation from completely independent data channels?

MR. KERR: I think you are using the same instrumentation for both safety and control -- protection and control, which I think is a good idea, but I do not want to get separation.

MR. ROSSI: This is Ernie Rossi again. I understood his answer before to be separation in the sense that you isolate control and protection and follow rules about what a single failure in the protection system and affects both might do. I did not interpret his answer to be totally dependence on separation between control and protection.

MR. MORRISON: I meant it like Ernie was saying.

MR. MAC RAE: And he did indicate some

misgivings about the words in the criteria saying limiting.

MR. MORRISON: The words are minimize.

MR. KERR: Separation has been overemphasized. What one ought to look at is reliability and if separation enhances it, if loss of reliability makes it worse, you forget it. As I said, I do not want to push this.

MR. MORRISON: The last one on here, if we use a common data channel we end up with operational simplicity and if the plant control systems operating off the same information you don't end up with the situation where you have one channel callibrated differently or operating at a different point than the others, so that it would be control and protection that had to operate together as an integrated system within the plant.

And using these common channels, if you will, assures that they are operating from the same data base for generating the control and the protection.

The interface features we have designed into the system, again we have isolators that are qualified as Class 1E devices. These isolational devices are located within the protection system cabinets themselves.

We have median selectors in the control system to prevent control system action on single failure, so we don't generate a transient which might tend to challenge the protection system.

MR. KERR: What is the significance of saying that an isolater is qualified as Class 1E? Does that mean that it's resistant to a seismic event?

MR. MORRISON: It has been qualified for any anticipated worst case environment, temperature, humidity, changes in power source, seismic. So it has a safety-grade qualification program applied to it, just as the other protection equipment. It is qualified as though it were part of the protection system.

Again, we do monitor the PPS channels by the computer. This is used as a diagnostic to alert the operator that there are signal mismatches, where he might want to do some monitoring or go into a maintenance operation.

We also supply hard-wired readouts on the main control panel, where that function can be done by the operator himself, so he does not have to depend upon the computer to do that. The operator can compare the redundant channels together at the main control panel.

The flow of information from --

MR. KERR: Excuse me. How does he do the comparison?

MR. MORRISON: He has a meter and a selector switch.

MR. KERR: One meter, he flips the switch?

MR. MORRISON: He flips between A, B and C, makes the comparison. They should be reading within a certain tolerance band during normal operation, and if they're not he can identify maintenance actions that are necessary. That same type of function is --

MR. KERR: I guess I really don't see why you put the meter there.

MR. MORRISON: These signals are also used within plant control. So he's monitoring flows, temperatures, flux levels. They are used during normal control.

MR. KERR: I just don't see why you can't rig up a computer system that would do it more reliably than the operator. But maybe you can.

MR. MORRISON: We have both. The operator does it manually --

MR. KERR: We agreed after TMI-2, or at least some people did, that one of the problems was cluttering up a control panel with stuff that was not needed. I guess I just sort of wonder, is this meter really needed? It's a small point.

MR. MORRISON: It's needed for more than just this function.

MR. MACRAE: Part of our licensing position is that the plant can be operated without the computer, so you must have the meters.

MR. ROSSI: This is Ernie Rossi again from ICSB.

Many plants have, instead of a meter and a switch, they have a meter on every channel.

MR. KERR: I recognize this.

MR. ROSSI: I provide that as clarification.

MR. KERR: Even though I'm very old and very wise, I'm not in favor of the status quo in all cases.

(Laughter.)

MR. MORRISON: The flow of information we have is from the protection system to the control system. We never take any signals back from the control system into the protection system to do protection system action.

MR. EBERSOLE: Those isolators are incapable of seeing any variable burden on the low side, aren't they?

MR. KERR: Jess, I don't know what you mean. Explain to me.

MR. EBERSOLE: They can't see short-circuits and load conditions on the low end?

MR. MORRISON: They've been qualified for voltage short-circuits, application of voltages across the output.

MR. EBERSOLE: I'm saying they can't see a wholesale failure on the control side.

MR. MORRISON: No. Any control fault that we've identified we have put into our qualification tests. We have tested to make sure that any fault on the output side is not reflected back to the input side.

(Slide.)

The concern that was being brought up by Mr. Rossi was this particular criteria, in that if we have -- if we can generate a single failure which generates a transient on the plant and can also fail the protection system function that's designed to mitigate that particular transient, then we must have the capability to provide protection even when degraded by a second random failure. That is the criteria out of IEEE.

MR. EBERSOLE: Is that scoped just to include the control systems and safety systems, or protective systems?

MR. MORRISON: Yes.

MR. EBERSOLE: If you draw a line through where it says "control system" and say simply, "can cause an action that has nothing to do with the control," there's no limitation on it, then you run down and add on the next to the bottom line "a second active failure," to a large degree you will be covering then one of the areas that I referred to earlier.

This is scoped to include just protection and control systems. There are a lot of other physical systems. There are impulse lines, all sorts of things that are not covered in this narrow scope document.

MR. ROSSI: We have asked them to look at the impulse lines, and we believe that we are basically trying to apply the same criteria to the impulse lines. Other places it makes sense to apply it, I believe we're trying to do it there, too.

I haven't read the ANS documents recently, so I can't say to what extent they're not doing exactly what's in there. But I think we are doing more than just a very narrow interpretation of this.

MR. EBERSOLE: Yes, as a rather informal practice. It is not formalized.

MR. ROSSI: That's probably true.

MR. EBERSOLE: You're not going back to older plants. Well, that's another problem.

MR. WARD: Ernie, does that go beyond trying to apply it to fluid systems and trying to apply it to mechanical systems? The analogy gets a little more difficult.

MR. ROSSI: I can't really speak to to what extent it's being done on the mechanical systems.

MR. EBERSOLE: That's why I stuck the word "active" in there, because you don't necessarily have redundant pipes.

MR. KERR: If it weren't almost 6:00 o'clock, I would pursue this considerably longer. Do you want to pursue it further?

MR. EBERSOLE: I'm done.

(Slide.)

MR. MORRISON: I can go back to the slide here on the system configuration. Again, for normal system operation, if all three channels are operating normally, one channel fails, we don't generate a transient in the plant because of the median select.

We do have a special case where in order to meet the functional test criteria on this system we may have taken one of these channels out of service or we would be supplying it with the functional test system. In those cases the channel coming over to the median select would not be connected to the processor. It would be reflecting the processor or whatever was going on during the channel test, under the channel test condition.

If under those conditions we generate a failure in the second channel, such as channel B, we then could generate a situation where the median select provides a bad control signal output to the control system. We have looked at that area.

(Slide.)

These are just some examples of the things that we have done. For instance, in the power range flux area, we assume channel A is under test, and during all of our test conditions we do trip the channel, so that we take the trip redundancy down to a one out of two consideration for a scram for that particular function.

So if channel A is under test, it has been tripped, channel B is assumed to experience a failure, and these are the various low-high-high conditions. These are combinations of possible test signals that might be going on at that particular time to get that second channel failure.

These are the control system responses over here under those combinations, as you can see, we have generated. For this particular condition the protection system actions are not required, mainly because the flux control tends to decrease control or another outer temperature loop comes into play within the reactor control, bringing the plant back to the normal condition.

So for this series of events, even with the channel under test and the second failure, we don't generate a challenge to the protection system in those cases.

(Slide.)

Now, there is in the second example, again the same situation occurs up here. Channel A is under test, channel B has failed. Down under the primary heat transport, sodium. This is flow measurement here. We generate combinations of failures and so forth.

You can see down in this last line, we do generate a decrease in flow, a decreased flow signal, because we show a high flow signal coming out of the median select, which tends to drive the flow down on the flow control for that loop, and under those conditions we require the primary shutdown system to respond with a speed mismatch function.

So in general I think our conclusion has been that for normal operation the primary and secondary shutdown systems individually meet the single failure criteria of 279. Under the limited condition of this testing during functional testing of these channels, both systems together will meet the single failure criteria of IEEE 279.

MR. KERR: How did you decide on a three-channel, as opposed to four-channel system, in your protection system?

MR. MORRISON: I think the main forcing function for that was the experience on FFTF. They have a three-channel system. We did initially have a two out of four system, but in the design evolution that occurred in the early '74 or '75 area that was dropped in favor of using the FFTF design.

MR. KERR: I don't understand what experience at FFTF drove you to the three-channel system, other than the fact that you had done it.

MR. MORRISON: We had done it. We had built the hardware. We had some long-term testing on it.

MR. KERR: I should ask, why did the FFTF guys decide on three channels.

MR. MACRAE: George Macrae of Westinghouse.

I think the driving force in this direction is really, there was a desire to make an investment in improved instrumentation. We decided the best way to do this would be by two configurations of this type, rather than increasing one.

The dividend that came out from common mode failure improvements was considered to outweigh any sort of improvements you could make with any single system. Even in this case which Gary has discussed, we showed one case where you hadn't --

MR. KERR: I'm not making myself very clear. There are a number of light water reactors using a four-channel system. My impression is the people who use the four-channel system have not repented of four channels and got excited about the three, although I may be wrong.

And I just wondered why, with the experience with the four-channel system, which has been reasonably satisfactory, one decided to go back to three.

MR. MACRAE: Because three-channel systems were considered to be better than one full channel.

MR. KERR: What about the four-channel system?

MR. MACRAE: That would substantially increase the problems of maintenance and operation.

MR. KERR: So you really wouldn't get any increase in reliability with a four-channel system? You're telling me a three is really better than the four because of all the additional maintenance and things like that?

MR. MACRAE: Right. Two three's, particularly when you get the diversity dividend.

MR. TINDER: Six is better than eight. We have two three's. We have six flux channels, so the separation -- but if you went to the two out of four and you did that twice, now you've got eight separations to keep track of.

MR. KERR: But you concluded that two three-channel systems would be more reliable than two four-channel systems; is that right?

MR. TINDER: I would think that that is probably true.

MR. KERR: I would think it probably isn't.

MR. TINDER: How many separations can you have? You only have one control room.

MR. ROSSI: Could I make a comment? I think three channels are the minimum number of channels that you have to have in order to meet a criteria that says a single failure will not cause a trip, nor a single failure won't prevent a trip. That takes three channels.

I think people who have ended up with four channels have done so -- there are an awful lot of three-channel systems still around. A lot of PWR's use two out of three logic on individual loops and that kind of thing, so they are still used. A lot of people have gone to four channels simply because they have two loops or four loops and it's hard to split three channels among that number of loops, so they've done it for that reason.

Some people have gone to four channels to meet this criteria up here. So I don't know that anyone has gone to four channels just for the reason that four is better than three.

MR. KERR: I'm really trying to find out why Westinghouse or somebody made this decision. I guess what I'm hearing is, you had a choice between three channels and four channels.

MR. DICKSON: I don't think that's correct.

MR. KERR: I'm open to suggestions.

MR. DICKSON: I don't know how it came about. I know that both the FFTF and Clinch River have a factor of three on loops. Poor layout, everything you can name, the number of diesel generators. I think --

MR. KERR: Now we're back to Fiddler on the Roof. Tradition, right?

MR. DICKSON: I think so. I think everybody just thinks that there should be a factor of three symmetry on everything.

MR. KERR: I'll accept that.

Mr. Ward?

MR. WARD: I want to ask a more general question about how your organization approaches the design of reactivity control systems. The protection systems are designed for a criteria of Class 1E. Do you have internally a set of written requirements for reactivity control systems design that would be different from, let's say, the secondary system control?

MR. MORRISON: The secondary has no control on it. We only control the primaries.

MR. WARD: There are controls on the secondary?

MR. MORRISON: Let Bob answer.

MR. WARD: Do you have sort of a written Class 2E?

MR. TINDER: No, we don't have a generic control requirement document. The plant itself, the control specifications for the plant itself has requirements that were developed specifically for the control system, which brings them to require interlocks and things not to challenge the PPS. But it's not a generic control specification that is applied to control.

MR. WARD: Do you think the reactivity control system should be of a higher quality than other electrical systems in the plant?

MR. TINDER: I don't know about higher quality. It should have many more requirements placed on it. But you know, the wire and the resistor and the capacitor, I don't know if the quality would be any different.

MR. WARD: I meant the system quality. Presumably, the requirements give you better system quality.

MR. TINDER: Yes, we do write a specific requirements document for reactivity controls, but not --

MR. WARD: You don't have a generic set?

MR. TINDER: No, we don't have a generic set that's used on anybody's reactivity control.

MR. WARD: Thank you.

MR. KERR: Thank you, Mr. Morrison.

Was that the presentation being made by Morrison and Tinder, Macrae and Tinder?

MR. WARD: Macrae and Tinder equal Morrison.

MR. TINDER: With some side comments.

MR. DICKSON: That concludes us unless you want an answer to how much movement there is in that piston.

MR. KERR: How long would it take to get such an answer?

MR. DICKSON: 30 seconds.

MR. LAWRENCE: The top end of the piston itself can move an inch, and the clearance between the tension rod and the tube that it runs in, as I indicated before, is a quarter inch. That is the maximum and it varies less than that in many cases. So the analysis shows that there isn't the standing way, there isn't enough room to set up on, and there just isn't any way to heat up, for it to drop out the bottom end.

MR. KERR: Thank you.

Mr. Stark?

MR. STARK: Richard Stark from the Staff again.

As I indicated earlier today, we have two groups represented today that are essentially identical to cover the material covered by the Applicant today. The first presenter will be Gerry Mauck from the Instrumentation and Control Systems Group. The second presenter will be Dave Moran from the Clinch River Project Office. So I would like to turn the meeting over to Gerry Mauck, who will give a more detailed indication of the status in his area.

MR. MAUCK: My name is Jerry Mauck. I am with the Instrumentation and Control Systems Branch. The thrust of my presentation is just to try to let you know where we have been with the Chapter 7 list and where we stand at the present time and where we are going in the future up to the final SER date.

We do have some consultants helping us with this. We have two engineers from EG&G Idaho. And they started with the Chapter 7 review at the end of November. They have devoted approximately full time in the Chapter 7 review.

We first got started with the review with a series of meetings that took place with Westinghouse and the applicant starting November 17. And as you see, we met on different subject matters for a total of seven meetings that took us through the end of February.

Shortly after that, we compiled a list or requests for information on 59 items that resulted from these meetings that we came, plus our review of the PSAR; that is, the NRC review and the EG&G review.

We transmitted these to the applicants on March 24. At that time, we were in the process of writing a draft construction permit SER that we did get written on August 24. And that draft SER contained 86 items that included the 59 above.

I should note that the majority of these were clarification or documentation of criteria. I should also note that the applicant had started to respond to these to the requests for information in sometime early June, but because of timing we could not factor his responses into the draft SER.

(Slide.)

The last item that has taken place in the past was a recent meeting that we had with the applicant and Westinghouse with regard to the 86 items that we had listed in this draft SER. As a result of this meeting, we felt at the present time that they had resulted in approximately 30 items that do remain under an active review.

(Slide.)

The next section of the presentation is just to give you a status of the review. The first note is that the review is being done in accordance with the Standard Review Plan. We have found that the same criteria is applicable in the instrumentation and control area for both the computer and the light-water reactors that we review. We are using consultants from EG&G of Idaho.

MR. KERR: I am sorry. You said you had found that the same criteria are applicable? Did you just stumble on this some way? How did you find this to be the case?

(Laughter.)

MR. MAUCK: Well, I guess as a result of the review of the PSAR and the meetings that were held with the applicant, we did not find any new or any new instrumentation that we felt could not be reviewed according to the guidelines that we had used for light-water reactors.

There is a set of Clinch River GDCs that are listed in Chapter 3, but most of those do apply to areas other than the INC area.

MR. KERR: I should conclude, therefore, that you considered the same standards of reliability to be appropriate for this reactor as has been the case for water reactors, for example?

MR. ROSSI: Well, basically, I think what Gary is saying, the review is being done according to reg guides IEEE 279 and that sort of thing without reliance on a quantitative reliability goal.

MR. KERR: I am not talking about quantitative reliability right now. Presumably, the rules were set up in order that one would, if one followed them, have a reliable plant. I do not think they are ends in themselves. If one uses the same criteria for review, it seems one is probably going to try to come out with about the same reliability.

I am trying to find out if the conclusion, if it just happened that way or if the decision was made that we would think about the same reliability ought to be required of this plant as has been required of the water reactor, hence we ought to use the same criteria.

MR. ROSSI: With one qualification. That is, that we do recognize the fact that they have the diverse trip systems, so we are basically applying our criteria to each of those trip systems and making a qualitative judgment.

MR. KERR: I am not talking for the time being now about what they have, but rather what your criteria were. What I think I am hearing is that you decided maybe in the course of your review that the same criteria were probably okay.

MR. ROSSI: I think that is a fair statement.

MR. KERR: What I was asking was is it implicit in that decision that you decided that about the same level of reliability is also appropriate? I am not trying to be critical, I am just trying to understand how you reached the conclusion.

MR. MORRIS: This is Bill Morris. There are two criteria that somewhat establish the overall reliability goal without having any particular reliability figure in mind. Those are the criteria for redundant diverse independent diverse shutdown systems and decay heat removal systems. They are fairly general criteria that establish a general goal.

I think what Jerery is talking about are the detailed criteria such as you would find in reg guides and IEEE 279 that provide the details of implementation of those broad criteria in an effective way. But I do not think he has been applying any particular criteria that could easily be related back to these broad criteria. I am not sure that I got that message across.

MR. KERR: What I am trying to find out -- and maybe it is not a proper question -- is whether the Staff, in thinking about this, decided, we would like to have about the same level of reliability for the system as we think we have been getting in water reactor systems; or if you decided, we are going to use the same criteria but we are going to get more reliability?

MR. MORRIS: I think it was intended in the development of these two criteria that I mentioned, that we would be aiming for somewhat better reliability. I think that there is a distinction in our minds with regard to the requirement for diverse and independent and redundant shutdown systems.

MR. KERR: The criteria that are applied to water reactors require that, too, do they not? It may be that the interpretation is different here than it is there, but the general criteria, as I understand them, do require two independent and diverse shutdown systems.

MR. MORRIS: I think we are still laboring with the exact wording of the principal design criteria. There was a letter that was written from Denise to Captain, dated May 6, 1976, in which these two principles, among others, were presented to the Department of Energy. The intent of those criteria, as we are now interpreting them, implies that the two shutdown systems will involve two independent diverse redundant shutdown systems, each of which acting independently is capable of mitigating anticipated occurrences in accidents.

To look at the criteria for shutdown systems for a light-water reactor, I do not think they say quite the same thing as the criteria for this plant. So there is a slight edge of difference there. If you look at the criteria for heat removal systems for light-water reactors, I think you will not see such a strong statement about independent redundancy and diversity as we have in our criteria.

MR. KERR: This is what I am trying to get at. It is your view that you are asking for a somewhat more reliable system, at least in these two areas?

MR. MORRIS: Yes.

MR. KERR: Thank you. Maybe I did not ask my question very well.

MR. MAUCK: Okay. Going on to examples of items that we consider important and that are now under active review. Item A, and I think we have already touched or someone has already touched on this today, is that we at this time feel that the primary and secondary shutdown systems should each individually meet IEEE 279.

Some of the areas that we are reviewing, IEEE 279, I do feel that this diversity at the present time we are looking at the fact that both systems do share the same power supplies. We are reviewing it with regard to a single failure and with regard to each, both primary and secondary shutdown systems should be separated from each other and from the control systems.

MR. KERR: Excuse me. Which two systems share the same power supply? The primary and secondary shutdown systems?

MR. MAUCK: Yes.

MR. KERR: You mean those guys came to you with a design like that and you did not scream at them or anything?

MR. MAUCK: We are looking at it now.

MR. KERR: There must be some reason for it. I need to look at it in more detail.

MR. MAUCK: And also as we touched base during the testing of the primary and secondary circuit systems, they did at that time each fail to meet IEEE 279. And manual initiation, we have looked at. Control in the protection system interaction is under review by the Staff at this time.

We have also questioned them on response times and are presently getting that area resolved.

MR. LIPINSKI: On the response time issue, we heard the primary system ends up with one set of damage limits and the secondary system ends up with a higher set. I believe that is due primarily to a longer response time on the system because the input parameters are not the same. Are you accepting that position?

MR. ROSSI: Bill, I believe you really ought to answer that one.

MR. MORRIS: Bill Morris, CRBR program office. We still have this under review, but we do not know just yet whether we find that acceptable.

MR. LIPINSKI: Maybe I will ask the project the question. Is it not because of additional response time on the secondary system that damage limit ends up being higher than the primary system?

MR. DICKSON: You are asking about the "chicken or the egg." You are saying we could not get the time, so therefore we changed the damage limit. No, that is not the case We set the criteria before the design.

MR. LIPINSKI: But you are getting higher temperatures as a result of running transients through the secondary system.

MR. DICKSON: Provided the response time and the first dollar are, in fact, all the way to the requirement. Yes, that is true, the temperatures will be slightly higher. You realize, of course, that the system is such that both systems should trip with every trip function signal, so that we would anticipate the failure of the primary to be a very rare thing and the secondary shutdown would be very uncommon and that additional damage is not going to add that much to the lifetime of the plant.

If I take 15 events such as the one I talked about where you run up in temperature and then trip down, 15 events a year, I would not expect very many of those, if any, in any given core life to also see the secondary system.

So it is not any worse than, say, one event that we put on as a natural circulation event. So from the standpoint of core damage, I think it is appropriate to do that.

The second factor you should be aware of, we are designing the system so that any time the secondary is tripped, it will cut off the power to the primary as well. So the probability of a secondary trip is quite small and quite acceptable, I think, from the standpoint of damage.

From the safety standpoint, both of those do not approach the safety limits. The upset in emergency are only core damage.

MR. LIPINSKI: I think the comparison between light-water, say, on an ATWS event where the control rods fail to respond, you do go to higher pressures and temperatures and put in boric acid, and the core is not damaged.

MR. DICKSON: Our core is not damaged either.

MR. LIPINSKI: You have a higher temperature.

MR. WARD: It really just affects the core lifetime.

MR. DICKSON: I can take that higher temperature degree once in a lifetime and the other many, many, many, many times. Neither is challenging a safety function. That is the point I am trying to make.

So that the probability of that higher temperature occurring because of the primary scram signal failing to respond is no higher than the probability of that total loss of all AC power. That also comes under that higher temperature. It is the same kind of category. So the core life can take it. It is not a safety function.

MR. KERR: Please continue.

MR. MAUCK: Okay. The next item is sensing lines. We are presently looking at the sensing lines with regard to protection from freezing. This includes sodium lines, lines full of water, and lines full of steam.

We are also looking at the sharing of common instrument lines or common instrument capsules.

(Slide)

The next item I have does not really follow with the agenda we have talked on today, but we have been doing a review on the direct heat removal system with regard to the portion being safety grade, the degree of separation from the steam generator auxiliary heat removal system, and the sharing of process parameters diversity, and the independence of that system.

The next item, the applicant talked on this, the remote shutdown system. We have given them the staff position with regard to remote shutdown systems where we do require redundant safety grade methods to shut the plant down remotely from the control room. We are close to having that review completed.

Okay. The next item is another system that we haven't touched on today, the steam generator auxiliary heat removal system. Again, we're looking at that with regard to the IE system being safety grade, meeting the single failure criterion, autoinitiation capability, fail safe analysis for various valves that they are claiming to fail in a safe position, the degree of diversity for that system and the testability.

The next item is source range monitors. This is presently looking at the need for providing source range trips to the protection system. Therefore, we are requiring the source range monitors to be safety grade. We are also looking at the need for an intermediate range to overlap the source range monitor.

MR. LIPINSKI: Is there currently a gap between source range?

MR. ROSSI: Only for one primary -- only for the primary trip system, I believe. So one of the trip systems has this overlap and lacks a trip down in the source range. The other trip system has the overlap, and I believe trips all the way up.

MR. LIPINSKI: They have the fission detectors, too.

MR. ROSSI: Right. But the primary system does not, and our question has to do with do you want to complete diversity between the primary and secondary to do the same kind of functions everywhere. That is part of our question.

MR. LIPINSKI: It seems like the terminology has been reversed in terms of the primary system giving the total information and the secondary system giving you second best.

MR. ROSSI: Here, the secondary system has a more complete coverage, as I understand.

(Slide.)

MR. MAUCK: The last item that I'm going to talk about is we have issued what we call a standard question on multiple control system failures. That would include power sources, common sensors, common hydraulic headers and common impulse lines with regard to these control systems and their failures.

MR. KERR: What sort of question does one ask? I guess I should have seen this.

MR. MAUCK: We have asked them to analyze multiple control system failures and to tell us whether after this is done, if the plant gets into any --

MR. KERR: Is that the way you asked the question, or did you say analyze specific points, or did you just say analyze multiple control systems?

MR. ROSSI: This is Ernie Rossi again. The basic question was if you had a concern where a single power source, a single hydraulic header was used for several control functions, our specific question has to do with the concern of the loss of the power supply. One loss of one power supply might affect several control functions simultaneously.

Our question is if that does happen and we do not that it does, would the transient be bounded by something that is covered in Chapter 15?

Now, in view of what we've seen today and as we think more about control systems, we may have a broader concern which we will probably pursue with the applicant over tying common or credible failures in the control system with what is analyzed in Chapter 15. This is sort of a subset of this concern.

MR. LIPINSKI: Was this carried out for Crystal River 3 events?

MR. ROSSI: This question we are currently asking on all near-term operating plants. It has to do in part with the Crystal River event, but it also has to do with a general concern on the unresolved safety issue that has to do with control systems.

MR. KERR: What sort of answer do you expect to get?

MR. ROSSI: The answer that we are getting on -- we haven't gotten an answer here yet, but the answer that I guess we require, not just expect to get, eventually is that single credible failures of power supplies that may affect several control functions simultaneously, that they have analyzed those kind of transients, and they've demonstrated they meet the appropriate criteria. That's the kind of answer we expect to get and will want.

MR. KERR: Thank you.

Is that the end of your presentation?

MR. MAUCK: No. I have one slide on future actions.

(Slide.)

What we presently have planned to take place between now and March are presently writing a revised draft CP SER to reflect the status of the review as it stands at the present time. We have slated that date for November the 1st. After the November 1st date we will be having future meetings with Westinghouse and the applicant to discuss the remaining issues, and will have a final CP SER to be written for publication March the 4th to reflect the status of the review at that time.

MR. KERR. Thank you.

Questions?

(No response.)

MR. KERR: What do you think of this instrumentation control system? Is it any good?

(Pause.)

MR. KERR: I'm going to ask you a question. I go out and talk to groups. They invariably ask me would you be willing to live next door to this nuclear power plant. I'm going to ask you. Having seen this control system, would you be willing to live next door to the CRBR?

MR. MAUCK: I don't think I've had any

problems with that at the present time.

MR. ROSSI: When we finish our review we will be definitely willing to live next to it.

(Laughter.)

MR. WARD: Are you going to ask Ebersole that?

(Laughter.)

MR. KERR: Who's next, Mr. Stark?

MR. MORAN: Good afternoon. My name is David Moran. I am assigned to the Clinch River Breeder Reactor Program Office, NRC. I am going to talk very briefly about the review of control rod systems that is ongoing and try to give you a thumbnail idea of what we are doing and the actions that are underway.

(Slide.)

We are at this time for this particular safety evaluation reviewing the criteria, principally the criteria presented by the applicant, to determine whether it is appropriate and complete.

Now, because of the status of the Clinch River breeder reactor project itself -- it's gone on for a long time; there's a lot of hardware that's been built, a lot of tests that have been completed -- so we are also looking at the design itself. In some cases it's in pretty good detail.

We are looking at the acceptability of the design.

(Slide.)

We have had quite a few meetings with the applicant, with Westinghouse, and with General Electric. We have gone to Walt's Mill. We have gone out to GE in Sunnyvale, in San Jose, and discussed with the designers the details of the control rod system. We've looked at the test setup. We've looked at test hardware. And in some cases we've gone into detail of certain aspects of the design.

