MR. HOPKINS: Right, and I wasn't trying to insinuate that.

CHAIRMAN WALLIS: And so you don't want a letter from us. I think it would be inappropriate for us to write a letter now until perhaps you have reached some firm conclusions on these points. Is that a correct assessment?

MR. HOPKINS: I agree with that assessment, yes.

CHAIRMAN WALLIS: And so you are going to appear before the full committee?

MR. HOPKINS: Yes.

CHAIRMAN WALLIS: Is that what we plan to do? And do you somehow have to shorten this presentation to something that the rest of the committee needs to know?

DR. BOEHNERT: We can discuss what we want to do as far as having them come before the committee next month. There are some issues that --

CHAIRMAN WALLIS: You do need to focus on some other issues that we need to worry about. That is the important thing. Otherwise, it is really a question of whether you are on track with your review, and that is more of a management issue for you folks than it is for us. We may have an opinion, but it is not really our job to plan your activities.

MR. HOPKINS: Yes.

CHAIRMAN WALLIS: We may catch you in the hallway and say something about that and say whatever.

MR. HOPKINS: I understand that it is a management decision, and new priorities are looked at continuously. All I can say is that the Duane Arnold power uprate is a high priority.

CHAIRMAN WALLIS: I think we need to be somehow assured that the bases are properly covered and that things are done by October and something is not overlooked, and that is the sort of thing that we worry about.

MR. HOPKINS: I appreciate that.

CHAIRMAN WALLIS: Is there anything else from the other members of the committee at this point? Can we move ahead then. Is this Jack Rosenthal?

MR. HOPKINS: Yes.

CHAIRMAN WALLIS: Thank you very much.

MR. ROSENTHAL: My name is Jack Rosenthal, and I am the newly appointed branch chief of the safety margins and systems analysis branch. Farouk L. Quila (phonetic) is my division director.

DR. KRESS: Is that a new branch? I have never heard of that branch?

MR. ROSENTHAL: No, it is Farouk's branch. Farouk was promoted to be the division director.

DR. KRESS: I knew that and we need to congratulate him I guess. Did you change the branch name or --

MR. ROSENTHAL: No, no, the branch has always been the same, but it was Farouk's branch. This is a reorganization from a year ago March, and about every two years we reorganize. So Farouk became the acting division director, and I became the acting branch chief for a while.

DR. KRESS: And how it is no longer acting.

MR. ROSENTHAL: Right. And I am not pretending either. And although I am speaking from a branch perspective, I did coordinate what I have to say with the risk assessment people, and also with the division of engineering.

And we do fuels, thermal-hydraulics, and severe accidents, and consequence analysis. And I don't mean this to be -- I won't dwell on the point, and I don't want to be overly scholastic, but we see lots of system interactions that we can think of, and I have yet to come up with what I consider synergy.

And let me explain what I meant. I went

to my fuels expert, and he says, gee, if you run the fuel a little bit harder, or a little bit hotter temperature, don't you release more fission and gas, and he said, yes, we have known that for 35 years, and it is a sensitive function of the temperature.

And if you go to higher burnup, core average burnup, because you still want the same overall fuel cycle, don't you end up with a bigger fission -- and he said, yes, we know that also.

And I said, well, is there a situation where 3 percent and 3 percent ends up as 9 percent rather than 6 percent, and the answer was no. So that we sort of know these effects.

And so I have yet to come up with what I consider a synergy. And distinct from that, we know of lots of interactions. I mean, we clearly know that the fluents goes up and the effect on the vessel, which is small for a boiler --

DR. KRESS: Was this Ralph Myer that you were talking to?

MR. ROSENTHAL: Yes, sir, who is part of the branch. Some of the phenomenological interactions are things like the effect on the core instabilities that would be the result of -- well, as it turns out, if you have an ATWS, you trip the recirc pumps.

And once you trip the recert pumps, automatically you fall into the unstable breaches as it turns out, but what that would mean in terms of fuel performance is an outstanding question.

DR. CRONENBERG: Let me give you a synergy there, Jack. Flow assisted corrosion. Corrosion by itself will take a certain amount of time.

MR. ROSENTHAL: Right.

DR. CRONENBERG: And flow by itself would rip away material from a piping wall.

MR. ROSENTHAL: Right.

MR. CARUSO: But corrosive products with added flow could be a compounding effect. So you asked Ralph for a quick answer, and maybe you should have asked some materials people, and you might have gotten a different answer.

MR. ROSENTHAL: Fair enough.

DR. KRESS: And I think that Ralph is basically correct on those