MR. KERR: What do you want the systems to do?

MR. MORAN: We want them to respond on command.

MR. KERR: With zero probability of failure?

MR. MORAN: We are looking at the -- I'm principally talking about the mechanical review of the control rod system.

MR. KERR: You're carrying out a view with the idea that when you get through something, it will do something. What is it you want it to do?

MR. MORAN: At the present time we are looking at the criteria that the applicant is following. We at this time are looking to see if that is appropriate.

MR. KERR: Is it your view that if the applicant has followed his criteria the control rods will do what you want them to do?

MR. MORAN: Well, the design should be guided by these criteria. Then the testing and design results --

MR. KERR: You see, I'm interested in performance. The criteria are a means to an end. The end is performance. It seems to me before you write criteria or before you examine criteria you have to decide what it is you want the thing to do. That is what I'm trying to get at. How have you gone about deciding what you want these systems to do?

MR. MORAN: Well, the criteria lead to performance requirements. We are evaluating the designs, evaluating the test results as they are coming out to determine if they meet the performance requirements.

MR. STARK: Let me take another crack at it. Before I think Dr. Morrison indicated that we wanted two independent, diverse shutdown systems that act very quickly. So what we are looking at --

MR. KERR: Let me ask, do you want them to be more reliable than the systems in water reactors, about equally reliable, not as reliable?

MR. STARK: The fact that we want two independent, diverse, fast actor systems says we are asking for more than in light-water reactor systems. So we're asking for them to be more reliable and that either one can do the job.

MR. KERR: You want the individual systems to be more reliable as individual systems, individual rod drives, or have you decided? I'm not trying to be critical of this thing, believe me.

MR. STARK: The combination of the two systems makes them more reliable. We're taking two very reliable systems and making them independent and diverse with the hope that the combination will, of course, be even more reliable than a light-water plant.

MR. KERR: So can I interpret what you're saying as suppose that I have a drive that individually is about as reliable as water reactor drives in the new environment and so on. Now, I take those drives and I construct two separate systems from them. When I get through I ought to have a total system that is more reliable than a single system.

MR. STARK: That's the intent, yes, that the common mode failures that might apply to one system would tend not to apply to the other, so it would be a benefit.

MR. KERR: So you're not looking for a degree of reliability from the individual component that is maybe about the same as you have been seeing in water reactor drives. You expect that you will get overall system performance which is somewhat better, is that right?

MR. STARK: That's correct. Let me put it another way. By using what Jerry Mauck indicated before, by using the techniques we used on the light-water plants, we will assure ourselves that for that we're getting at least comparability to a light-water review by requiring additional systems that do the same thing. So we feel we're getting an enhancement or an improvement beyond that.

MR. KERR: But at this point if you had to quantify that improvement, you might have some difficulty.

MR. STARK: That's correct.

MR. KERR: Thank you. I apologize for not making my question clearer.

(Slide.)

MR. MORRIS: We are following a standard review plan. These are the sections which are appropriate to the control rod systems.

(Slide.)

I'll give you some examples here of the areas under a fairly intensive review at this time. The secondary control rod hydraulic impulse scram assist force is being reviewed. We have concern that the -- about the amount of force that is imparted by the impulse and the length of time that is imparted and whether it is sustained for a long enough period of time for the scram to be really advertised as a scram assist. We have gravity working for us, but we simply want to go into that in detail, so we're looking at that.

The next item is the possibility of the primary control rod drive system stepper rod driving out a control rod inadvertently. Now, that was discussed today, and we have asked for information that will allow us the details of the stepper motor design so we can determine for ourselves what has been discussed today and put forth as a fact.

The secondary control rod latching mechanism and strength are being reviewed. This is the determination of whether the stress analysis on the fingers of the latch has been sufficient, looking at the self-welding, those things. We are picking out specific pieces of the control rod mechanisms which are of concern to us, and looking at them, several of them, in this kind of detail.

The secondary control rod testable scram valve function and design are being reviewed. This had to be redesigned after some of the tests were underway, and we haven't had reports come through yet on what the new design has done to improve the testable scram valve and what the tests have been after the new design, if they've indeed been completed.

The last item, the seismic classification and testing of primary and secondary systems are being reviewed. The kinds of things we're concerned about are the actual tests for the secondary rod: are they similar, are they being run in a similar manner to the primary rod? I'm talking about the test facility, the type of physical testing that is going to be done to prove out the systems when they are classified to be seismically capable of seismic events.

(Slide.)

Lastly, I wanted to give you an idea of the design -- the principal criteria which we are looking at and which we are using as entry points to evaluate the applicant's design and performance criteria which should in all cases stem from these.

This is our entry point. Then we go on into detail as these come out in the PSAR and in briefings on control rod mechanisms as a result of our meetings and questions.

That's all I have, gentlemen. If you have any questions, I'll be glad to answer them.

MR. KERR: Are there questions?

(No response.)

MR. KERR: Mr. Ward?

MR. WARD: No.

MR. KERR: Let me thank all of you who have participated today. I think this will be the first of several meetings. And I guess it's up to us to tell you at least what we would like to hear further and for you to tell us what you would like to tell us if we haven't heard, if there isn't an overlap between the two.

Among the things that I would be interested in hearing are at least some of the things that I have mentioned today that I need some more literature on before I ask an intelligent question. But I am curious as to what the current status of "reliability" is in the review process, and I probably will learn that when I get the up-to-date supplement.

I would also like to learn more than I know about the changes in the system that have resulted from TMI-2. I am very much interested -- I didn't hear very much about it today -- in what has been done to try to decrease the contribution of human error. Maybe the answer is a whole lot -- I don't know -- but it has received enough attention that I am sure it has gotten enough attention from you and you've either decided that it wasn't important, or you've taken care of it, or whatever. Those are some of the things that occur to me.

Dave, do you have any additional topics that you can think of at this point?

MR. WARD: Not at this point.

MR. KERR: Walt?

MR. LIPINSKI: No.

MR. KERR: Okay. Dick and I will get together, and Dick will be getting in touch with you. You may want to talk to Dick about things that you think we should hear.

Are there any additional comments that you want to make?

Mr. Dickson?

MR. DICKSON: I just wanted to comment on one thing relative to your reaction that it seemed as though the secondary trip was used -- that the secondary was the primary trip in that it had the wide range. I admit that sounds goofy, but when you think about it, when the power range is off-scale, you're below a megawatt. You're somewhere between zero power to critical to startup. If you did have a need for a trip at that point, you want to trip the secondaries because they're full out, and the primaries are anywhere from bottom to just coming out. That is why it was done that way.

It is independent of the question that NRC has: is it appropriate to have those two hook up separately and not have complete overlap? But that's why you choose that, assuming you can do that separation, you assume in that order.

MR. LIPINSKI: The big question is what's on the console that guides the operator as he goes through the power change, because that's really where you discuss instrument overlap, where you're taking the reactor up manually from source level into the power range, and the operator has to do manual manipulations. He has the total information in front of him. That's all that's important.

MR. ROSSI: I don't think that's a problem. The other concern that I have about going up from source range to the power range is that when you start to pull the rods, you have a trip from a range where you see a live indication when you're pulling the rods, and they don't have that in the primary trip system at this time. They still have the trip on the power range if you have an accident, but I'm a little concerned about the fact that you can't tell -- I mean all the detectors in the power range could be disconnected, and the guy wouldn't know it until he gets up into the power range and finds out it is not reading.

So I like to see a system where you have a source range trip and you start pulling rods, and you know that the source range detectors are working and most of the electronics are working because you can see a live indication there. As you get up then into the intermediate range where you're sure it's working and you have a signal, there you take out the source range trip and you rely on the intermediate range until you get up to where the power range is indicated.

MR. LIPINSKI: That's a single channel, but if I have two channels side by side, I have the ability to track power.

MR. KERR: I'm going to let you two guys get together in separate rooms and design the system.

MR. ROSSI: They don't have it in the primary.

MR. KERR: Thank you again. The meeting is adjourned.

(Whereupon, at 6:50 p.m., the meeting was adjourned.)

NUCLEAR REGULATORY COMMISSION

This is to certify that the attached proceedings before the

____

in the matter of: ACRS/Clinch River Breeder Reactor Working Group on Systems Integration

Date of Proceeding: September 30, 1982

Docket Number: ______________________

Place of Proceeding: Washington, D.C.

were held as herein appears, and that this is the original transcrip thereof for the file of the Commission.

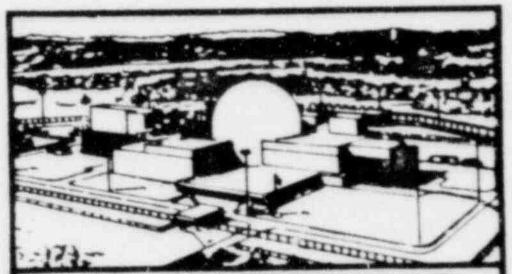
Jane N. Beach

Official Reporter (Typed)

Jane N. Beach

Official Reporter (Signature)

CLINCH RIVER BREEDER REACTOR PLANT



CRBRP PROJECT

PLANT PROTECTION AND INSTRUMENTATION AND CONTROL

BRIEFING FOR

ADVISORY COMMITTEE ON
REACTOR SAFEGUARDS (ACRS)
WORKING GROUP ON SYSTEMS
INTEGRATION AND INSTRUMENTATION
AND CONTROL

SEPTEMBER 30, 1982

T1

BRIEFING ON

CRBRP PLANT PROTECTION AND INSTRUMENTATION AND CONTROL

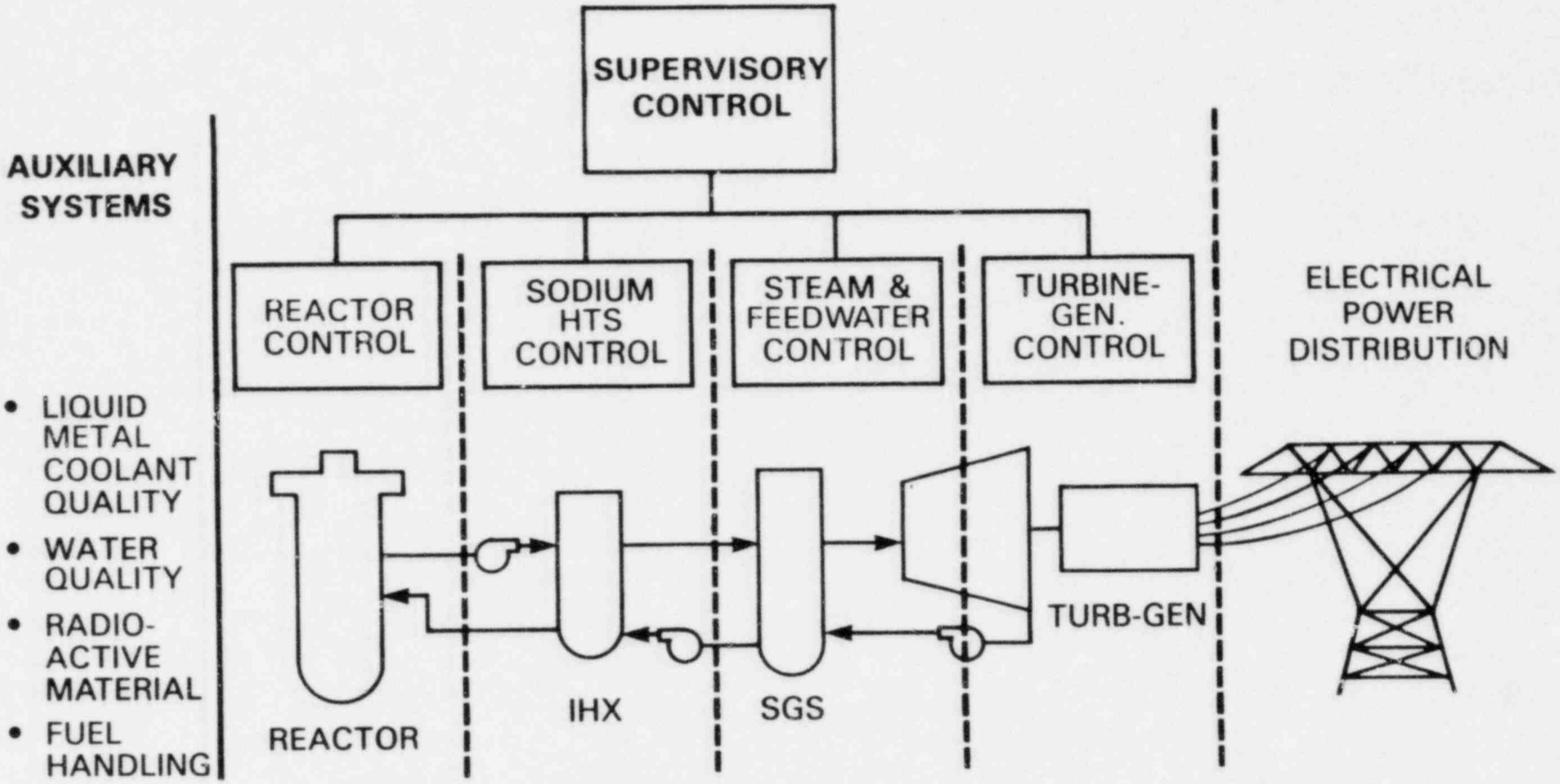
FOR THE
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WORKING GROUP ON SYSTEMS INTEGRATION AND
INSTRUMENTATION AND CONTROL

WASHINGTON, DC
SEPTEMBER 30, 1982

AGENDA

• INTRODUCTION	P.W. DICKSON
• REACTIVITY CONTROL	D. DONCALS
• REACTOR CONTROL MECHANISMS	
– PRIMARY CONTROL ROD SYSTEM	G. SMITH
– SECONDARY CONTROL ROD SYSTEM	R. LAWRENCE
• PLANT CONTROL/PLANT PROTECTION SYSTEM	
– PLANT CONTROL SYSTEM	R. TINDER
– PLANT PROTECTION SYSTEM	G. MACRAE
– CONTROL SYSTEM/ PROTECTION SYSTEM INTERACTIONS	G. MORRISON

CRBRP CONTROL FUNCTIONS



SUPERVISORY CONTROL

AUXILIARY SYSTEMS

- LIQUID METAL COOLANT QUALITY
- WATER QUALITY
- RADIO-ACTIVE MATERIAL
- FUEL HANDLING

REACTOR CONTROL

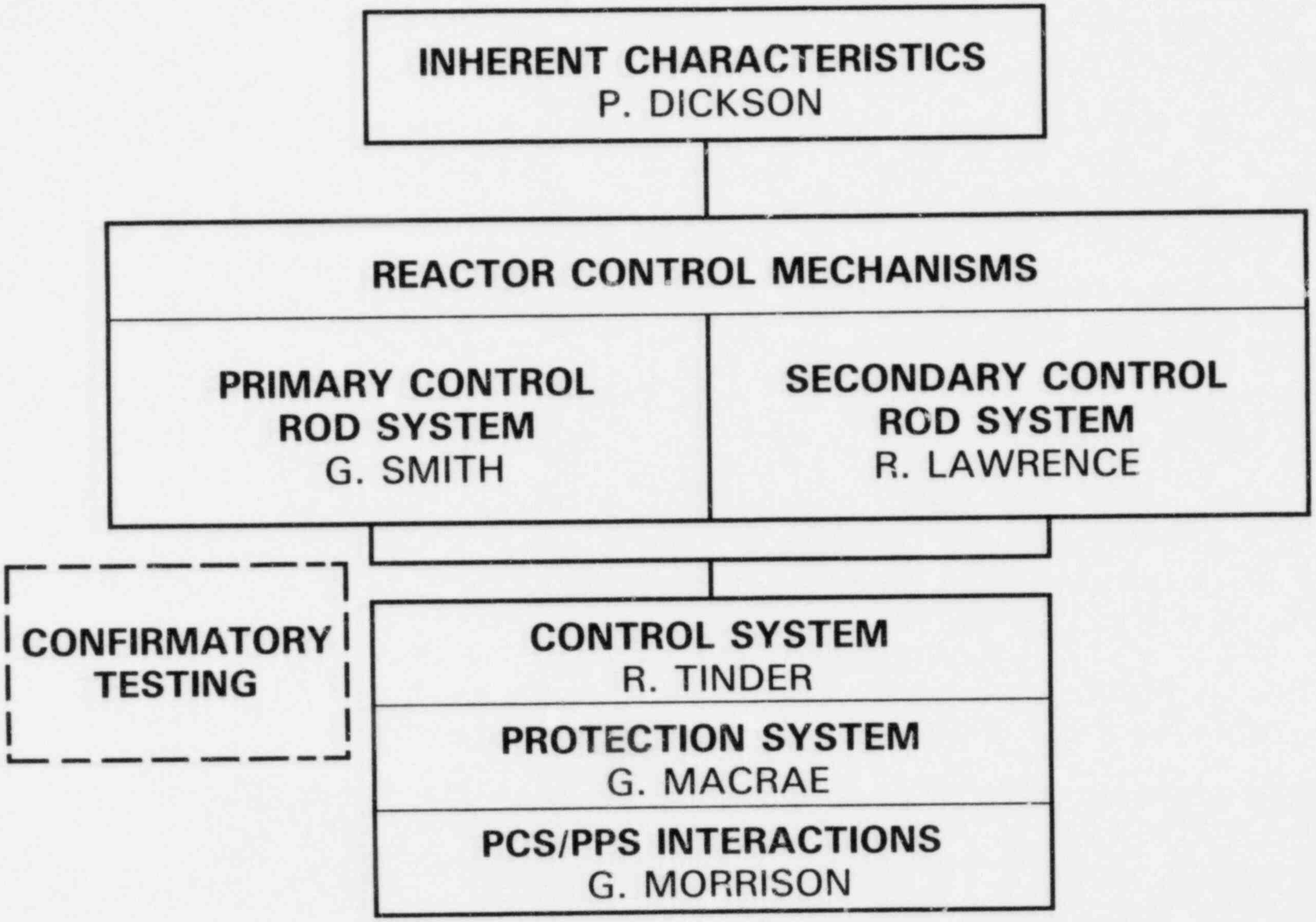
SODIUM HTS CONTROL

STEAM & FEEDWATER CONTROL

TURBINE-GEN. CONTROL

ELECTRICAL POWER DISTRIBUTION

CRBRP REACTOR CONTROL



INHERENT CHARACTERISTICS
P. DICKSON

REACTOR CONTROL MECHANISMS

PRIMARY CONTROL ROD SYSTEM
G. SMITH

SECONDARY CONTROL ROD SYSTEM
R. LAWRENCE

CONFIRMATORY TESTING

CONTROL SYSTEM
R. TINDER

PROTECTION SYSTEM
G. MACRAE

PCS/PPS INTERACTIONS
G. MORRISON

CRBRP PLANT PROTECTION AND INSTRUMENTATION AND CONTROL

BRIEFING FOR

ADVISORY COMMITTEE ON
REACTOR SAFEGUARDS (ACRS)
WORKING GROUP ON SYSTEMS
INTEGRATION AND INSTRUMENTATION
AND CONTROL

INTRODUCTION

PRESENTED BY:

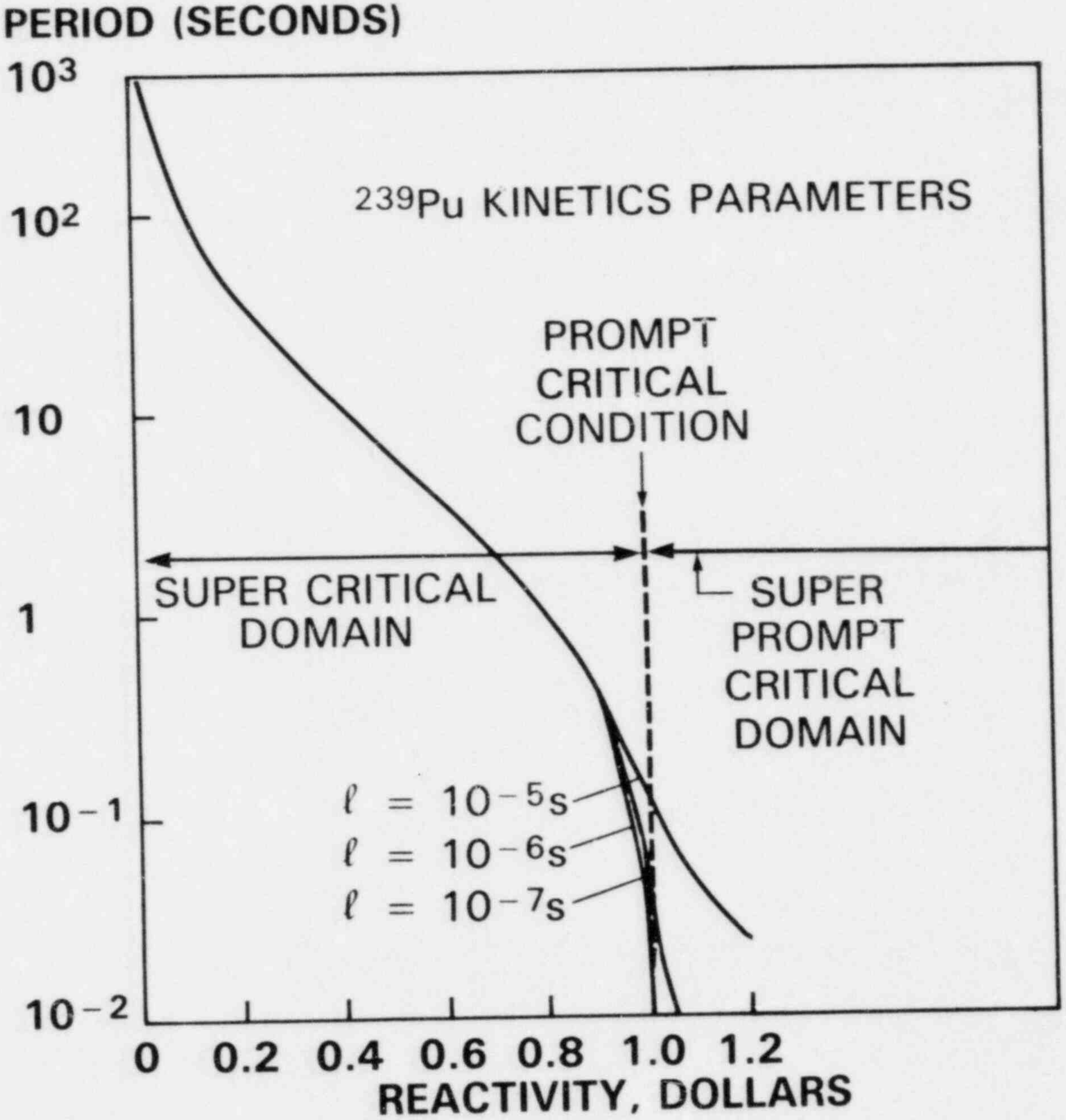
P.W. DICKSON
TECHNICAL DIRECTOR
WESTINGHOUSE–OR
CRBRP PROJECT

SEPTEMBER 30, 1982

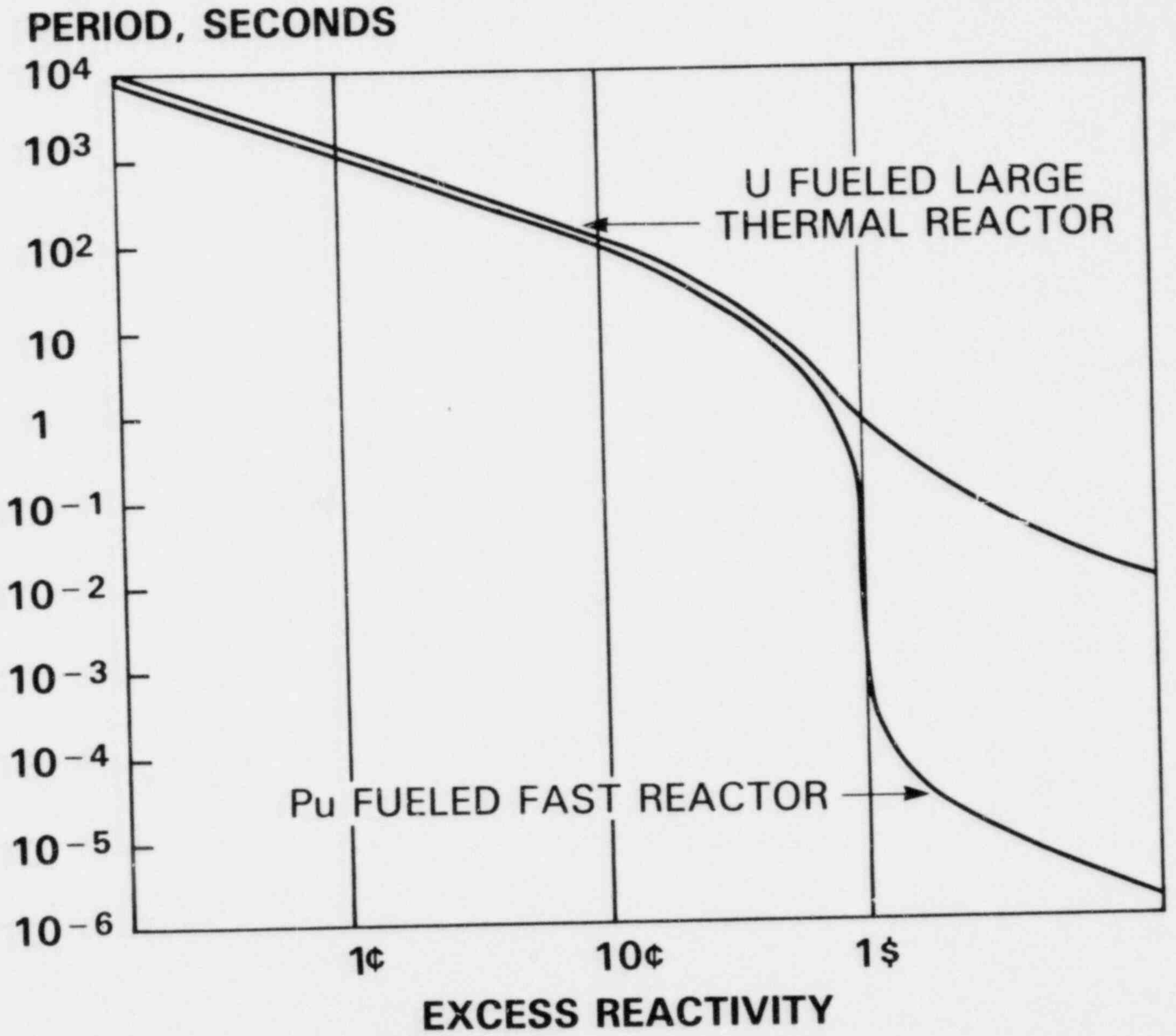
COMPARISION OF CRBRP VS TYPICAL LWR

	CRBRP	TYPICAL LWR
• CORE POWER TRIP POINT	115%	118%
• DELAY TIME FROM TRIP TO START OF ROD MOTION	0.2 SECONDS	0.5 SECONDS
• TIME TO INSERT 1$ NEGATIVE REACTIVITY	0.31 SECONDS	1.4 SECONDS

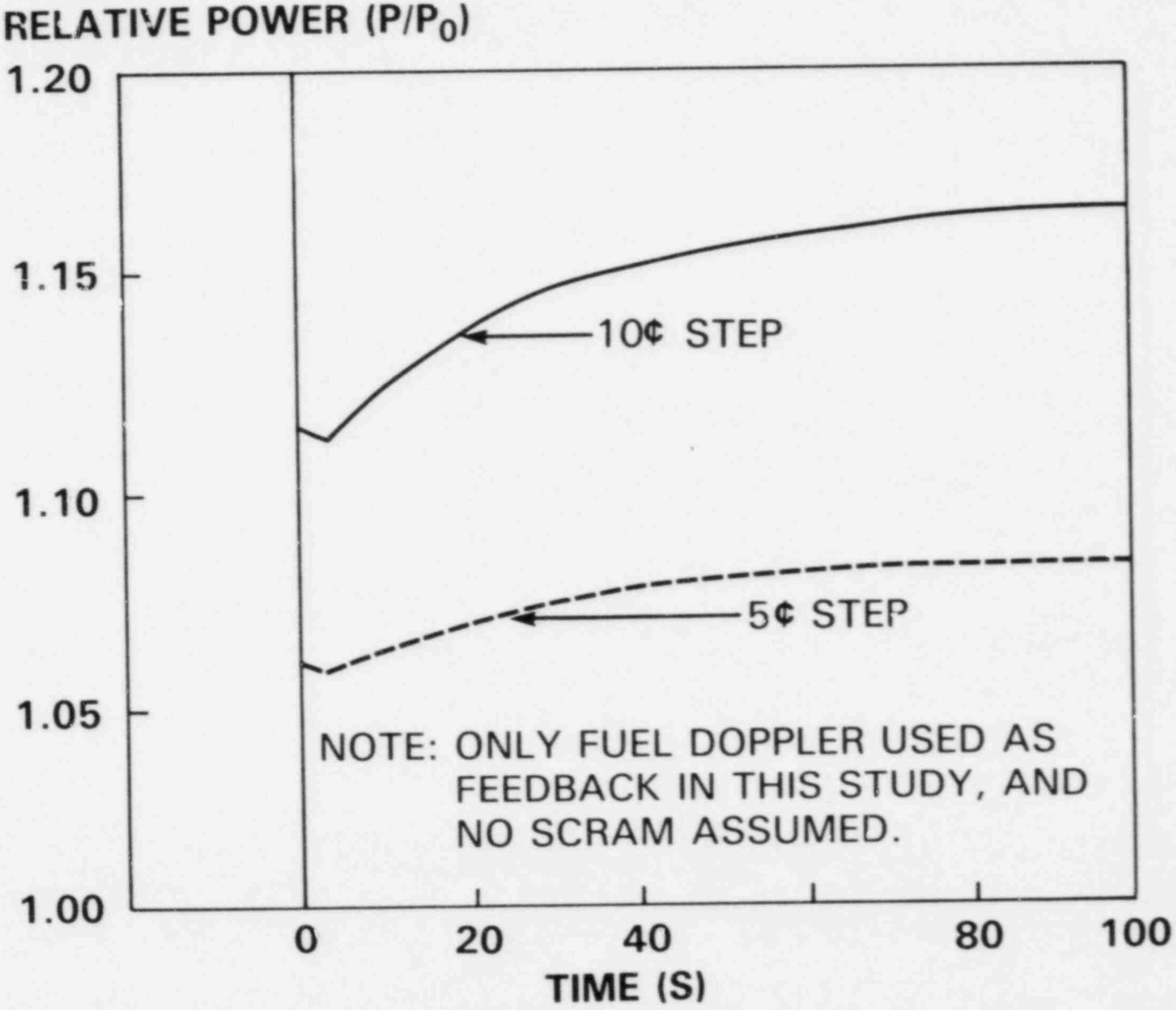
REACTOR PERIOD VS REACTIVITY



ASYMPTOTIC PERIOD VS EXCESS REACTIVITY



POWER VS TIME, SMALL STEP REACTIVITY INSERTION



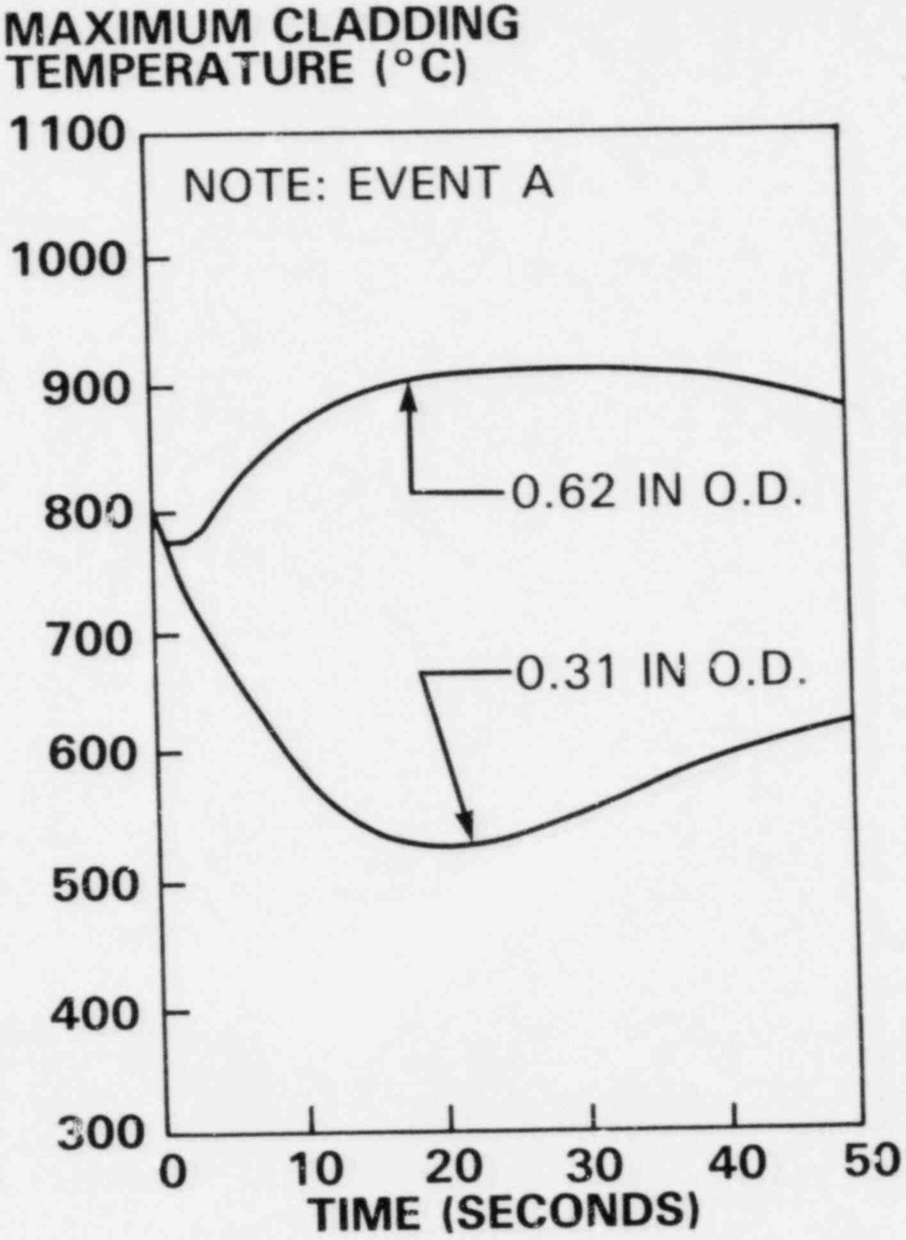
LMFBR TYPICAL LIMITING EVENTS ASSUMED AND TYPICAL LIMITS

EVENT	CATEGORY	TYPICAL LIMIT
A. 115% OVERPOWER FOR 300 SECONDS FOLLOWED BY A SCRAM	UPSET	1500°F CLADDING TEMP
B. LOSS OF ALL AC POWER, COAST DOWN TO NATURAL CIRCULATION	EMERGENCY	1600°F CLADDING TEMP
C. SEISMICALLY INDUCED LOSS OF POWER, 60^{c} STEP INSERTION, AND RETARDED CONTROL ASSEMBLY SCRAM	FAULTED	NO SODIUM BOILING

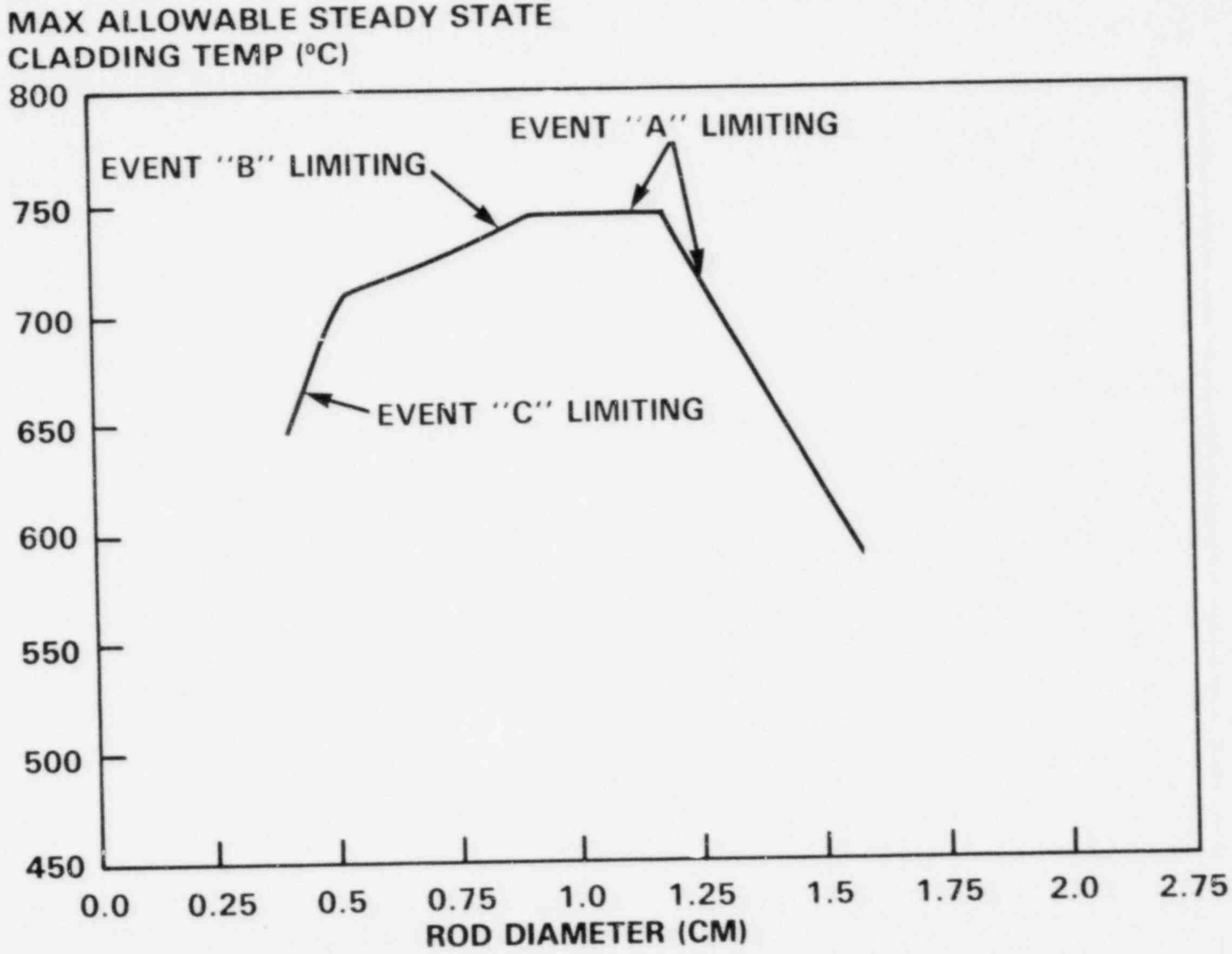
BREEDER INHERENT CHARACTERISTICS

- LOW Cp COOLANT
- LARGE CORE ΔT
- DIFFERENT SIZE BLANKET AND FUEL RODS

TYPICAL MAX. CLADDING TEMPERATURE VARIATION



TYPICAL TRANSIENT LIMIT ENVELOPE



SUMMARY

- PUMP COASTDOWN MUST BE FAIRLY RAPID TO AVOID THERMAL SHOCK OF UPPER INTERNALS STRUCTURES, BUT IS DESIGN DEPENDENT
- CONTROL ROD F INSERTION RATE REQUIREMENT EVEN MORE DESIGN DEPENDENT, BUT IS FAIRLY RAPID FOR CRBRP

STARTUP PROCEDURE

- Na FLOW IS INCREASED FROM ~10% TO 40%.
- SIX SECONDARY CONTROL RODS AND THREE PRIMARY CONTROL RODS ARE FULLY RETRACTED
- REMAINING SIX PRIMARY RODS ARE THEN RETRACTED TO BRING THE REACTOR CRITICAL AND INCREASE POWER TO 40%.
- POWER TO FLOW RATIO IS THEN UNITY. IT IS MAINTAINED UNITY FOR ALL POWER LEVELS FROM 40% to 100%.

PHYSICS FEATURES RELEVANT TO CRBRP CONTROL AND PROTECTION SYSTEMS

ACRS WORKING GROUP MEETING AT WASHINGTON, D.C.

September 30, 1982

by

R. A. Doncals

WESTINGHOUSE ELECTRIC CORPORATION
Advanced Reactors Division
Madison, Pennsylvania 15663

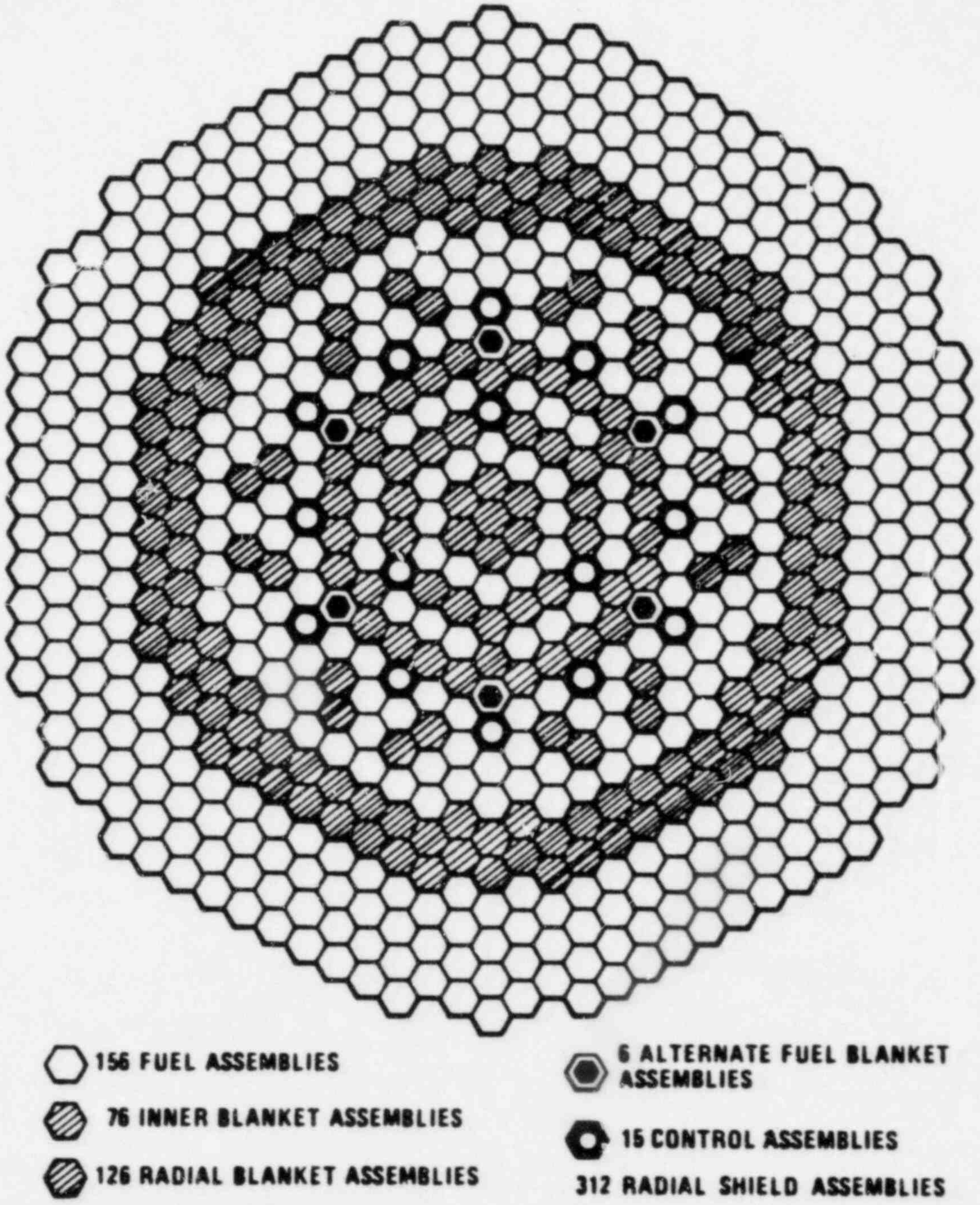
T2

OUTLINE

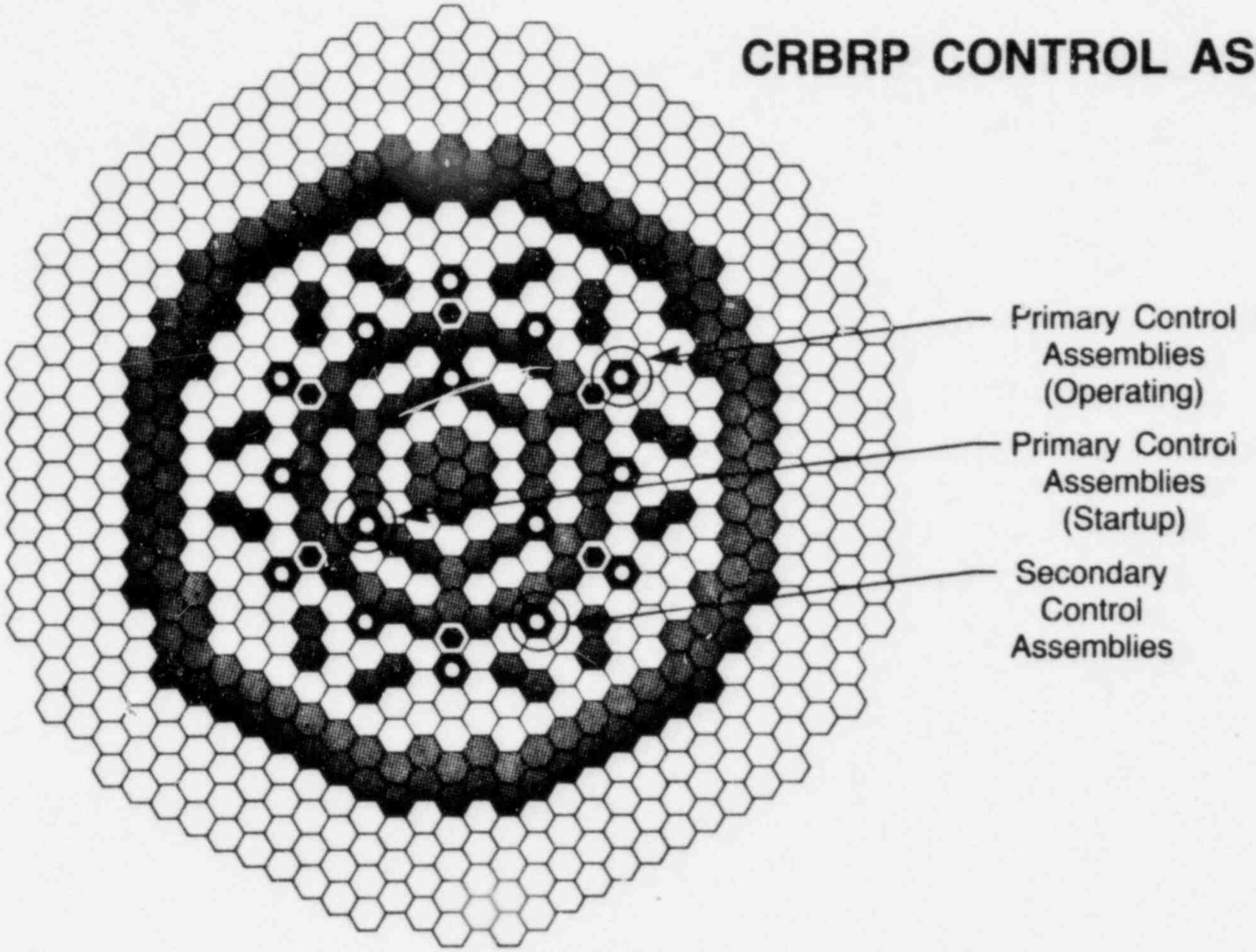
- Control assembly locations and operating history
- Design basis and criteria
- Control assembly worths versus requirements
- Rod withdrawal reactivity insertion rates
- Shutdown worths from hot-full power

CONTROL ASSEMBLY LOCATIONS AND OPERATING HISTORY

CLINCH RIVER BREEDER REACTOR CORE LAYOUT



CRBRP CONTROL ASSEMBLIES



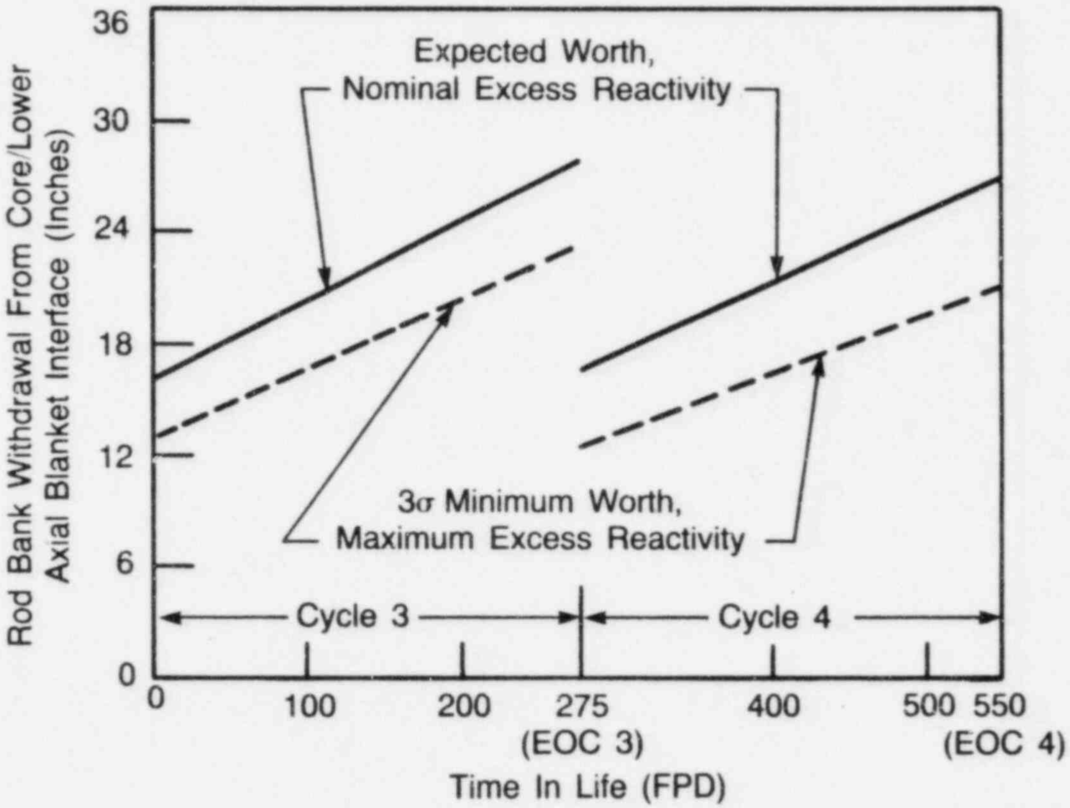
Primary Control Assemblies (Operating)

Primary Control Assemblies (Startup)

Secondary Control Assemblies

Ⓦ Advanced Reactors Division

ROW 7 CORNER CONTROL ROD BANK WITHDRAWAL HISTORY CORE TWO (CYCLES 3&4)



DESIGN BASIS
AND
CRITERIA

Ⓦ Advanced Reactors Division

CRBRP AND REACTIVITY CONTROL PROTECTION REQUIREMENTS

Appendix A to Title 10, Part 50 of Code of Federal Regulations as interpreted for CRBRP in Section 3.1 of the PSAR.

- Protection system requirements for reactivity control malfunctions (Criterion 23)
- Reactivity control system redundancy and capability (Criterion 24)

CONTROL ASSEMBLY WORTHS VERSUS REQUIREMENTS

CONTROL ROD WORTH REQUIREMENTS

Primary control system

- Shut the reactor down from hot full power to zero power at the hot shutdown temperature
- Compensate for excess reactivity loaded in the fuel enrichments for burnup and operational requirements as well as for criticality, reactivity feedback, refueling worth and other uncertainties
- Allowance for the maximum reactivity fault associated with any anticipated occurrence (postulated to occur upon the accidental withdrawal of the highest worth control rod inserted in the reactor)
- Assume failure of any single active component (highest worth control rod stuck)

Secondary control system

- Shut the reactor down from hot full power to zero power at the refueling temperature
- Allowance for the maximum reactivity fault
- Assume highest worth rod stuck

SECONDARY CONTROL SYSTEM REACTIVITY REQUIREMENTS AND WORTHS (%ΔK/K)

	BOC1	EOC1	BOC2	EOC2
Requirements				
Hot-to-cold	1.05 ± .37	0.99 ± .37	0.97 ± .36	1.08 ± .39
Reactivity "fault"	0.72 ± .25	0.33 ± .19	0.79 ± .28	0.20 ± .22
Control Worths				
6R7F	4.49	4.62	4.68	4.78
Stuck rod	-1.67	-1.93	-1.95	-1.99
	2.62 ± .31	2.69 ± .32	2.73 ± .33	2.79 ± .33
Balance				
(Worth-requirement ± 3σ uncertainty)	0.85 ± .46(3σ)	1.37 ± .47(3σ)	0.97 ± .49(3σ)	1.51 ± .51(3σ)

SECONDARY CONTROL SYSTEM REACTIVITY REQUIREMENTS AND WORTHS (%ΔK/K)

	BOC3	EOC3	BOC4	EOC4	BOC5
Requirements					
Hot-to-cold	1.02 ± .36	1.06 ± .38	1.00 ± .37	1.11 ± .39	1.02 ± .36
Reactivity "fault"	0.95 ± .30	.16 ± .19	0.95 ± .37	0.18 ± .28	1.00 ± .29
Control Worths					
6R7F	4.27	4.56	4.63	4.72	4.37
Stuck rod	-1.78	-1.90	-1.77	-1.34	-1.82
	2.49 ± .30	2.66 ± .32	2.86 ± .34	3.38 ± .41	2.55 ± .31
Balance					
(Worth-requirement ± 3σ uncertainty)	0.52 ± .46(3σ)	1.44 ± .48(3σ)	0.91 ± .55(3σ)	2.09 ± .51(3σ)	0.53 ± .47(3σ)

PRIMARY CONTROL SYSTEM REACTIVITY REQUIREMENTS AND WORTHS (%ΔK/K)

	BOC1	EOC1	BOC2	EOC2
Requirements				
Hot-to-cold	0.74 ± .33	0.67 ± .33	0.66 ± .32	0.77 ± .35
Excess reactivity	2.95 ± .63	1.59 ± .66	3.17 ± .70	1.04 ± .85
Reactivity "fault"	0.72 ± .25	.33 ± .19	0.79 ± .28	0.20 ± .22
Control Worths				
6R7C	6.27 ± .77	6.04 ± .74	6.35 ± .78	5.94 ± .73
3R4	1.63 ± .20	1.95 ± .24	1.94 ± .24	2.42 ± .30
Stuck rod	-1.68 ± .41	-1.99 ± .35	-1.64 ± .43	-2.08 ± .36
Balance				
(Worth-requirement ± 3σ uncertainty)	1.81 ± .98(3σ)	3.41 ± 1.01(3σ)	2.03 ± .106(3σ)	4.27 ± 1.60(3σ)

PRIMARY CONTROL SYSTEM REACTIVITY REQUIREMENTS AND WORTHS (%ΔK/K)

	BOC3	EOC3	BOC4	EOC4	BOC5
Requirements					
Hot-to-cold	0.70 ± .32	0.74 ± .34	0.70 ± .32	0.81 ± .34	0.70 ± .32
Excess reactivity	3.57 ± .63	0.85 ± .77	3.61 ± .87	1.00 ± 1.15	3.73 ± .63
Reactivity "fault"	0.95 ± .30	0.16 ± .19	0.95 ± .37	0.18 ± .28	1.00 ± .29
Control Worths					
6R7C	6.13 ± .75	5.75 ± .71	6.29 ± .77	5.72 ± .70	6.25 ± .77
3R4	1.44 ± .18	2.06 ± .25	2.16 ± .26	2.72 ± .33	1.55 ± .19
Stuck rod	-1.40 ± .45	-2.04 ± .33	-1.46 ± .50	-1.92 ± .39	-1.40 ± .45
Balance					
(Worth-requirement ± 3σ uncertainty)	0.95 ± .95(3σ)	4.02 ± 1.09(3σ)	1.73 ± 1.19(3σ)	4.53 ± 1.43(3σ)	0.97 ± 0.97(3σ)

ROD WITHDRAWAL REACTIVITY INSERTION RATES

SINGLE ROD WITHDRAWAL REACTIVITY INSERTION RATES

Rod Withdrawal Speed	Reactivity Insertion Rate
9 Inches/Minute (Maximum Operational Speed)	2.3¢/Sec.
73 Inches/Minute* (Maximum Mechanical Design Limit)	18.5¢/Sec.

*Prototype tests indicate speed less than 45 inches/minute

PRIMARY AND SECONDARY SHUTDOWN WORTHS FROM HOT-FULL-POWER

CRBRP PRIMARY AND SECONDARY SCRAM SHUTDOWN WORTH FROM HOT-FULL-POWER MINIMUM SHUTDOWN CONDITIONS (%ΔK/K)

(3σ Maximum Excess Reactivity And Minimum Control Rod Worth)

Time In Life	Stuck Rod	Primary Control System R7C Bank Insertion (Inches)	R7C Shutdown Worth (%ΔK/K)	R4 Shutdown Worth (%ΔK/K)	Secondary Control System R7F Shutdown Worth (%ΔK/K) With 1 Rod Stuck Full Out
BOC1	1R4, full out	20.2	2.27	.90	2.87
	1R7C, partly in		1.75	1.43	
BOC2	1R4, full out	21.1	2.08	1.08	2.99
	1R7C, partly in		1.62	1.70	
BOC3	1R4, full out	23.3	1.50	.80	2.73
	1R7C, partly in		1.19	1.26	
BOC4	1R4, full out	23.7	1.47	1.21	2.96
	1R7C, partly in		1.17	1.90	
EOC4	1R4, full out	15.1	3.33	1.51	3.02
	1R7C, partly in		2.41	2.39	
BOC5	1R4, full out	23.6	1.46	.86	2.79
	1R7C, partly in		1.17	1.36	

SUMMARY

- The CRBRP primary and secondary control systems are designed to meet design requirements using pessimistic assumptions about the maximum reactivity fault and the stuck rod criteria
- Conservative values of the resulting shutdown reactivity worths are used in the evaluation of primary and secondary control rod scram reactivity insertion requirements

PRIMARY CONTROL ROD SYSTEM

Mechanical Functions of PCRS

1. Control Function

   Move control assemblies to control power

2. Negativity Reactivity Insertion

   Scram response to signal from PPS system

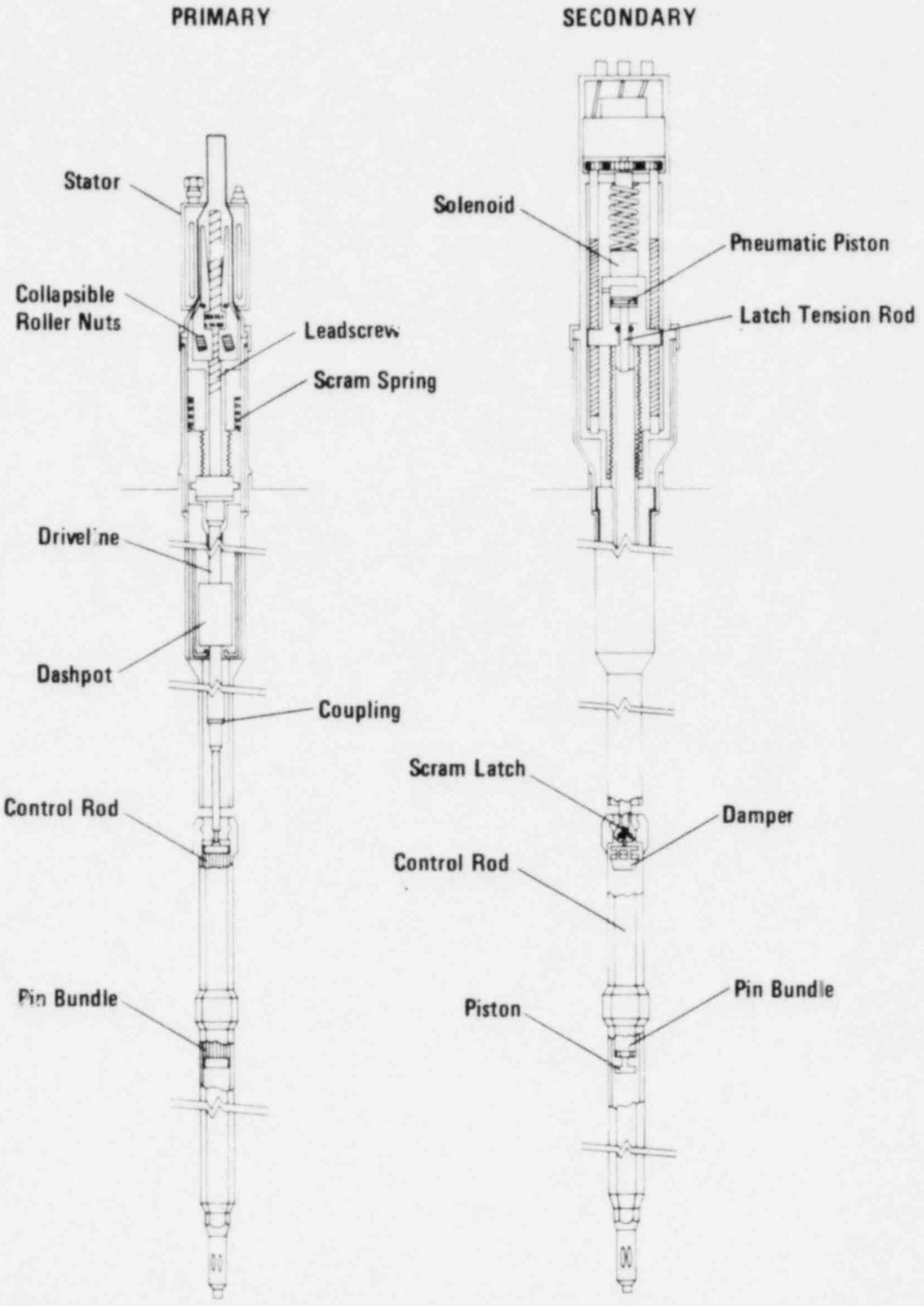
Smith
T4

[illegible]


SECONDARY CRDM
SOLENOID/ SCRAM VALVES
CRDM SUPPORT NOZZLES
TENSION ROD
CRDM SHIELDING & SEISMIC SUPPORT
DRIVELINE SHROUD TUBES
UPPER INTERNALS STRUCTURE
COUPLING FOR REFUELING
UPPER INTERNALS STRUCTURE KEYWAYS
CORE FORMER RING
SCRAM RELEASE LATCH
SECONDARY CONTROL ROD (ABSORBER PINS)
PISTON
INLET MODULES

ARD

CONTROL ROD SYSTEMS COMPARISON

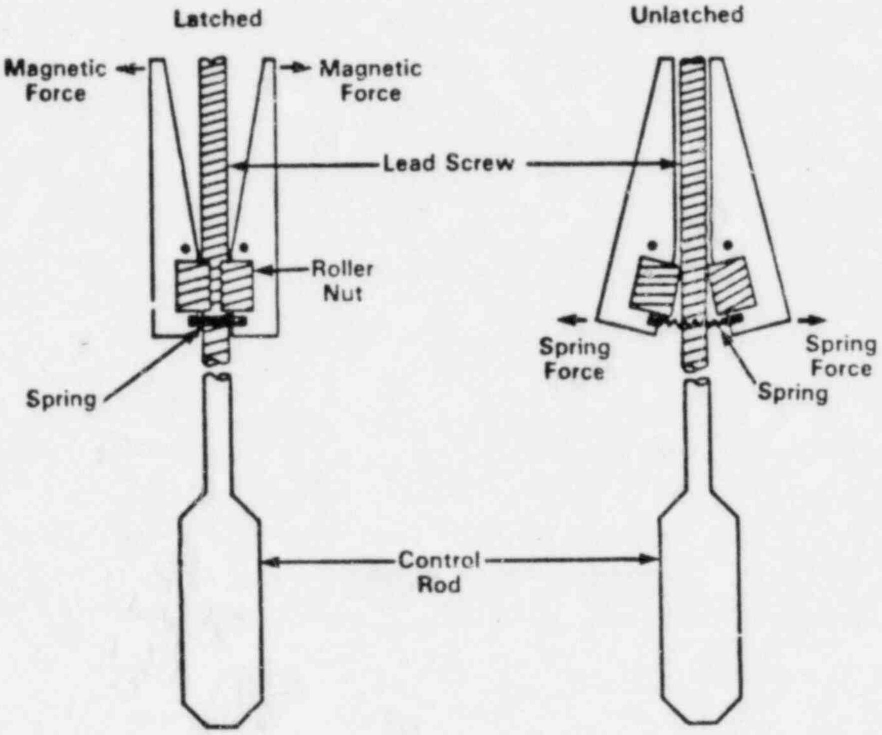


7063-73

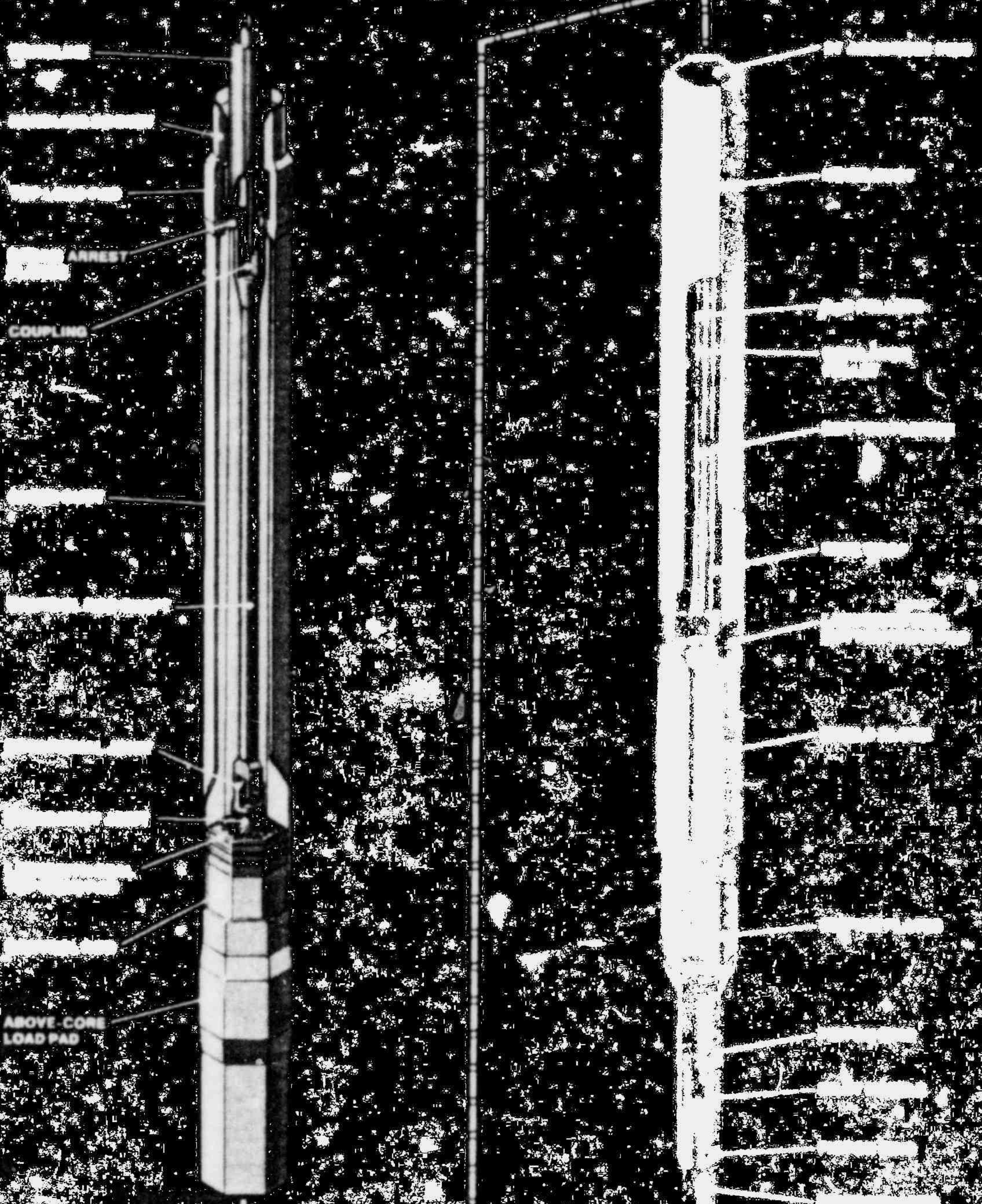
ARD

PRIMARY CONTROL ROD SYSTEM

ROLLER NUT DESIGN



[illegible]ARY CONTROL ASSEMBLY



PCRS CONTROL FUNCTIONAL REQUIREMENTS

- Seismic Catagory 1 and Safe Class 1
- Two Independent Position Indication System

  Absolute system accuracy = ± 0.5 inches

  Relative system accuracy = ± 0.15 inches

- Selectable Rod Motion Between 0.36 to 9.0 inches/min at 0.025 inch steps
- Withdrawal stroke shall be 36.0 inches minimum and 37.8 inches maximum
- Lifetime Requirements

  Mechanism - 30 years (732 scrams, 17000 feet of travel)

  Driveline - 10 years

  Control Assembly - 1 year

- Minimum of 1000 lbs insertion force to free a stuck rod

PCRS SCRAM FUNCTIONAL REQUIREMENTS

- PCRS SHALL PROVIDE THE PRIMARY SHUTDOWN SYSTEM.

- THE SPEED OF RESPONSE SHALL BE SUFFICIENT TO ASSURE THAT REQUIED FUEL DAMAGE SEVERITY LIMITS ARE NOT EXCEEDED INDEPENDENT OF THE SCRS.

- THE SYSTEM SHALL BE CAPABLE OF FUNCTIONING BOTH DURING AND AFTER AN OBE.

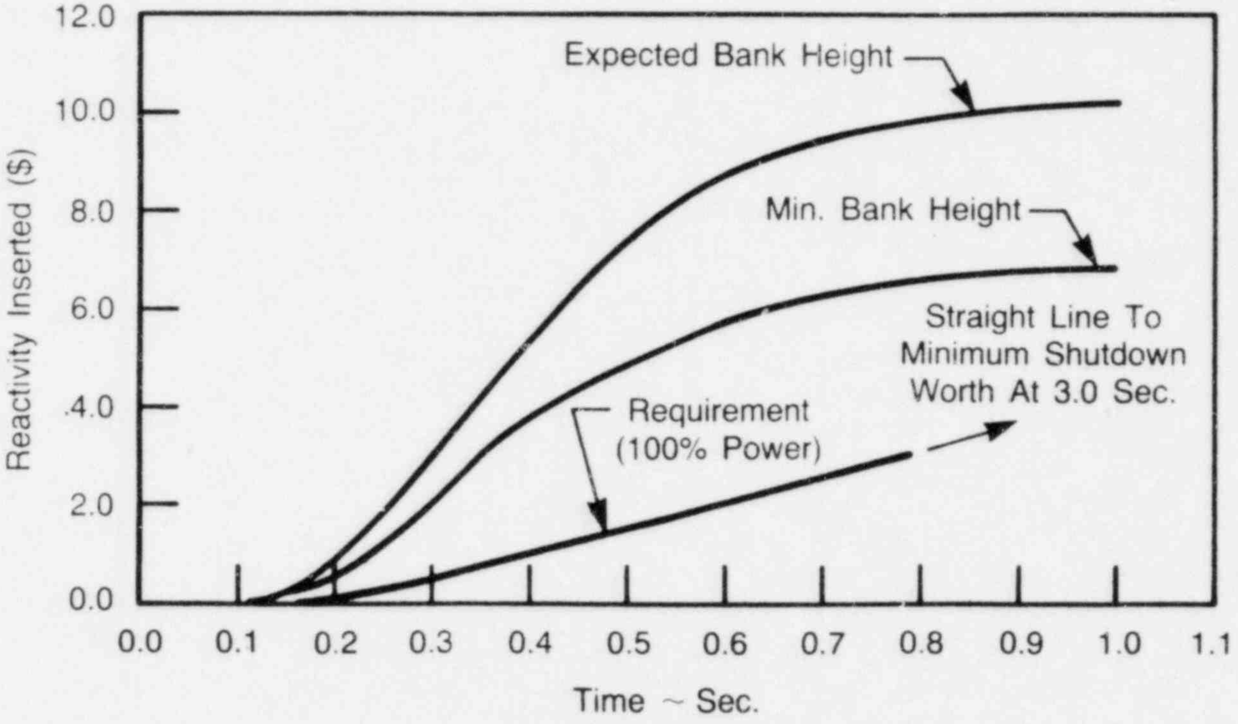
- THE SYSTEM SHALL BE CAPABLE OF SHUTTING DOWN THE REACTOR DURING A SSE.

- NO ELECTRIC OR OTHER EXTERNAL POWER SHALL BE REQUIRED FOR A SCRAM OF ANY CONTROL ROD.

- THE SYSTEM SHALL SATISFY ALL OPERATIONAL AND SCRAM INSERTION REQUIREMENTS UNDER MAXIMUM MISALIGNMENT DESIGN CONDITIONS.

ARD

PCRS REACTIVITY INSERTION PERFORMANCE



7608-1

On the basis of extensive analysis and testing, the Primary Control Systems satisfies all its' functional requirements and provides a reliable means for operational reactivity control and shutdown for CRBRP.

CRBRP PLANT PROTECTION AND INSTRUMENTATION AND CONTROL

BRIEFING FOR

ADVISORY COMMITTEE ON
REACTOR SAFEGUARDS (ACRS)
WORKING GROUP ON SYSTEMS
INTEGRATION AND INSTRUMENTATION
AND CONTROL

SECONDARY CONTROL ROD SYSTEM

PRESENTED BY:

R.E. LAWRENCE
WESTINGHOUSE–OR
CRBRP PROJECT

SEPTEMBER 30, 1982

T6

9-82-2996-1

OVERVIEW

- BASIS AND BENEFITS OF A SECOND FAST-ACTING SHUTDOWN SYSTEM
- DESIGN REQUIREMENTS
- FUNCTIONAL DESCRIPTION
- DIVERSITY OF THE TWO SHUTDOWN SYSTEMS
- SUMMARY OF SCRS OPERATION
- CONCLUSIONS

BASIS FOR A SECOND FAST-ACTING SHUTDOWN SYSTEM

CRBRP GENERAL DESIGN CRITERION 24

- TWO INDEPENDENT REACTIVITY CONTROL SYSTEMS OF DIFFERENT DESIGN PRINCIPLES.
  - ONE SYSTEM SHALL BE CAPABLE OF RELIABLY CONTROLLING THE RATE OF REACTIVITY CHANGES RESULTING FROM PLANNED, NORMAL POWER CHANGES--**PCRS**
  - ONE SYSTEM SHALL USE CONTROL RODS, PREFERABLY INCLUDING A POSITIVE MEANS FOR INSERTION, AND SHALL BE CAPABLE OF RELIABLY CONTROLLING REACTIVITY CHANGES TO ASSURE THAT SPECIFIED FUEL DESIGN LIMITS ARE NOT EXCEEDED UNDER CONDITIONS OF NORMAL OPERATION, INCLUDING ANTICIPATED OPERATIONAL OCCURRENCES-- **SCRS & PCRS**

DESIGN REQUIREMENTS

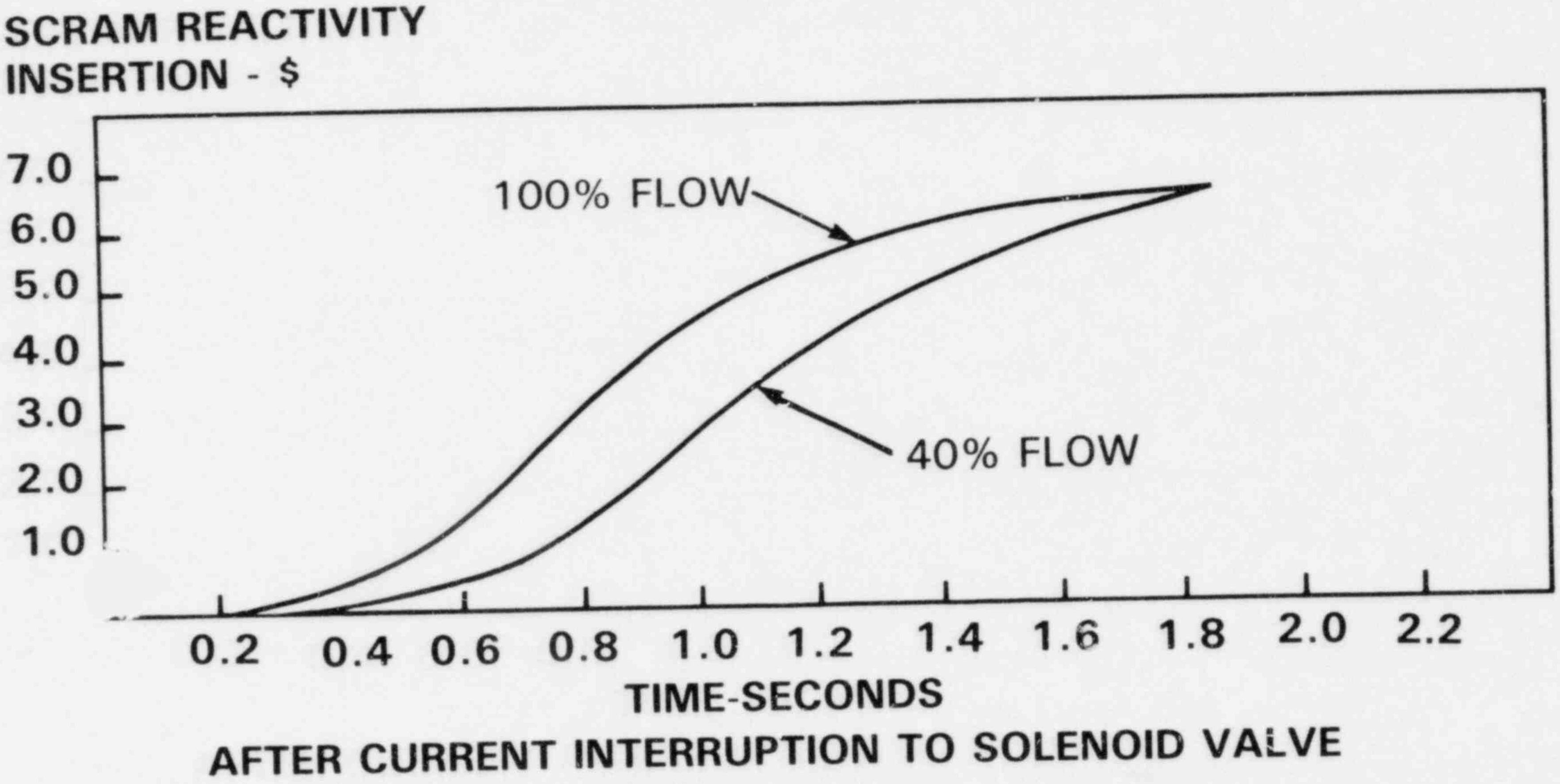
- SCRAM INSERTION
  - MECHANISM RESPONSE TIME < 0.1 SECOND
  - CONTROL ROD REACTIVITY VS. TIME
  - MISALIGNMENT - WORST CASE REFUELING AND OPERATING CONDITIONS
    - NO THREE POINT CONTACT

- DUTY CYCLE

	LIFE (YRS)	TRAVEL (FT)	SCRAM CYCLES
– DRIVE MECHANISM (SCRDM)	30	7700	700
– DRIVELINE (SCRD)	10	2360	260
– CONTROL ASSEMBLY (SCA)	1	500*	52*

*BASED ON TWO YEAR LIFE AS GOAL

SECONDARY CONTROL ROD SYSTEM MINIMUM SCRAM INSERTION REQUIREMENT



DESIGN REQUIREMENTS (CONT.)

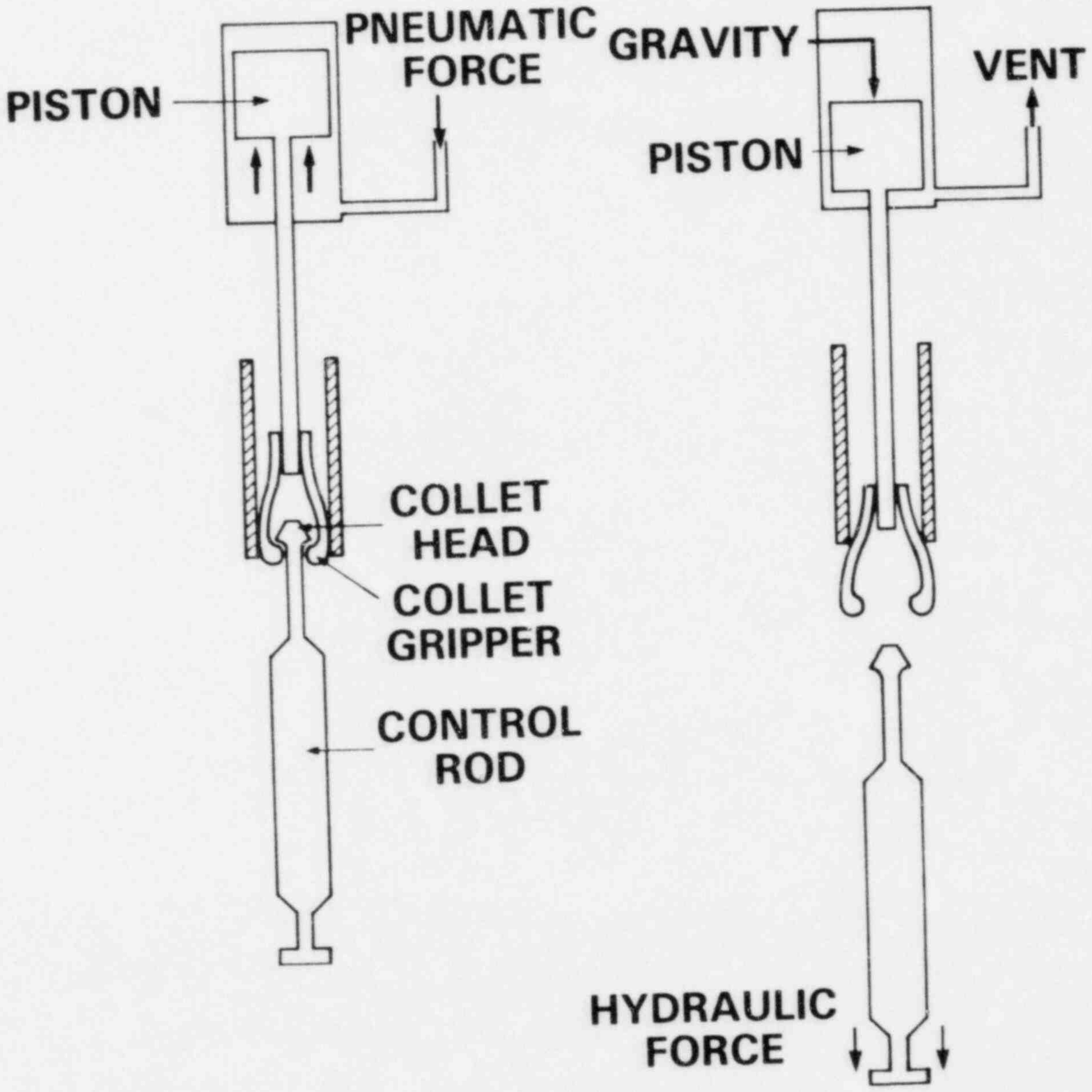
- MECHANICAL/STRUCTURAL
  - ASME CODE, SECTION III, CLASS 1 FOR PRESSURE BOUNDARY
  - SEISMIC CATEGORY 1, SAFETY CLASS 1
  - SCRAM STROKE OF 37.5 INCHES
  - SCA STRUCTURAL, THERMAL/HYDRAULIC, AND CLEARANCE REQUIREMENTS COMPARABLE TO PCA

FUNCTIONAL DESCRIPTION

KEY SCRAM-RELATED FEATURES

- LATCH
- PNEUMATIC VALVES/CYLINDER
- TENSION ROD
- HYDRAULIC SCRAM ASSIST

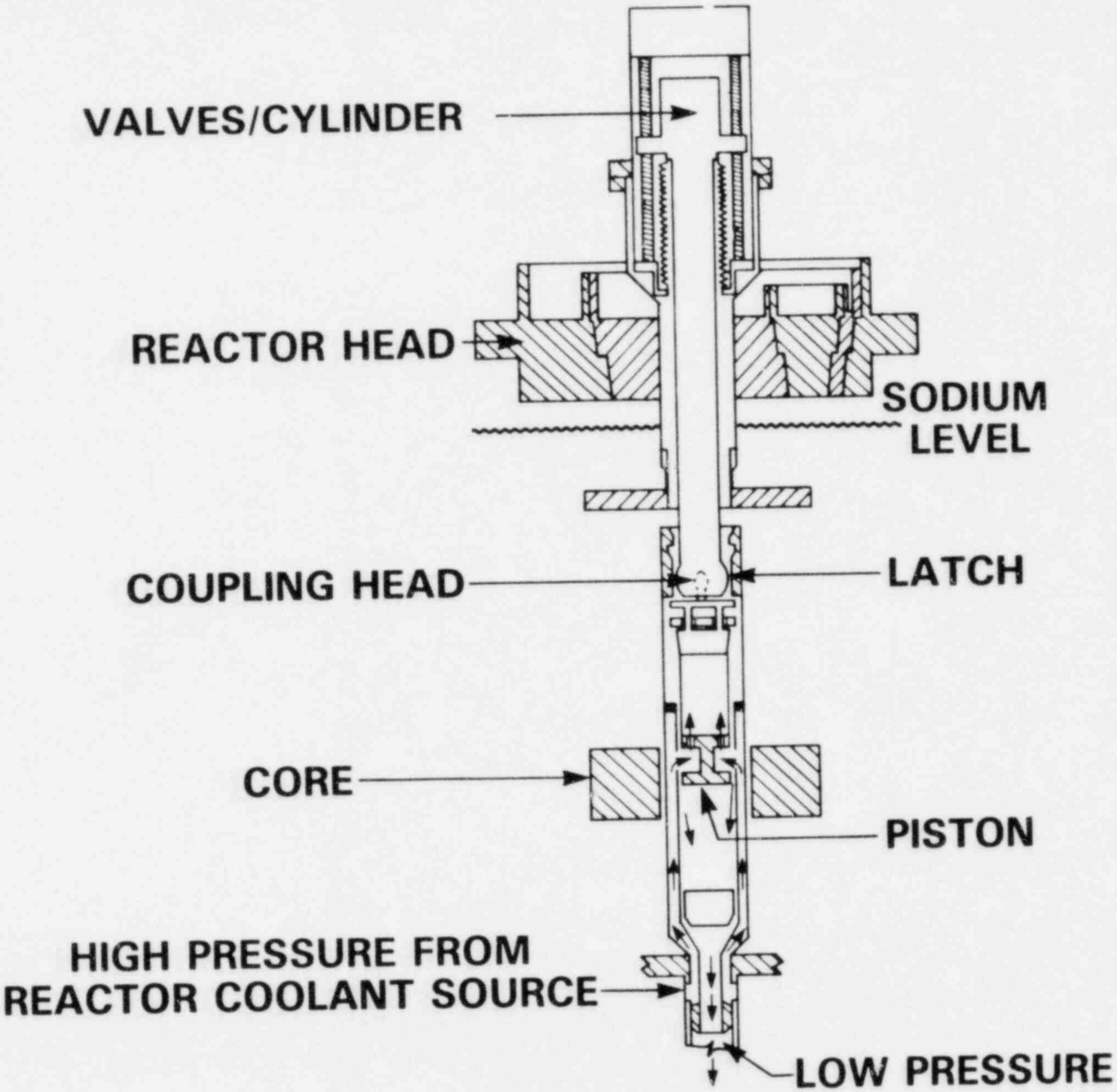
SCRAM-RELATED FEATURES



LATCHED

UNLATCHED

SECONDARY CONTROL ROD SYSTEM



VALVES/CYLINDER

REACTOR HEAD

SODIUM LEVEL

COUPLING HEAD

LATCH

CORE

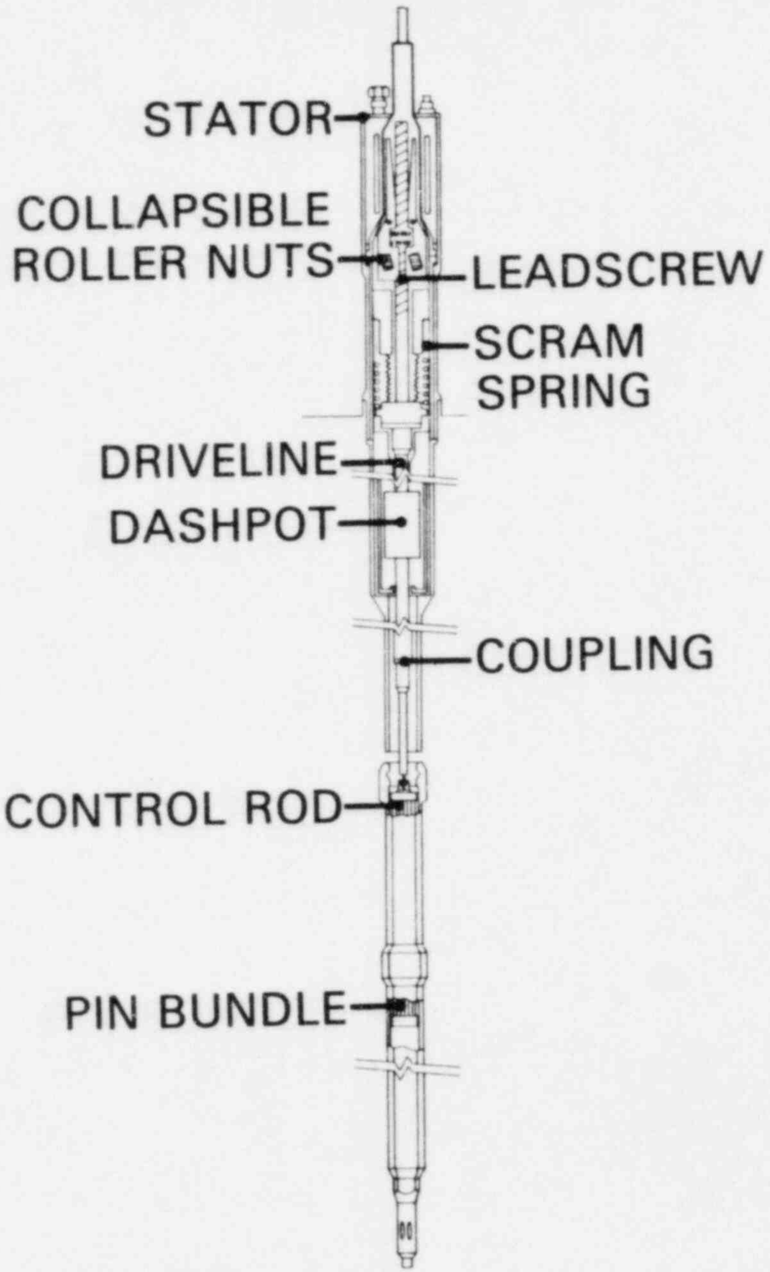
PISTON

HIGH PRESSURE FROM REACTOR COOLANT SOURCE

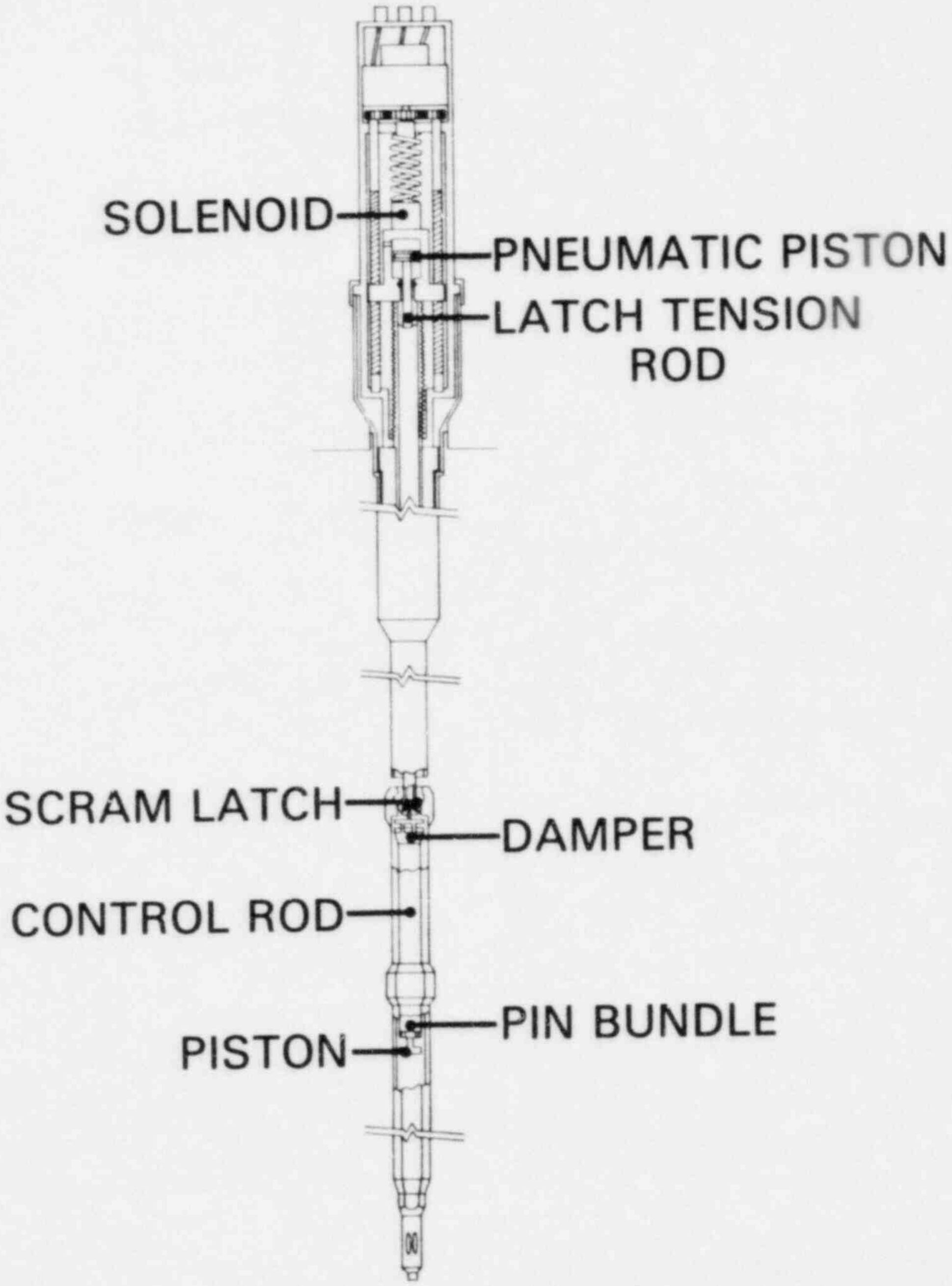
LOW PRESSURE

CONTROL ROD SYSTEMS COMPARISON

PRIMARY



SECONDARY



DIVERSITY BETWEEN SCRS AND PCRS

	DESIGN FEATURE (& LOCATION)	
SCRAM OPERATIONS	**SCRS**	**PCRS**
• SENSORS AND LOGIC GENERATE SIGNALS	GENERAL COINCIDENCE LOGIC	LOCAL COINCIDENCE LOGIC
• TWO-OUT-OF-THREE PPS INPUTS INITIATE SCRAM	SCRAM VALVE SOLENOIDS DE-ENERGIZE (INDIVIDUAL SCRDMs)	SCRAM BREAKERS TRIP (EQUIPMENT PANELS)
• POWER REMOVAL TRIPS MECHANISM	PNEUMATIC CYLINDER PRESSURE VENTS THROUGH SCRAM VALVES (INDIVIDUAL SCRDMs)	MAGNETIC FIELD COLLAPSES (INDIVIDUAL PCRDMs)
• FORCE HOLDING CONTROL ROD IS RELEASED	TENSION ROD DROPS 1/4 INCH CAUSING LATCH TO RELEASE CONTROL ROD COUPLING HEAD (TOP OF CONTROL ASSEMBLY-CORE REGION)	ROLLER NUTS DISENGAGE LEAD SCREW (PCRDMs–ABOVE REACTOR VESSEL HEAD)

DIVERSITY BETWEEN SCRS AND PCRS (CONT.)

	DESIGN FEATURE (& LOCATION)	
SCRAM OPERATIONS	SCRS	PCRS
• SCRAM ASSIST FORCE ACCELERATES CONTROL ROD DOWNWARD	SODIUM FLOW CAUSES NET DOWNWARD FORCE ON SCRAM ASSIST PISTON (BOTTOM OF MOVABLE CONTROL ROD)	SCRAM SPRING EXERTS FORCE ON DRIVELINE (ELEVATION ABOVE REACTOR VESSEL HEAD)
• CONTROL ROD MOVES INTO ACTIVE CORE REGION	ALL MOTION OCCURS BELOW CORE OUTLET (UNLATCHING REQUIRED 1/4 INCH MOTION THROUGH UPPER INTERNALS STRUCTURE)	DRIVELINE ATTACHED TO CONTROL ROD MOVES THROUGH REACTOR UPPER INTERNALS STRUCTURE
	CIRCULAR BUNDLE INSERTS INTO A CIRCULAR DUCT	HEXAGONAL BUNDLE INSERTS INTO A HEXAGONAL DUCT

SECONDARY CONTROL ROD SYSTEM OPERATION

- START-UP
  - WITHDRAW TO ABOVE TOP OF CORE, PRIOR TO CRITICALITY
- POWER OPERATION
  - PARKED ABOVE CORE, NO BURNUP REACTIVITY CONTROL
- SCRAM
  - PPS DE-ENERGIZES SCRAM VALVE SOLENOIDS, VALVES VENT CYLINDER
  - SCRD TENSION ROD DROPS APPROXIMATELY 1/4 INCH, RELEASES SCA COUPLING HEAD
  - SCRAM ASSIST FORCE ACCELERATES CONTROL ROD FOR INSERTION
- NORMAL SHUTDOWN
  - AFTER PCRS INSERTION, DRIVE CARRIAGE DOWN TO ''ROD BOTTOM'' INDICATION
  - MANUALLY SCRAM TO COMPLETE SCA INSERTION

EXTENSIVE ANALYSES AND TESTING HAVE DEMONSTRATED SCRS DESIGN MEETS FUNCTIONAL AND DESIGN REQUIREMENTS

- FIVE PROTOTYPES TESTED
- OVER 3600 SCRAMS PERFORMED
- NO FAILURES TO SCRAM
- ALL SCRAMS WITHIN REQUIRED INSERTION TIME
- ADDITIONAL 1260 SCRAMS OF VALVE/CYLINDER, ALL MEETING REQUIREMENT

SECONDARY CONTROL ROD CONCLUSIONS

- SCRS ASSURES CLINCH RIVER OF A HIGHLY RELIABLE INDEPENDENT AND DIVERSE SHUTDOWN SYSTEM

ⓌARD

PLANT [REACTIVITY] CONTROL

PRESENTATION TO

ACRS

SEPTEMBER 30 1982

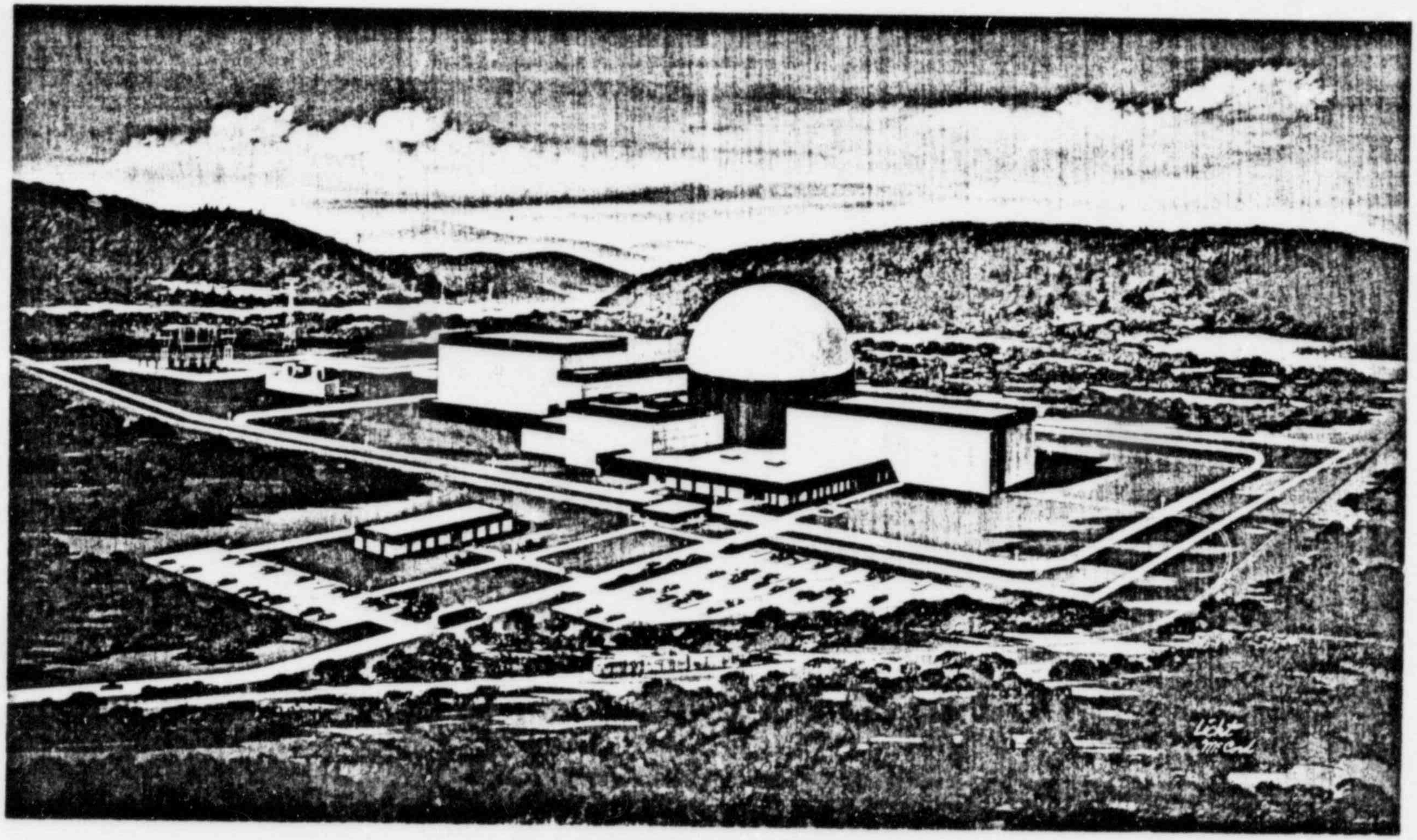
BY

R.J.TINDER, WESTINGHOUSE
ADVANCED REACTOR DIV

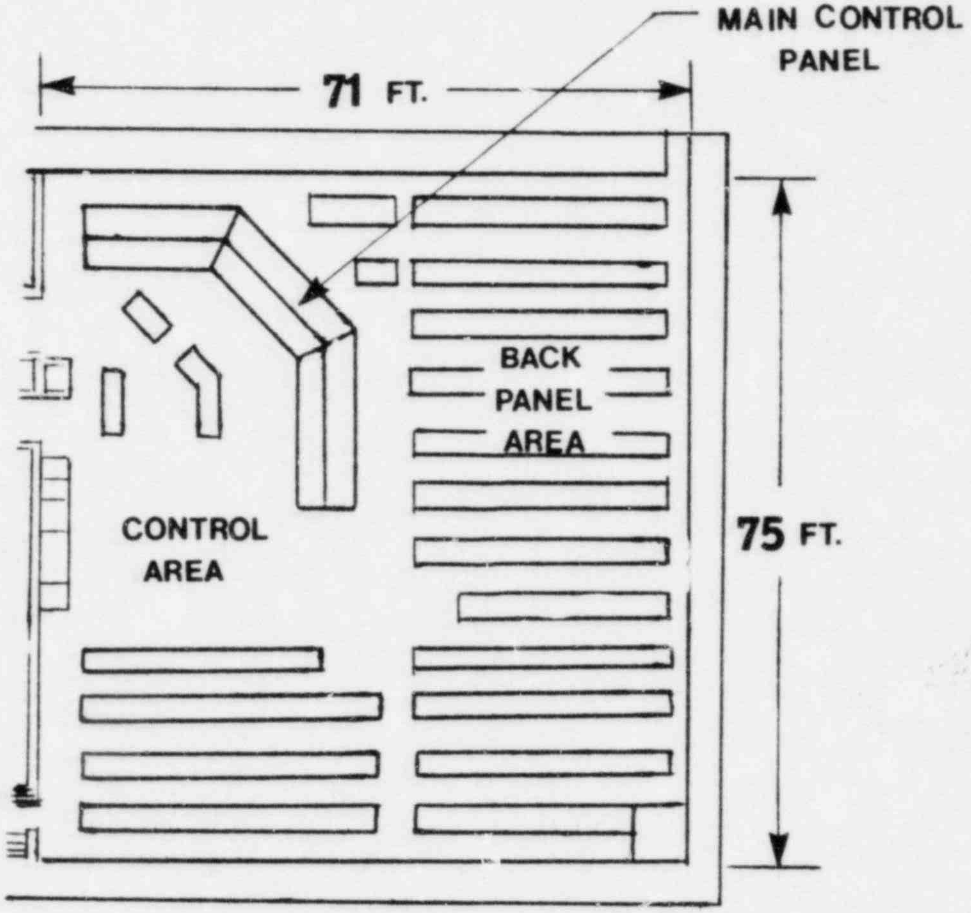
T8

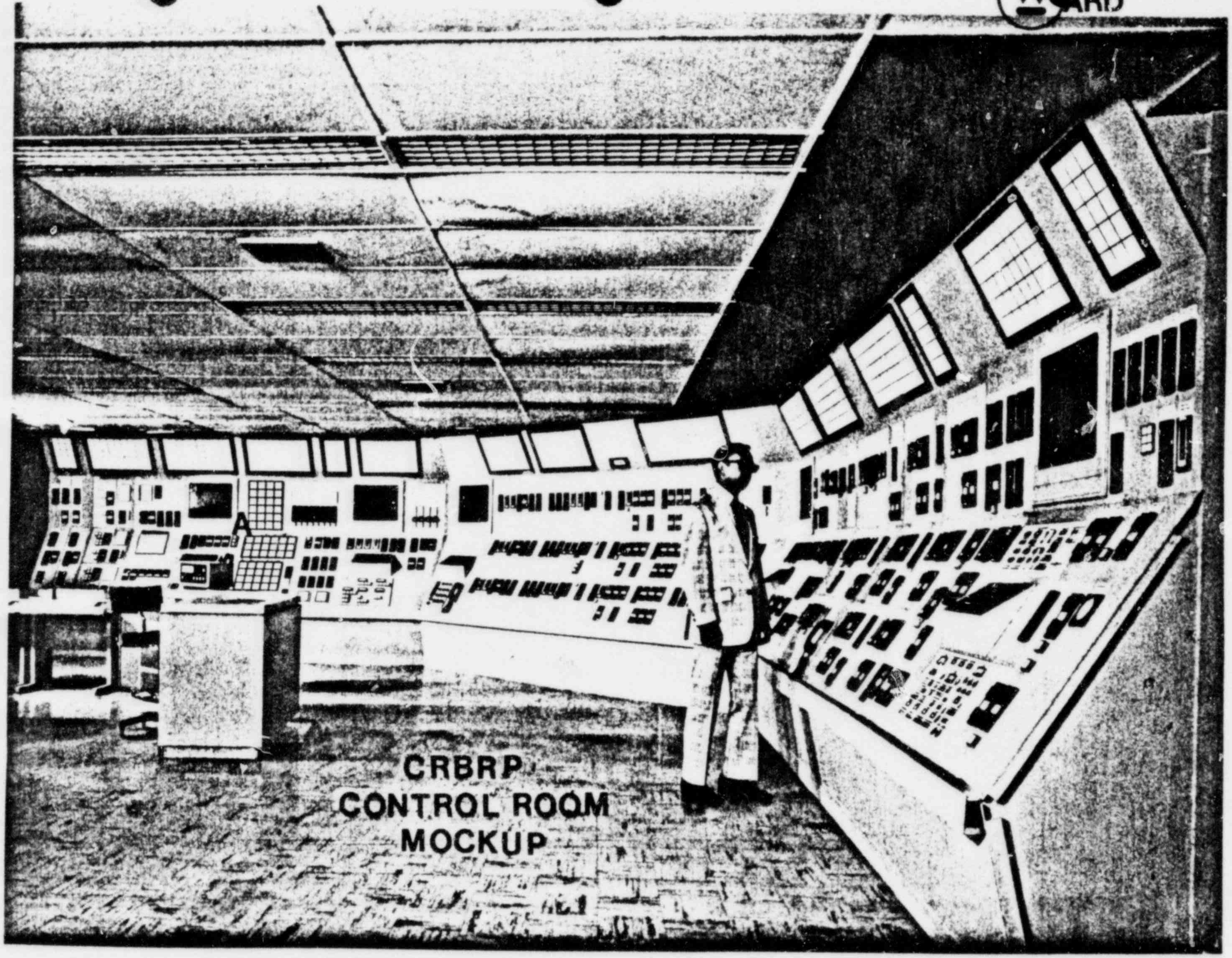
TOPICS ADDRESSED

- CONTROL AREA
- CONTROL REQUIREMENTS
- PLANT CONTROL SYSTEM
- REACTIVITY CONTROL SYSTEM
- CRDM CONTROL



CONTROL ROOM



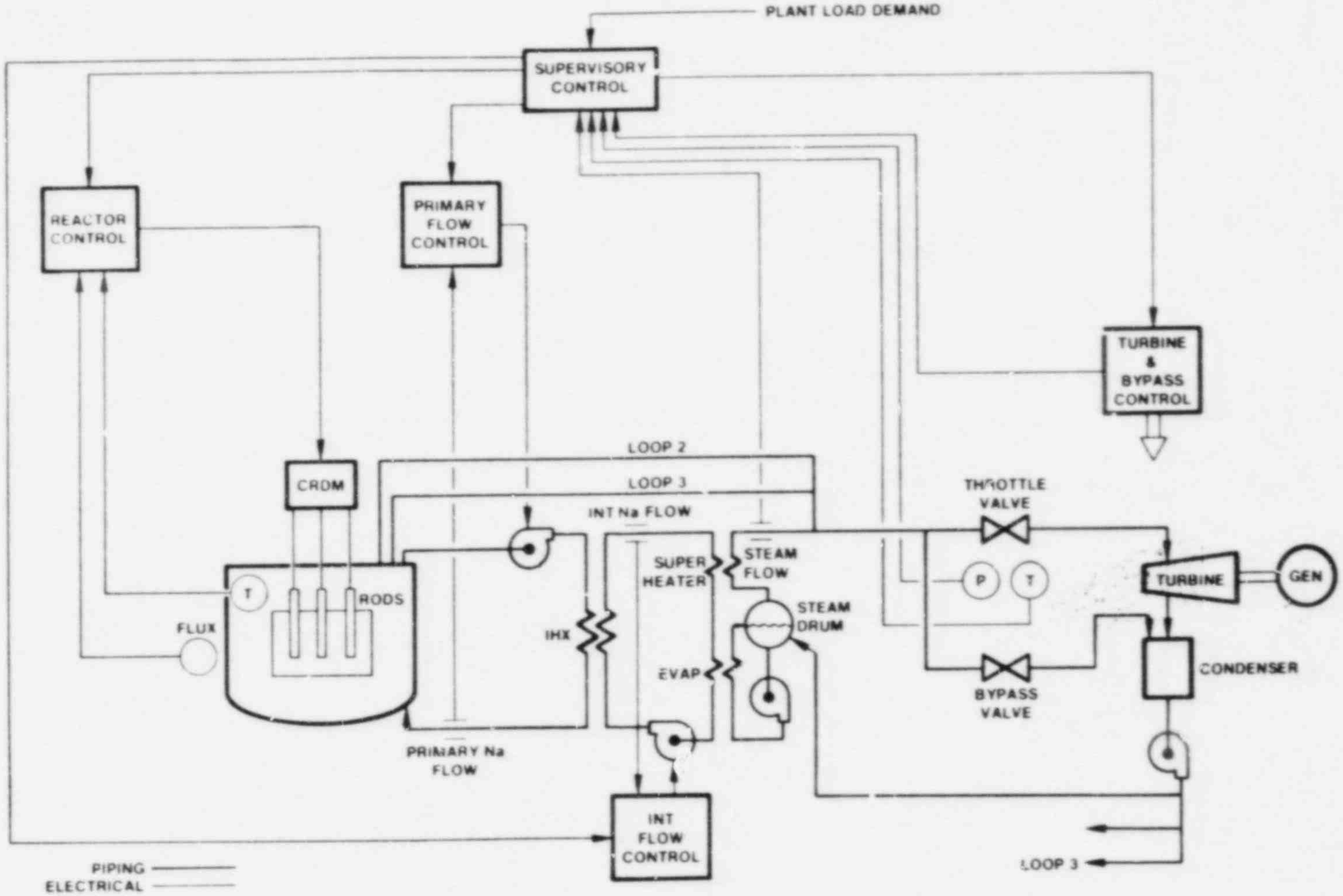


CRBRP
CONTROL ROOM
MOCKUP

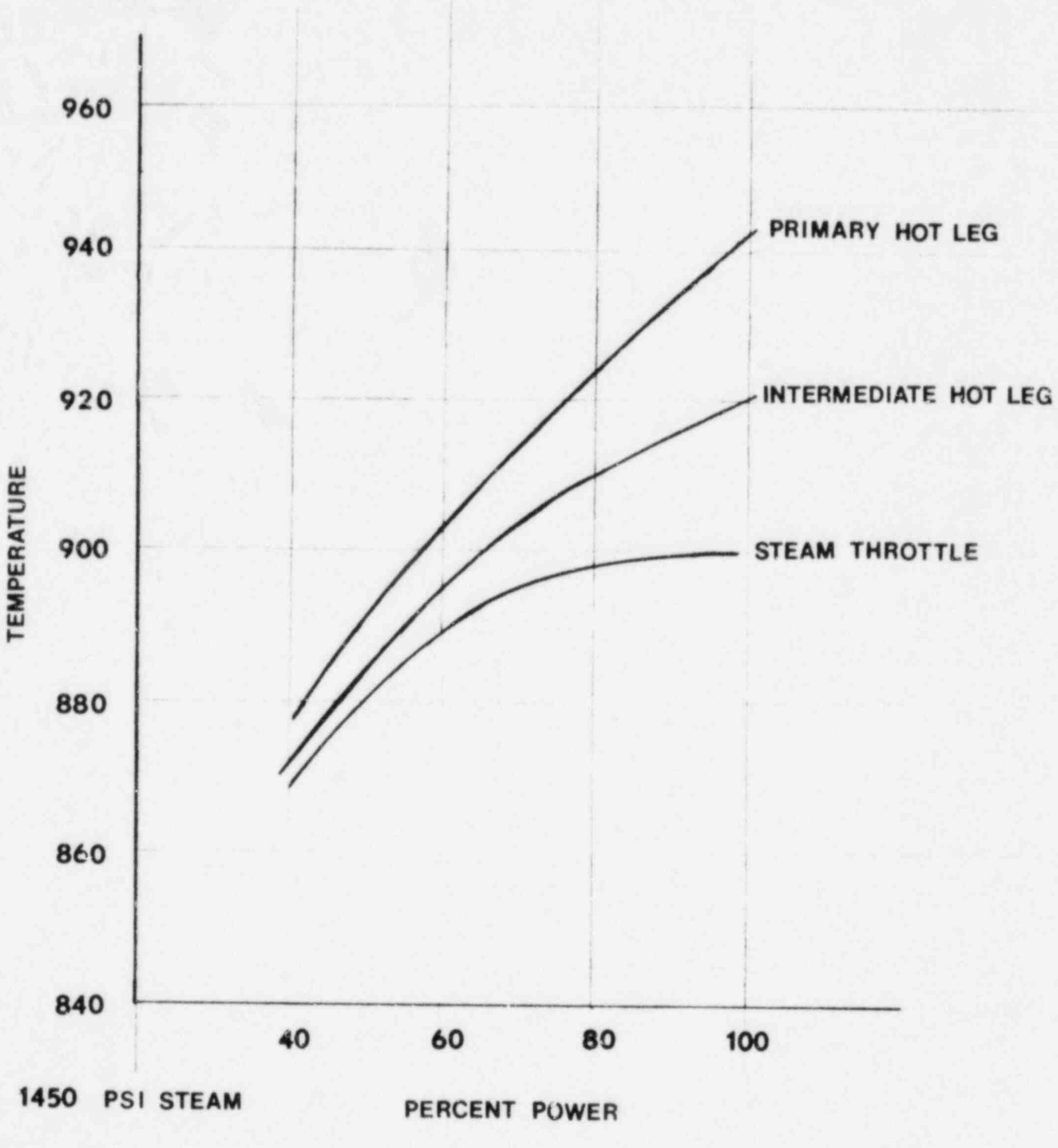
CONTROL REQUIREMENTS

- INTEGRATED CONTROL IN MAIN CONTROL ROOM
- AUTOMATIC CONTROL ON PCRDM ONLY
- AUTOMATIC CONTROL RANGE 40% TO 100% POWER - SUPERVISORY
- LOAD FOLLOW CAPABILITY
  - 3% PER MINUTE RAMP
  - 10% STEP
- REGULATE PLANT VARIABLES OVER PART LOAD PROFILE
- OPERABLE WITH MINIMUM STAFFING REQUIREMENTS

CRBRP PLANT CONTROL

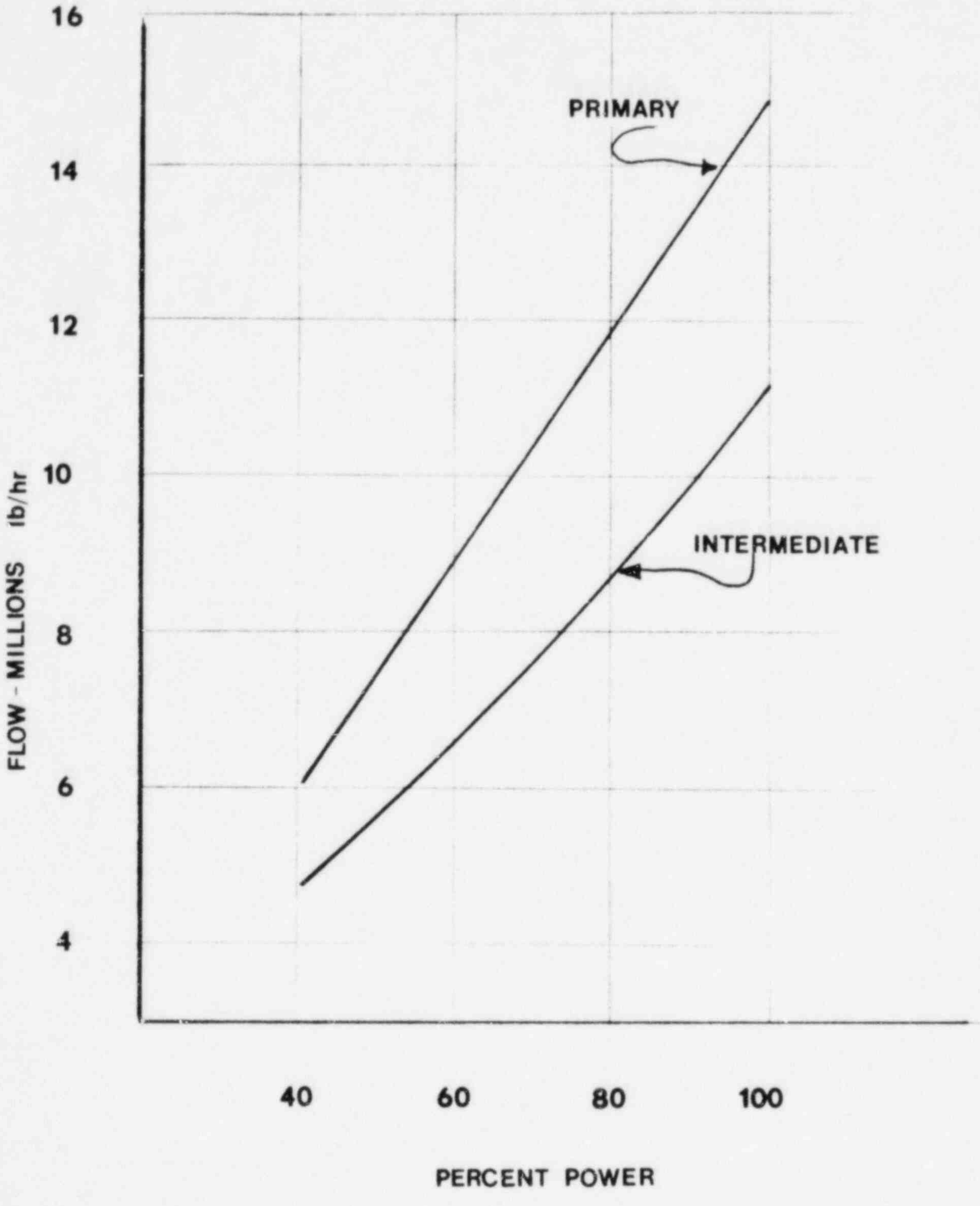


TEMPERATURE PROFILES

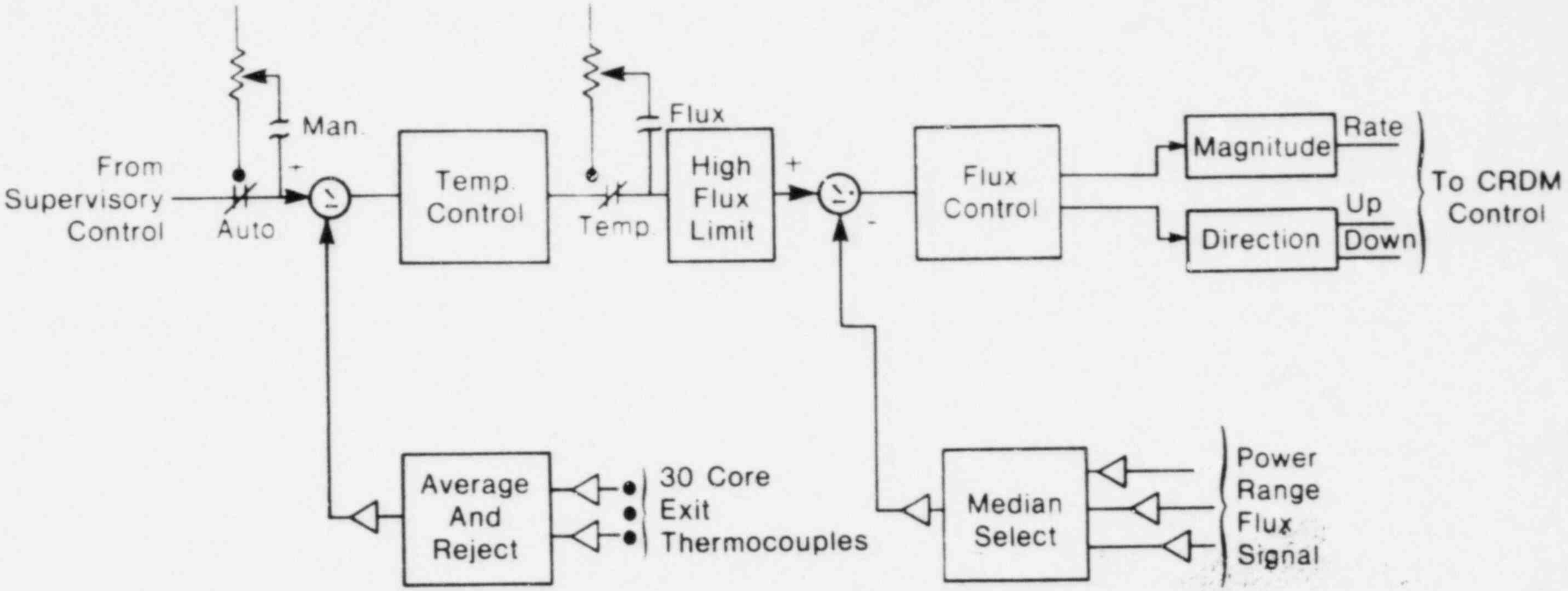


FLOW PROFILES

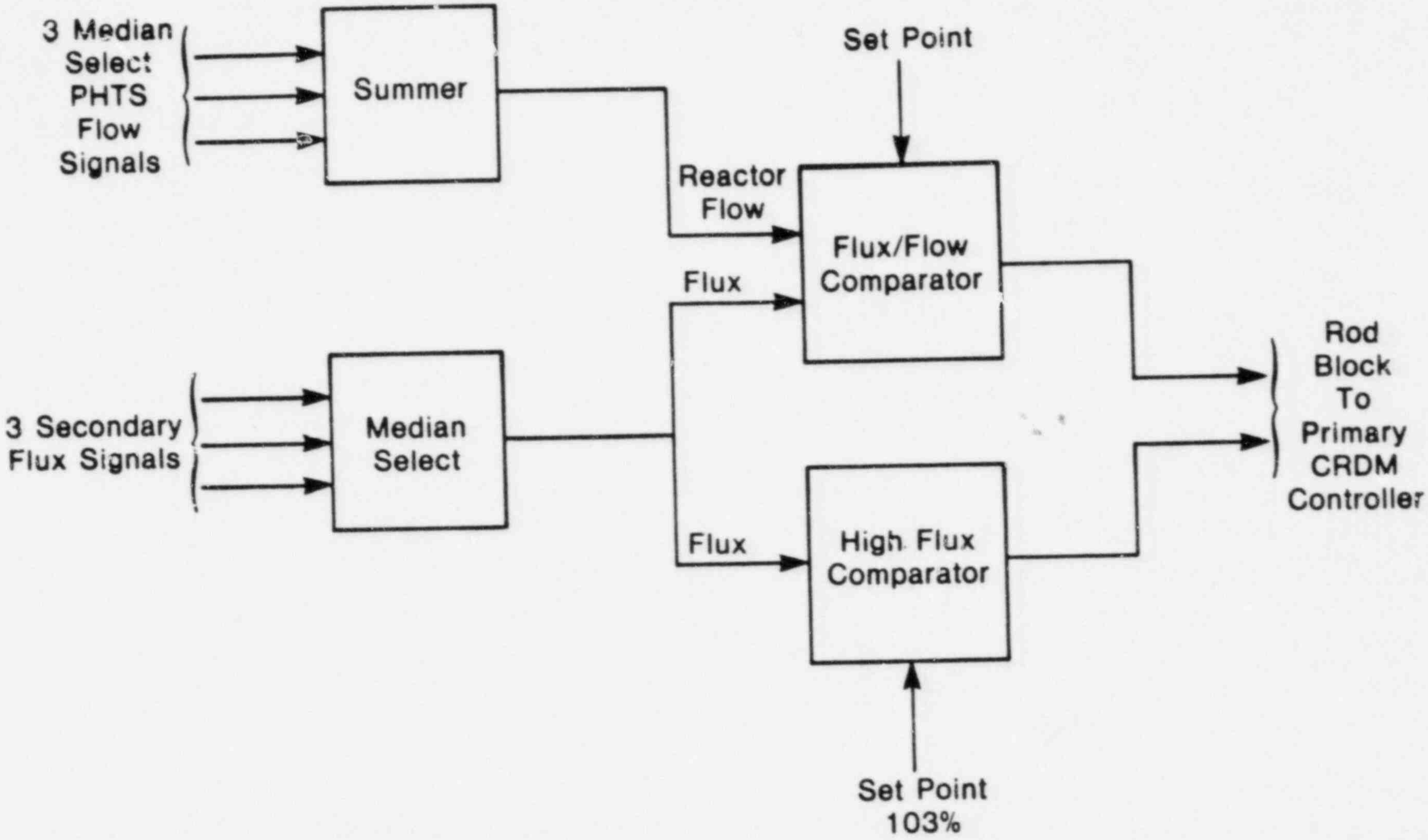
ARD



REACTOR CONTROL SYSTEM

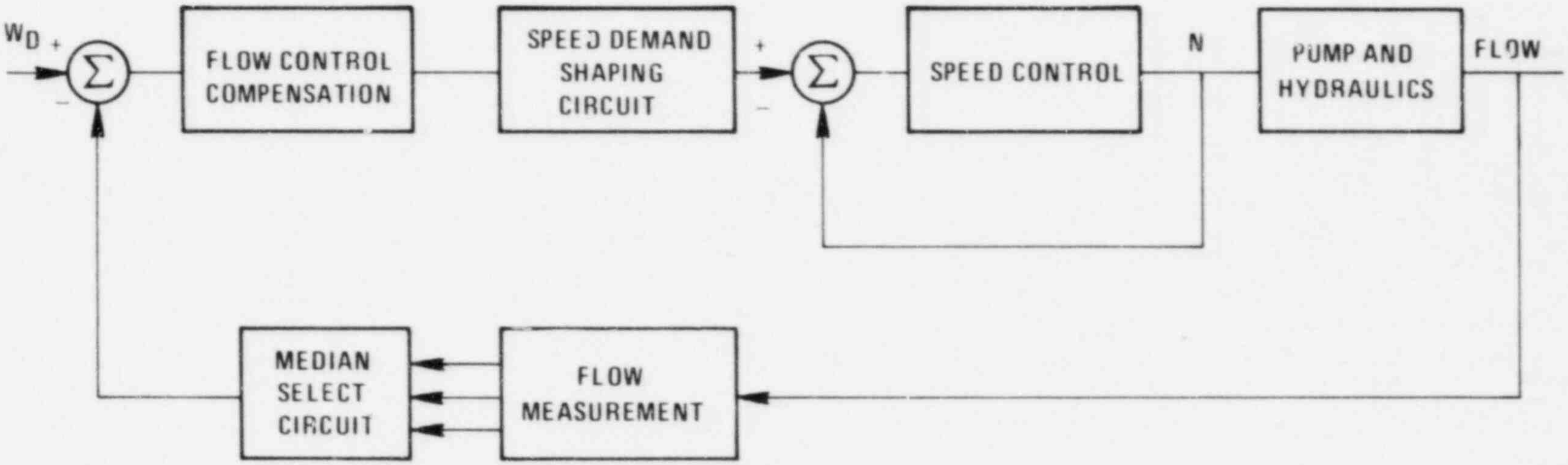


REACTOR CONTROL ROD BLOCK



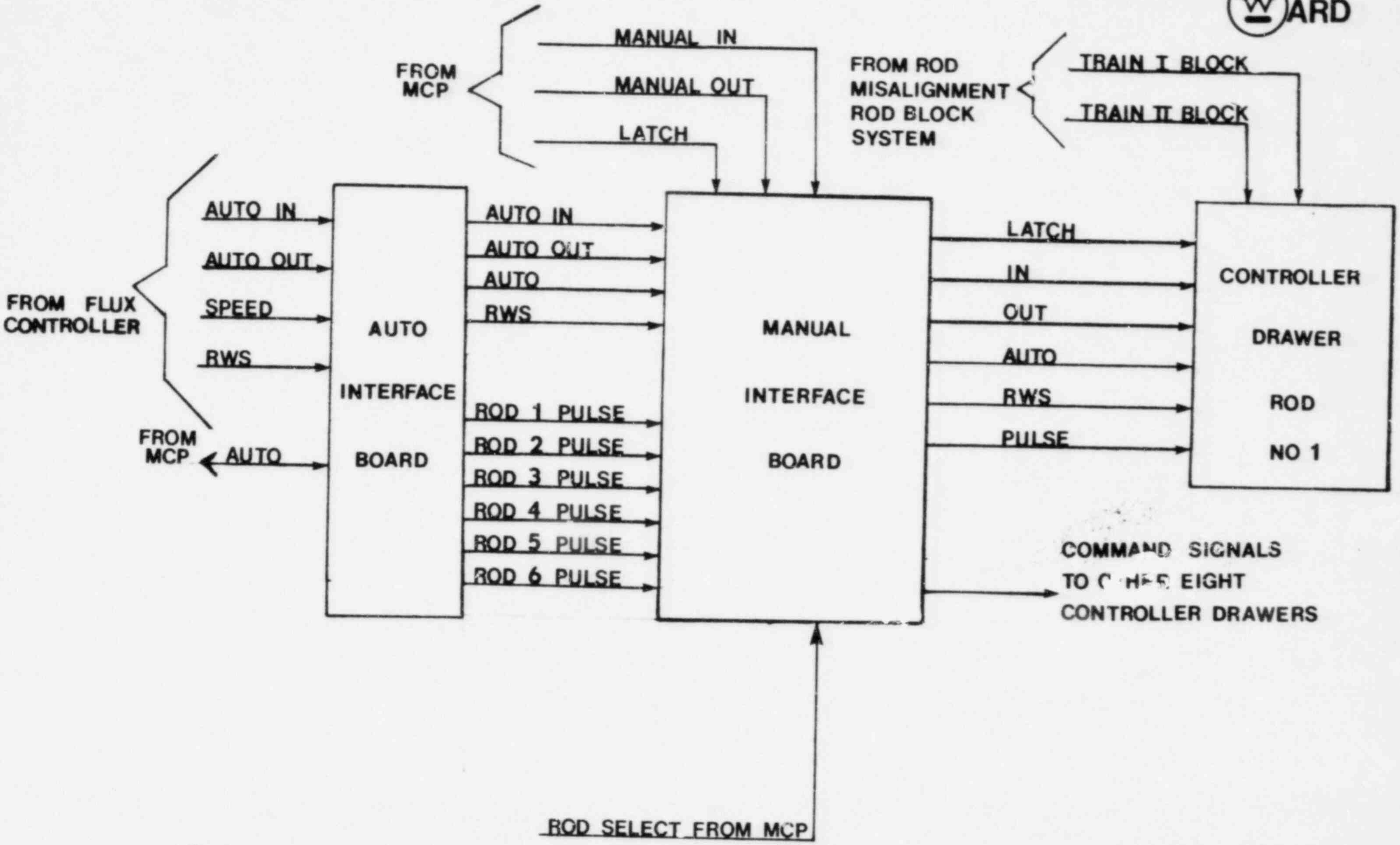
6054-78

FLOW CONTROL SYSTEM



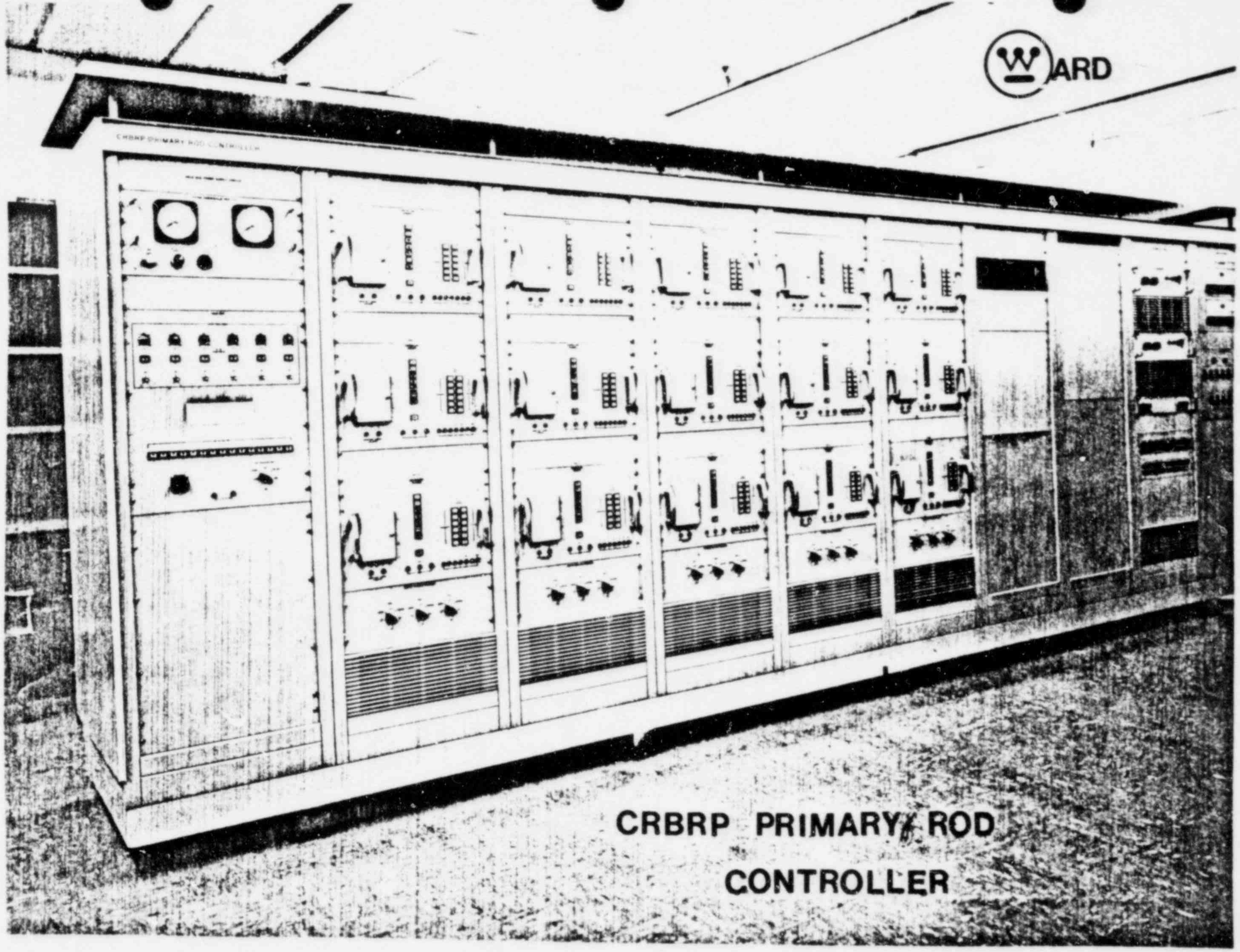
W_D = DEMAND FLOW

N = MOTOR SPEED



PRIMARY ROD CONTR

ARD



CRBRP PRIMARY ROD CONTROLLER

CHARACTERISTICS OF PRIMARY CRDM CONTROLLER

- Rod Insertion Commands Take Priority Over Rod Withdrawal Commands

- Two Overspeed Detection Circuits Stop Rod Motion On Overspeed Conditions

- Rod Controller Drawer Verifies Correct Control Rod Operation And Stops Rod Motion If An Error Is Detected

- Rod Bank Misalignment And Overpower Rod Blocks Are Provided

CONCLUSION

- PROVIDES AN INTEGRATED CONTROL SYSTEM USING SIX PCRDM'S FOR AUTOMATIC CONTROL OF THE PLANT.
- PROVIDES A NUMBER OF FEATURES TO PREVENT CHALLENGES TO THE PPS SYSTEM.
- THE DYNAMIC CONTROL SYSTEMS ARE SIMILAR TO COMMERCIAL CONTROL SYSTEMS.
- REACTOR CONTROL ON HOT LEG TEMPERATURE VS. AVERAGE TEMPERATURE IN PWR'S.

DESIGN FEATURES OF THE CRBRP REACTOR SHUTDOWN SYSTEMS

ACRS WORKING GROUP MEETING AT WASHINGTON, D.C.

September 30, 1982

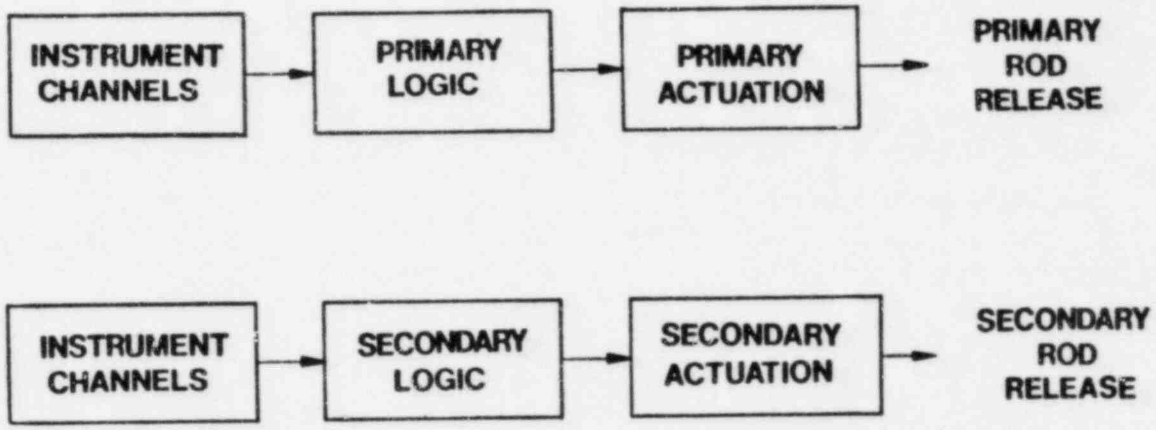
by

G. Macrae

WESTINGHOUSE ELECTRIC CORPORATION
Advanced Reactors Division
Madison, Pennsylvania 15663

T9

REACTOR SHUTDOWN SYSTEMS



INSTRUMENT CHANNELS → PRIMARY LOGIC → PRIMARY ACTUATION → PRIMARY ROD RELEASE

INSTRUMENT CHANNELS → SECONDARY LOGIC → SECONDARY ACTUATION → SECONDARY ROD RELEASE

REACTOR SHUTDOWN SYSTEMS

OUTLINE

DESIGN BASIS

FUNCTIONAL DESCRIPTION

INSTRUMENTATION

OTHER FEATURES

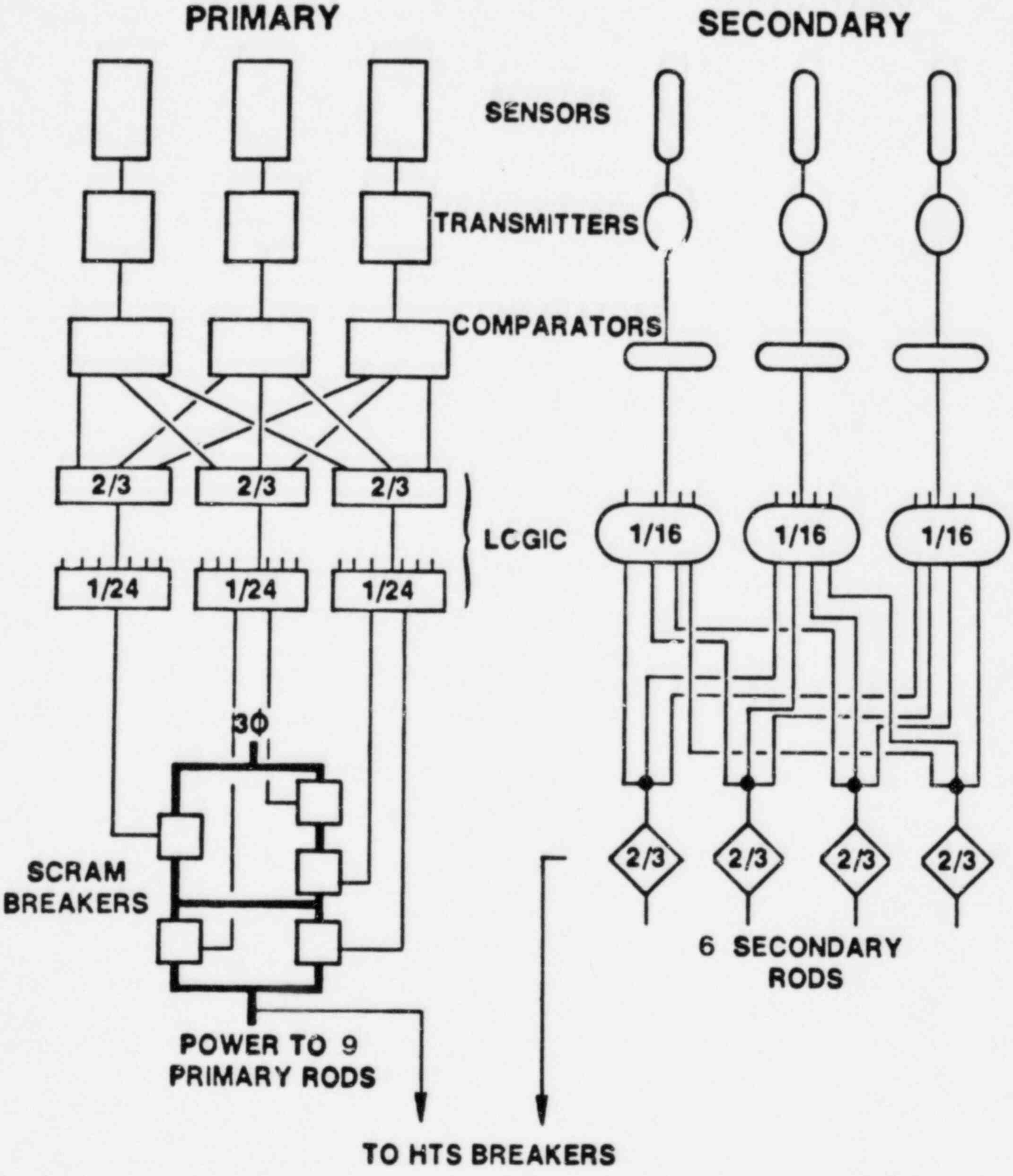
ELECTRICAL REACTOR SHUTDOWN SYSTEM DESIGN BASIS

- Two independent and diverse systems based on new design.
- Maintain plant parameters with acceptable limits established for each design basis event.
- Based on application to LMFBR of NRC General Design Criteria and other Regulatory Positions.
- Conformance with Industry Standards.
- Utilization of FFTF Technology and experience as well as test program results.

REACTOR SHUTDOWN SYSTEM DIVERSITY

	PRIMARY SYSTEM	SECONDARY SYSTEM
Control rod insertion	Gravity with spring assist	Gravity with hydraulic assist
Release	Circuit breakers in 2/3 arrangement	2/3 solenoid operated pneumatic valve
Logic	Local coincidence	General coincidence
Isolation	Light emitting diode	Direct coupled
Electronic circuitry	Integrated circuits	Discrete components
Main cable termination	Upper cable spreading room	Lower cable spreading room
Instrumentation	Compensated ion chambers Pressure & speed Steam & feedwater flow	Fission chambers Flow Steam drum level

CRBRP REACTOR SHUTDOWN SYSTEMS



BASIS FOR REACTOR SHUTDOWN SYSTEM
FUNCTIONAL DESIGN

Design basis events identified and categorized into three frequency classes.

Allowable damage categorized into three damage severity limits.

The more likely the event, the less the allowable damage.

Allowable damage levels for the Secondary Shutdown alone. System Response are one level higher than for the Primary Shutdown System.

TABLE 7.2-2

PPS DESIGN BASIS FAULT EVENTS

Fault Events	Primary Reactor Shutdown System	Secondary Reactor Shutdown System
I. Anticipated Faults		
A. Reactivity Disturbances$^{(1)}$		
Positive Ramps ≤5¢/sec and Steps ≤10		
Startup	Flux-Delayed Flux or Flux- Pressure	Startup Nuclear
5-40% Power	Flux-Delayed Flux or Flux- Pressure	Modified Nuclear Rate or Flux-Total Flow
40-100% Power	Flux- Pressure	Flux-Total Flow
Full Power	High Flux	Flux-Total Flow
Negative Ramps and Steps	Flux-Delayed Flux	Modified Nuclear Rate
B. Sodium Flow Disturbances		
Coastdown of a Single Primary or Intermediate Pump	Primary-Intermediate Speed Mismatch	Primary-Intermediate Flow Ratio
Loss of 1 HTS Loop	Flux-Pressure	Primary-Intermediate Flow Ratio
Loss of 3 HTS Loops	HTS Pump Frequency	Flux-Total Flow

TABLE 7.2-2 (Continued)

Fault Events	Primary Reactor Shutdown System	Secondary Reactor Shutdown System
C. Steam Side Disturbances		
Evaporator Module Isolation Valve Closure	IHX Primary Outlet Temperature	Evaporator Outlet Na Temperature
Superheater Module Isolation Valve Closure	Steam-Feedwater Flow Mismatch	Evaporator Outlet Na Temperature
Water Side Isolation and Dump of Single Evaporator	IHX Primary Outlet Temperature	Evaporator Outlet Na Temperature
Water Side Isolation and Dump of Single Superheater	Steam-Feedwater Flow Mismatch	Evaporator Outlet Na Temperature
Water Side Isolation and Dump of Both Evaporators and Superheater	Steam-Feedwater Flow Mismatch	Evaporator Outlet Na Temperature
Loss of Normal Feedwater	Steam-Feedwater Flow Mismatch	Steam Drum Level
Turbine Trip with Reactor Trip (Loss of Main Condenser or Similar Problem)	Steam-Feedwater Flow Mismatch	Steam Drum Level
Inadvertent Opening of Evaporator Outlet Safety Valve	Steam-Feedwater Flow Mismatch	Steam Drum Level
Inadvertent Opening of Superheater Outlet Safety Valve	Steam-Feedwater Flow Mismatch	Steam Drum Level
Inadvertent Opening of Evaporator Inlet Dump Valve	IHX Primary Outlet Temperature	Evaporator Outlet Na Temperature

TABLE 7.2-2 (Continued)

Fault Events	Primary Reactor Shutdown System	Secondary Reactor Shutdown System
II. Unlikely Faults		
A. Reactivity Disturbances(2)		
Positive Ramps ≤35¢/sec and Steps ≤60¢		
Startup	Flux-Delayed Flux or Flux-Pressure	Startup Nuclear
5-40% Power	Flux-Delayed Flux or Flux-Pressure	Modified Nuclear Rate or Flux-Total Flow
40-100% Power	Flux-Pressure	Flux-Total Flow
Full Power	High Flux	Flux-Total Flow
B. Sodium Flow Disturbances		
Primary Pump Seizure	Primary-Intermediate Speed Mismatch	Primary-Intermediate Flow Ratio
Intermediate Pump Seizure	Primary-Intermediate Speed Mismatch	Primary-Intermediate Flow Ratio
C. Steam Side Disturbances(3)		
Steam Line Break	Steam-Feedwater Flow Mismatch	Evaporator Outlet Na Temperature
Recirculation Line Break	Steam-Feedwater Flow Mismatch	Steam Drum Level
Feedwater Line Break	Steam-Feedwater Flow Mismatch	Steam Drum Level

TABLE 7.2-2 (Continued)

Fault Events	Primary Reactor Shutdown System	Secondary Reactor Shutdown System
Failure of Steam Dump System	Steam-Feedwater Flow Mismatch	Steam Drum Level
Sodium Water Reaction in Steam Generator(3)	Steam-Feedwater Flow Mismatch	Sodium-Water Reaction
III. Extremely Unlikely		
A. Reactivity Disturbances		
Positive Ramps ≤ $2.0/sec		
Startup	Flux-Delayed Flux	Startup Nuclear
5-40% Power	Flux-Delayed Flux or Flux-Pressure	Modified Nuclear Rate or Flux-Total Flow
40-100% Power	Flux-Pressure	Flux-Total Flow
Full Power	High Flux	Flux-Total Flow

---

(1) The maximum anticipated reactivity fault results from a single failure of the control system with a maximum insertion rate of approximately 4.1 cents per second.

(2) The maximum unlikely reactivity faults result from multiple control system failures leading to withdrawal of six rods at normal speed or one rod at the maximum mechanical speed.

(3) The PPS is required to terminate the results of these extremely unlikely events within the umbrella transient specified as emergency for the design of the major components.

TABLE 7.2-1

REACTOR SHUTDOWN SYSTEM PROTECTIVE FUNCTIONS

PRIMARY SHUTDOWN SYSTEM

- FLUX-DELAYED FLUX
- FLUX/PRESSURE
- HIGH FLUX
- PRIMARY TO INTERMEDIATE SPEED RATIO
- PRIMARY PUMP ELECTRICS
- REACTOR VESSEL LEVEL
- STEAM-FEEDWATER FLOW MISMATCH
- IHX PRIMARY OUTLET TEMPERATURE

SECONDARY SHUTDOWN SYSTEM

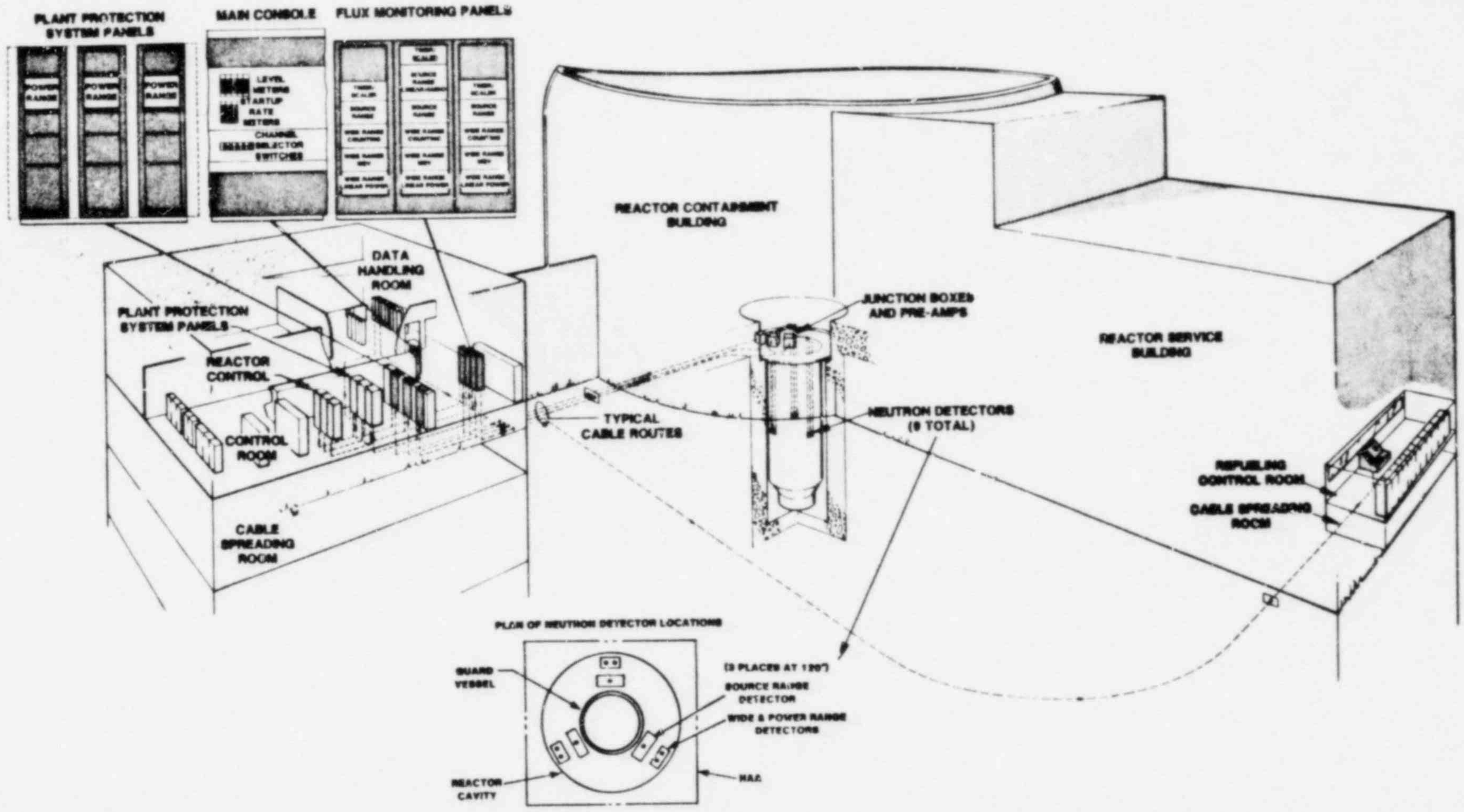
- MODIFIED NUCLEAR RATE
- FLUX-TOTAL FLOW
- STARTUP NUCLEAR
- PRIMARY TO INTERMEDIATE FLOW RATIO
- STEAM DRUM LEVEL
- EVAPORATOR OUTLET SODIUM TEMPERATURE
- SODIUM WATER REACTION
- SECONDARY PUMP ELECTRICS

REACTOR SHUTDOWN SYSTEM SENSORS

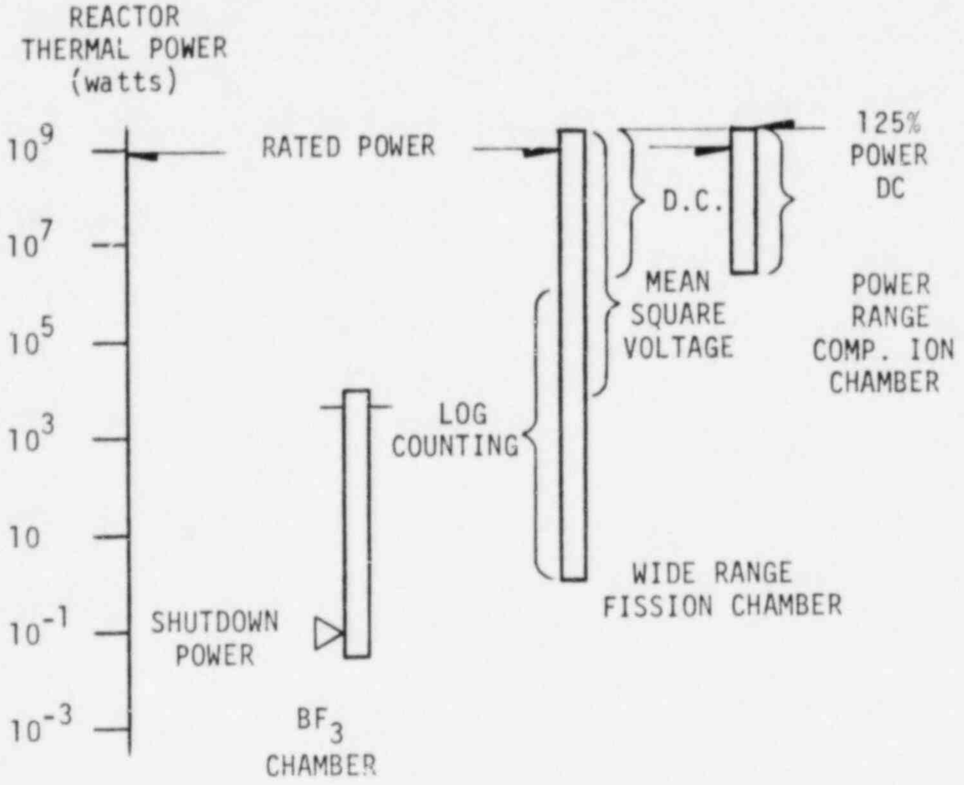
	SENSOR TYPE	LOCATION
	PRIMARY	
Nuclear Flux	Compensated ion chamber	Reactor cavity wall
Inlet plenum pressure	NaK transmission pressure sensor	Inlet plenum piping
Primary pump speed	Tachometer	Pump shaft
Intermediate pump speed	Tachometer	Pump shaft
Pump electrics	Underfrequency relays	Intermediate pump
Steam flow	Venturi with DP sensor	Superheater outlet pipe
Feedwater Flow	Venturi with DP sensor	Steam drum inlet pipe
Reactor vessel sodium level	Inductive probe	Reactor vessel
IHX primary outlet temperature	CR/AL Thermocouple	Primary IHX outlet
	SECONDARY	
Nuclear flux	Fission chamber	Reactor cavity wall
Primary pump flow	Permanent magnet flowmeter	Primary cold leg pipe
Intermediate pump flow	Permanent magnet flowmeter	Intermediate cold leg pipe
Steam drum level	DP sensor	Steam drum
Evaporator outlet sodium temperature	CR/AL thermocouple	Evaporator sodium outlet
Pump electrics	Undervoltage relays	Primary pump
Sodium water reaction	DP sensor	Reaction product dump lines

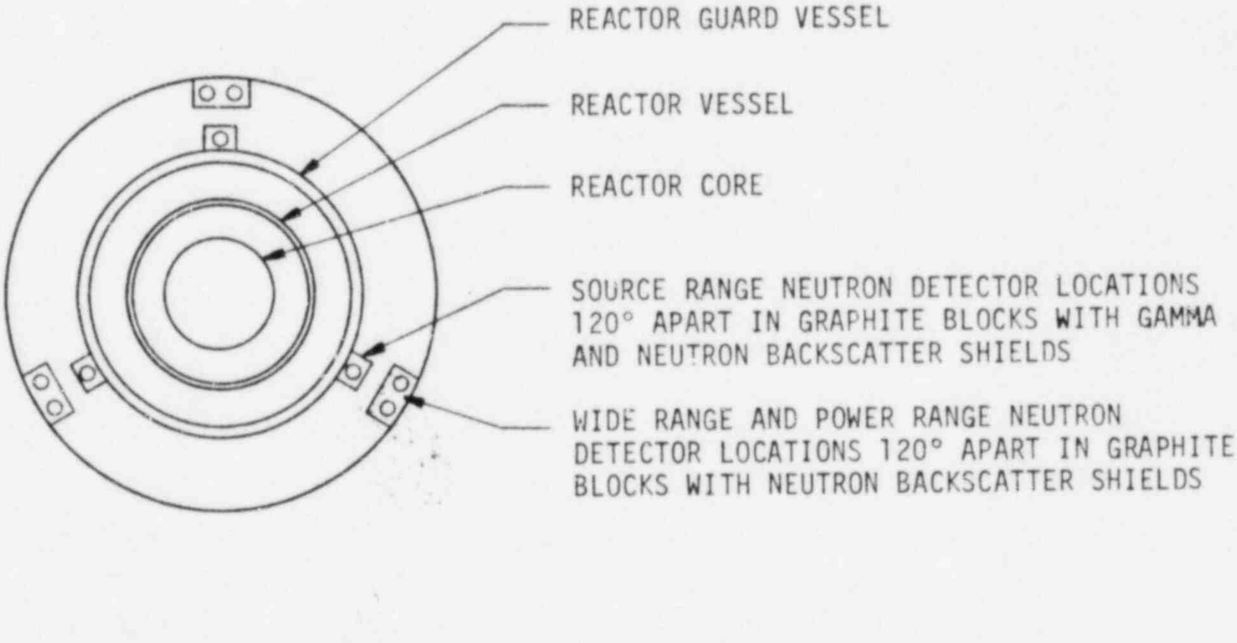
WARD

FLUX MONITORING SYSTEM
PICTORIAL VIEW



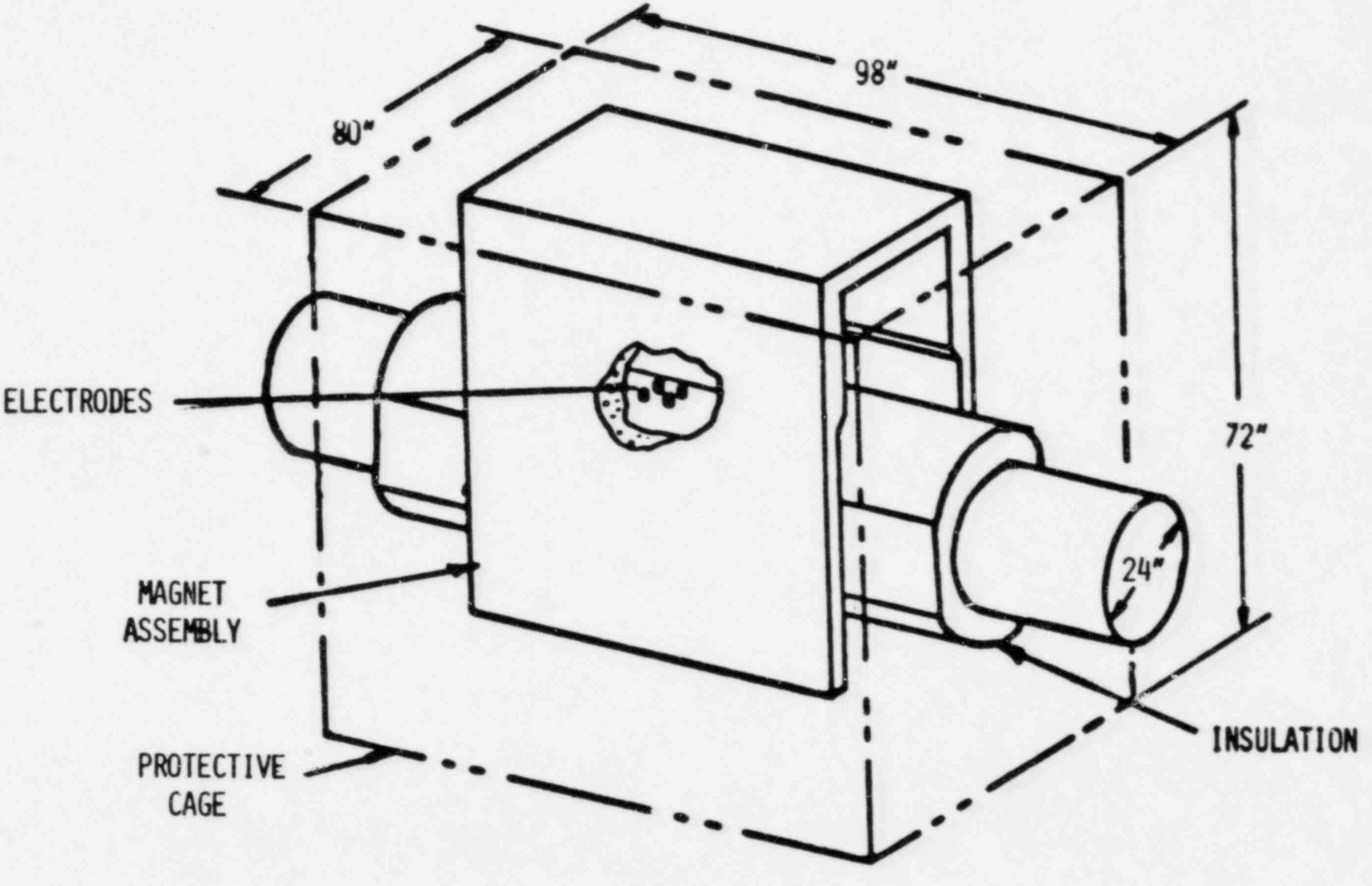
CRBRP FLUX MONITORING SYSTEM
INSTRUMENT RANGE COVERAGE





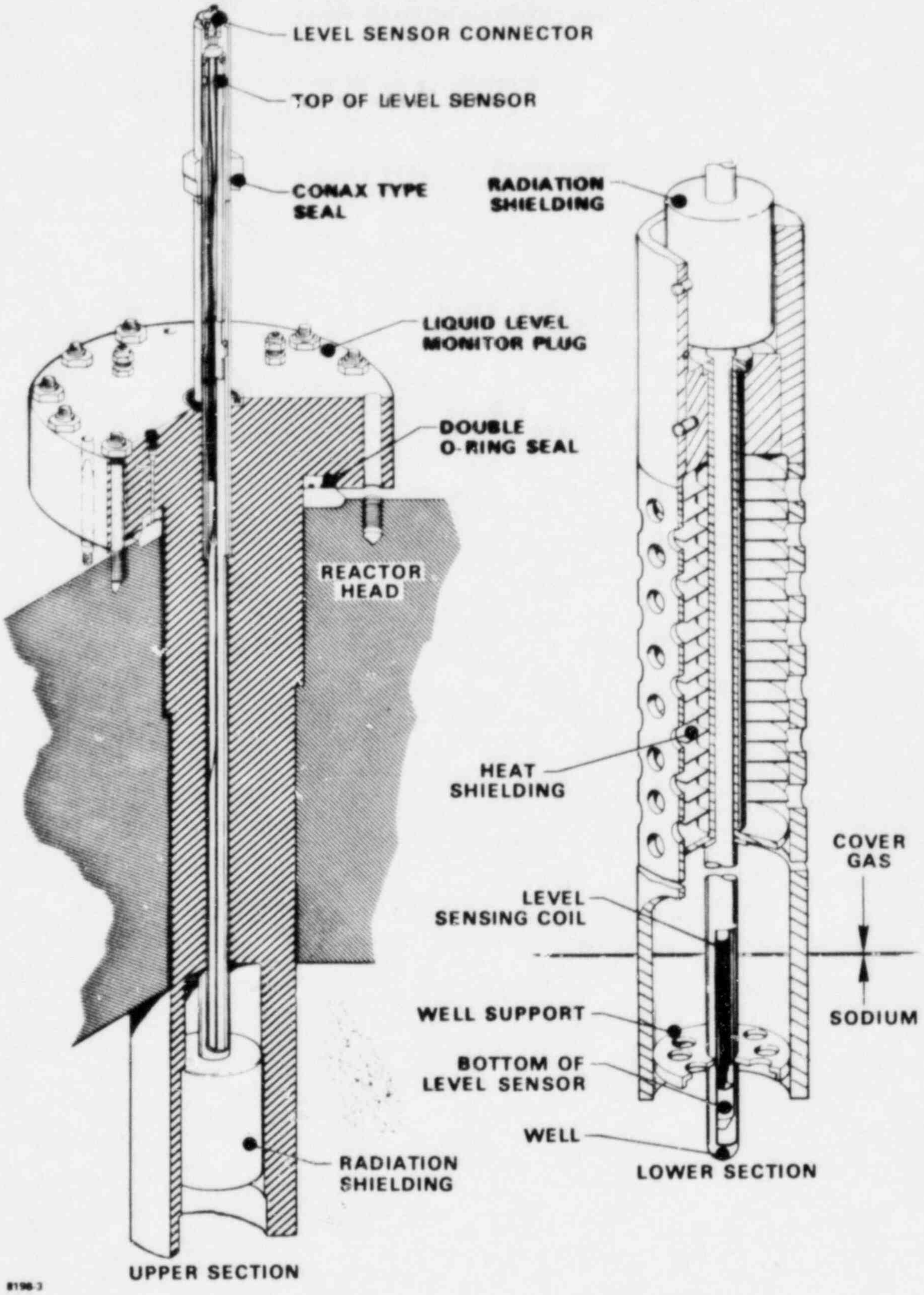
PERMANENT MAGNET FLOWMETER

ARD



REACTOR VESSEL SODIUM LEVEL SENSOR MOUNTING ARRANGEMENTS

ARD



8196-3

BASIS FOR INSTRUMENTATION ENVIRONMENTAL QUALIFICATIONS

- Conformance with IEEE Std. 323-1975
- Conformance will meet applicable portions of Reg. Guide 1.89
- Qualification will be based upon the most severe environment predicted to occur prior to and during those portions of the specific accident transients for which the equipment is required to perform its safety function.
- Aging will be based on accelerated aging to simulate the 30 years life in the normal environment
- CRBRP environmental qualification program

ESSENTIAL PERFORMANCE REQUIREMENTS FOR PPS INSTRUMENTATION

PLANT PARAMETER	ACCURACY (% OF SPAN)	RESPONSE TIME (MSEC)
NEUTRON FLUX		
PRIMARY	± 1.0	< 10
SECONDARY	± 1.0	< 10
REACTOR INLET PLENUM PRESSURE	± 2.0	< 150
SODIUM HTS PUMP SPEEDS	± 2.0	< 20
SODIUM HTS FLOW	± 5.0	< 500
REACTOR VESSEL SODIUM LEVEL	± 5.0	< 500
UNDERVOLTAGE RELAY	± 1.0	< 230
STEAM FLOW	± 2.0	< 500
FEEDWATER FLOW	± 2.5	< 500
EVAPORATOR OUTLET SODIUM TEMPERATURE	± 2.0	< 5000
STEAM DRUM LEVEL	± 1.0	< 1000
IHX PRIMARY OUTLET TEMPERATURE	± 2.0	< 5000
UNDERFREQUENCY RELAY	± 2.0	< 200

CONCLUSIONS

- Extensive diversity and independence meets design requirements for providing shutdown assurance.

- Use of technology extensively developed either for LWRs or FFTF.

- Conformance with NRC and Industry Standards.

CONTROL/PROTECTION INTERFACE

ACRS WORKING GROUP MEETING AT WASHINGTON, D.C.

September 30, 1982

by

G. Morrison

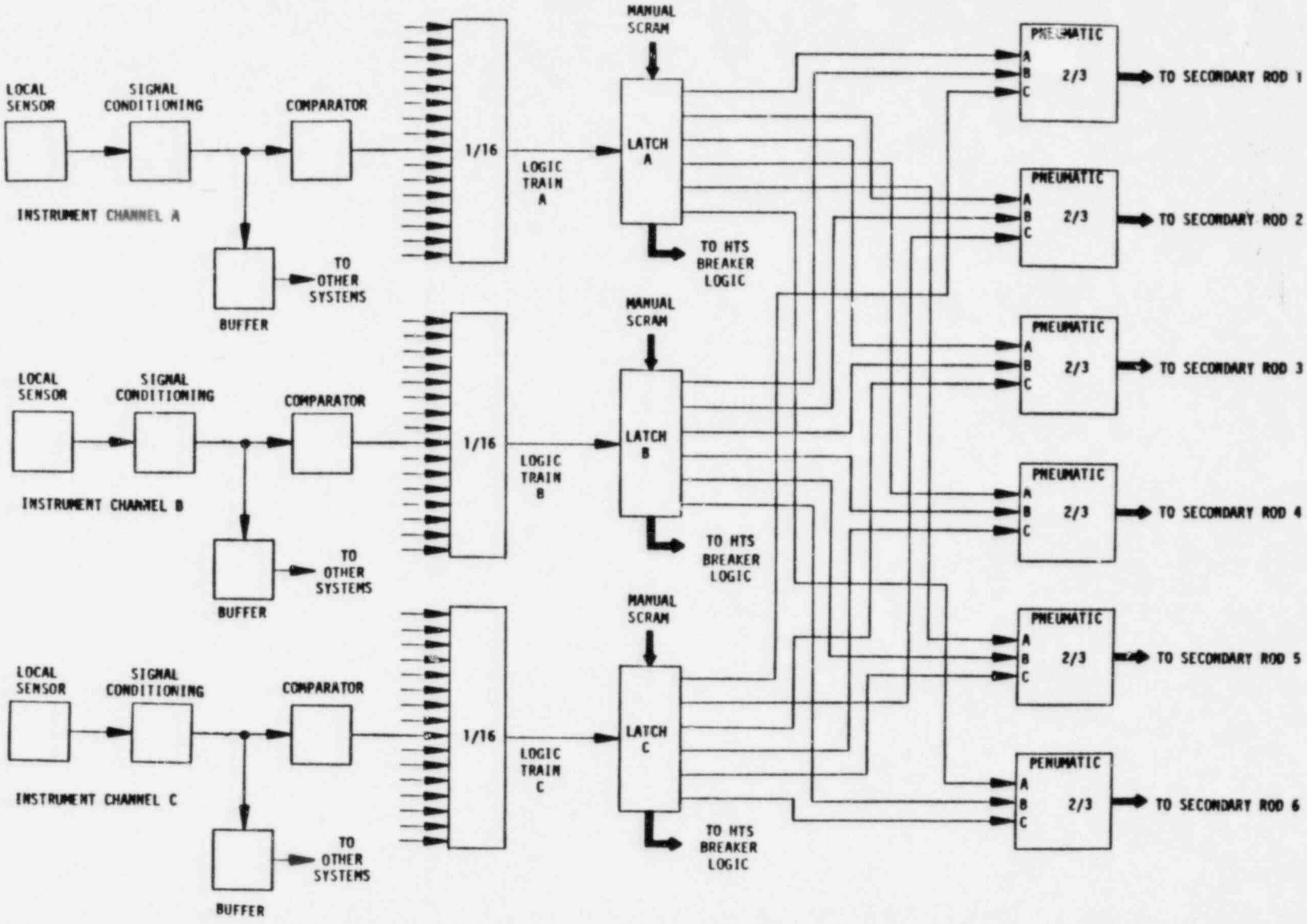
WESTINGHOUSE ELECTRIC CORPORATION
Advanced Reactors Division
Madison, Pennsylvania 15663

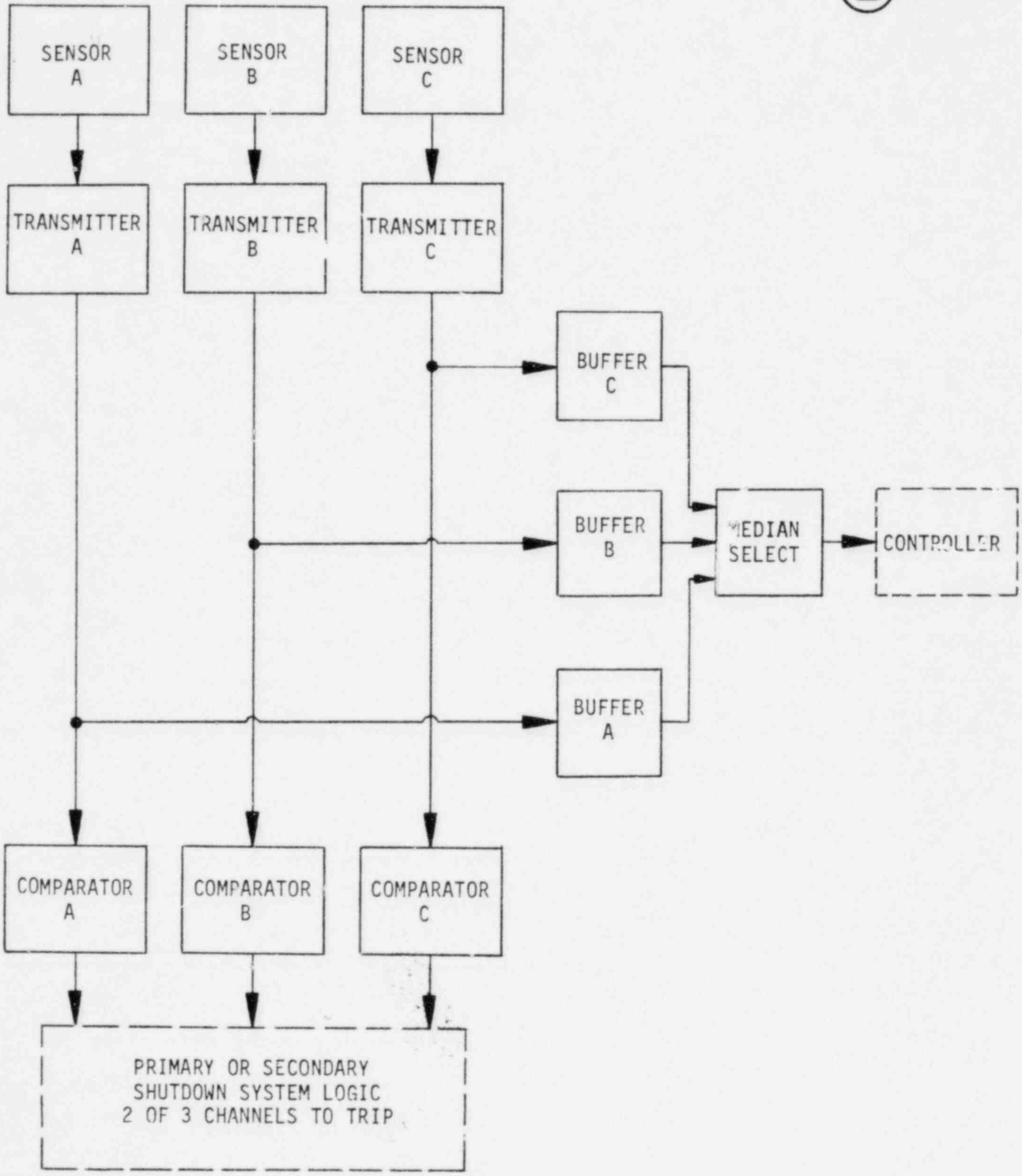
T11

APPLICABLE CRITERIA

CRBRP CRITERION 22	SEPARATION OF PROTECTION AND CONTROL SYSTEMS
IEEE 279 (SECTION 4.7)	CONTROL AND PROTECTION SYSTEM INTERACTION

CRBRP SECONDARY REACTOR SHUTDOWN SYSTEM CONFIGURATION





CONTROL/PROTECTION INTERFACE

ADVANTAGES OF USING PPS SENSORS FOR CONTROL

- REDUNDANT CONTROL SIGNALS INCREASE AVAILABILITY OF INFORMATION FOR PLANT CONTROL.
- REDUCES QUANTITY OF SENSOR PENETRATIONS.
- SHARED CHANNELS ARE SUBJECT TO PROTECTION SYSTEM MAINTENANCE AND TEST SCHEDULES.
- USE OF COMMON DATA CHANNEL PROVIDES OPERATIONAL SIMPLICITY.

CONTROL/PROTECTION INTERFACE FEATURES

- All signals from protection system are buffered with Class 1E qualified isolators.

- Isolation devices are located within protection system equipment.

- Signal selectors in control system prevent control action on single channel failure.

- Redundant PPS channels are monitored to alert operator to signal mismatches.

- Control system does not feed signals into protection system.

PROTECTION AND CONTROL SYSTEM INTERACTION

CRITERIA 4.7.3 OF IEEE 279

WHERE A SINGLE RANDOM FAILURE CAN CAUSE A CONTROL SYSTEM ACTION THAT RESULTS IN A GENERATING STATION CONDITION REQUIRING PROTECTIVE ACTION AND CAN ALSO PREVENT PROPER ACTION OF A PROTECTION SYSTEM CHANNEL DESIGNED TO PROTECT AGAINST THE CONDITION, THE REMAINING REDUNDANT PROTECTION CHANNELS SHALL BE CAPABLE OF PROVIDING THE PROTECTIVE ACTION EVEN WHEN DEGRADED BY A SECOND RANDOM FAILURE.

PROTECTION/CONTROL INTERACTION

SENSOR	CHANNELS $A^{(1)}$	$B^{(2)}$	C	MEDIAN	CONTROL SYSTEM RESPONSE	PROTECTION SYSTEM RESPONSE
Power Range Flux	H	L	N	N	Normal	Not required
	L	H	N	N	Normal	Not required
	H	H	N	H	Flux Control: Decrease in reactor power	Not required
					Temperature Control: Initial decrease in reactor power followed by partial/total recovery	Not required
	L	L	N	L	Flux Control: Increase in reactor power limited by rod block circuits (secondary flux)	Not required
					Temperature Control: Increase in reactor power limited by rod block circuits or temperature feedback loop	Not required

(1) Channel A is assumed to be undergoing test. Channel is tripped during test.

(2) Channel B is assumed to experience first failure. Signal deviation is assumed to be insufficient to cause a channel trip.

PROTECTION/CONTROL INTERACTION (CONTINUED)

SENSOR	CHANNELS A(1)	B(2)	C	MEDIAN	CONTROL SYSTEM RESPONSE	PROTECTION SYSTEM RESPONSE
WIDE RANGE FLUX	H	L	N	N	NORMAL	NOT REQUIRED
	L	H	N	N	NORMAL	NOT REQUIRED
	H	H	N	H	SPURIOUS ACTUATION OF ROD BLOCK CIRCUITS	NOT REQUIRED
	L	L	N	L	FAILURE OF ROD BLOCK CIRCUITS	NOT REQUIRED
PHTS SODIUM	H	L	N	N	NORMAL	NOT REQUIRED
	L	H	N	N	NORMAL	NOT REQUIRED
	L	L	N	L	SPEED/MANUAL FLOW CONTROL: NORMAL	NOT REQUIRED
					AUTO FLOW CONTROL: INCREASE FLOW IN ONE PRIMARY LOOP	NOT REQUIRED
	H	H	N	H	SPEED/MANUAL FLOW CONTROL: NORMAL	NOT REQUIRED
					AUTO FLOW CONTROL: DECREASE FLOW IN ONE PRIMARY LOOP	PRIMARY RSS RESPONDS UPON DEMAND

CONCLUSIONS

- FOR NORMAL OPERATION, THE PRIMARY AND SECONDARY REACTOR SHUTDOWN SYSTEMS INDIVIDUALLY MEET SINGLE FAILURE CRITERIA OF IEEE 279.

- DURING TESTING OF PROTECTION CHANNELS, BOTH SYSTEMS TOGETHER WILL MEET SINGLE FAILURE CRITERIA OF IEEE 279.

ICSB REVIEW TO DATE

I. THE FOLLOWING MEETINGS HAVE BEEN HELD WITH THE APPLICANT AND WESTINGHOUSE

- o NOVEMBER 17, 1981, CRBR OVERVIEW
- o DECEMBER 3, 1981, CRBR CONTROL ROOM DESIGN AND EVALUATION PROCESS
- o DECEMBER 10, 1081, EMERGENCY PREPAREDNESS
- o DECEMBER 14, 1981, CRBR INSTRUMENTATION AND CONTROL
- o JANUARY 11 & 12, 1982, PROTECTION SYSTEM HARDWARE
- o FEBRUARY 24, 1982, LOOSE PARTS MONITORING
- o FEBRUARY 25 & 26, 1982, CHAPTER 15 ANALYSES

II. REQUEST FOR INFORMATION TRANSMITTED TO THE APPLICANT ON MARCH 24, 1982 (CONTAINED 59 ITEMS)

III. DRAFT CP SER COMPLETED (STAFF & CONSULTANTS) ON AUGUST 24, 1982 (CONTAINED 86 ITEMS INCLUDING THE 59 ABOVE, THE MAJORITY OF THESE WERE CLARIFICATION OF DOCUMENTATION OF CRITERIA)

9/30/82

Mauck
T13

ICSB REVIEW TO DATE (CONT'D.)

IV. MEETING WITH THE APPLICANT AND WESTINGHOUSE WITH REGARD TO THE 86 ITEMS (SEPTEMBER 21-23, 1982) (APPROXIMATELY 30 ITEMS REMAIN UNDER REVIEW AS A RESULT OF THIS MEETING)

STATUS OF REVIEW

I. REVIEW IS BEING DONE IN ACCORDANCE WITH THE STANDARD REVIEW PLAN (SAME CRITERIA APPLICABLE IN THE I&C AREA).

- o THE STAFF IS USING CONSULTANTS FROM EG&G IDAHO INC. (IDAHO FALLS)

II. EXAMPLES OF ITEMS IMPORTANT UNDER ACTIVE REVIEW

A) PRIMARY AND SECONDARY SHUTDOWN SYSTEMS SHOULD EACH MEET IEEE-279

- o DIVERSITY (POWER SUPPLY COMMON MODE FAILURES)
- o SINGLE FAILURE
- o ELECTRICAL SEPARATION
- o PHYSICAL SEPARATION
- o TESTABILITY
- o MANUAL INITIATION
- o CONTROL/PROTECTION SYSTEM INTERACTIONS
- o RESPONSE TIME

B) SENSING LINES

- o PROTECTION FROM FREEZING (SODIUM, WATER & STEAM)
- o SHARING OF COMMON INSTRUMENT LINES OR COMMON INSTRUMENT TAPS

9/30/82

STATUS OF REVIEW (CONT'D.)

c) DIRECT HEAT REMOVAL SYSTEM (DHRS)
  - o SAFETY GRADE
  - o SEPARATION FROM SGAHRS
  - o SHARING OF PROCESS PARAMETERS
  - o DIVERSITY
  - o INDEPENDENCE

d) REMOTE SHUTDOWN SYSTEM (RSS)
  - o APPLICANT IS RESPONDING TO THE STAFF'S RSS POSITION

e) STEAM GENERATOR AUXILIARY HEAT REMOVAL SYSTEM (SGAHRS)
  - o SAFETY GRADE
  - o SINGLE FAILURE
  - o AUTO-INITIATION CAPABILITY
  - o FAIL-SAFE ANALYSIS
  - o DEGREE OF DIVERSITY
  - o TESTABILITY

f) SOURCE RANGE MONITORS
  - o NEED FOR PROVIDING TRIPS TO THE PROTECTION SYSTEM (SAFETY GRADE)
  - o NEED FOR AN INTERMEDIATE RANGE TO OVERLAP THE SOURCE RANGE

STATUS OF REVIEW (CONT'D.)

g) MULTIPLE CONTROL SYSTEM FAILURES (INCLUDING POWER SOURCES, COMMON SENSORS, COMMON HYDRAULIC HEATERS, AND COMMON IMPULSE LINES) AND HIGH ENERGY LINE BREAKS (CAUSING CONTROL SYSTEM FAILURES)

- APPLICANT IS RESPONDING TO THESE QUESTIONS

9/30/82

FUTURE ACTIONS

I. REVISED DRAFT CP SER TO BE WRITTEN (NOVEMBER 1) TO REFLECT THE STATUS OF REVIEW.

II. FUTURE MEETINGS TO BE HELD WITH THE APPLICANT AND WESTINGHOUSE TO DISCUSS REMAINING ISSUES (NOVEMBER THROUGH FEB.)

III. FINAL CP SER TO BE WRITTEN FOR PUBLICATION (MARCH 4) TO REFLECT THE STATUS OF THE REVIEW.

9/30/82

PURPOSE OF REVIEW OF REACTOR CONTROL ROD SYSTEMS

- ACCEPTABILITY OF THE CRITERIA CITED BY THE APPLICANT.
- ACCEPTABILITY OF PROPOSED DESIGN.

Moran

T14

REACTOR CONTROL ROD SYSTEMS REVIEW

THE FOLLOWING MEETINGS HAVE BEEN HELD WITH THE APPLICANT, WESTINGHOUSE AND GENERAL ELECTRIC CO.:

- o JANUARY 25, 1982: SEISMIC AND DYNAMIC QUALIFICATION OF ELECTRICAL AND MECHANICAL EQUIPMENT REVIEW WITH APPLICANT.
- o MAY 11-12, 1982: PSAR CHAPTER 4 REVIEW WITH APPLICANT.
- o MARCH 29 - APRIL 5, 1982: MEETING WITH GENERAL ELECTRIC REGARDING DETAILED DESIGN OF THE SECONDARY CONTROL ROD SYSTEM, VISIT TEST FACILITIES AND LOOK AT TEST ARTICLES, SUNNYVALE AND SAN JOSE, CALIFORNIA.
- o APRIL 7-9, 1982: MEETING WITH WESTINGHOUSE REGARDING DETAILED DESIGN OF THE PRIMARY CONTROL ROD SYSTEM, VISIT TEST FACILITIES AND LOOK AT TEST ARTICLES. WALTZ MILL, PA.
- o MAY 4, 1982: MEETING WITH GENERAL ELECTRIC REGARDING DETAILED DESIGN OF THE SECONDARY CONTROL ROD SYSTEM. SUNNYVALE, CALIFORNIA.

REACTOR CONTROL ROD SYSTEMS

THE APPLICABLE SECTIONS OF THE STANDARD REVIEW PLAN WHICH ARE BEING FOLLOWED ARE:

- SECTION 3.9.4 CONTROL ROD DRIVE SYSTEMS
- SECTION 4.5.1 CONTROL ROD DRIVE STRUCTURAL MATERIALS
- SECTION 4.6 FUNCTIONAL DESIGN OF CONTROL ROD DRIVE SYSTEM

REACTOR CONTROL ROD SYSTEMS

THE FOLLOWING ARE EXAMPLES OF ACTIVE AREAS UNDER REVIEW:

- SECONDARY CONTROL ROD HYDRAULIC IMPULSE SCRAM ASSIST FORCE IS BEING REVIEWED
- POSSIBILITY OF THE PRIMARY CONTROL ROD DRIVE SYSTEM STEPPER MOTOR DRIVING OUT A CONTROL ROD INADVERTENTLY IS BEING REVIEWED
- SECONDARY CONTROL ROD LATCHING MECHANISM FUNCTION AND STRENGTH ARE BEING REVIEWED
- SECONDARY CONTROL ROD TESTABLE SCRAM VALVE FUNCTION IS BEING REVIEWED
- SEISMIC CLASSIFICATION AND TESTING OF PRIMARY AND SECONDARY SYSTEMS ARE BEING REVIEWED

1.4 VIEW GRAPH

REACTIVITY CONTROL

CRITERIA CONSIDERED APPLICABLE TO REACTIVITY CONTROL SYSTEMS

PRINCIPAL DESIGN CRITERIA

1. QUALITY STANDARDS AND RECORDS
2. DESIGN BASES FOR PROTECTION AGAINST NATURAL PHENOMENA
3. FIRE PROTECTION
5. ENVIRONMENTAL & MISSILE DESIGN BASIS
8. REACTOR DESIGN
11. INSTRUMENTATION AND CONTROL
20. PROTECTION SYSTEM INDEPENDENCE
21. PROTECTION SYSTEM FAILURE MODES
23. PROTECTION SYSTEM REQUIREMENTS FOR REACTIVITY CONTROL MALFUNCTIONS
24. REACTIVITY CONTROL SYSTEM, REDUNDANCY AND CAPABILITY
25. COMBINED REACTIVITY CONTROL SYSTEMS CAPABILITY
28. QUALITY OF REACTOR COOLANT BOUNDARY
58. PROTECTION AGAINST ANTICIPATED OPERATIONAL OCCURRENCE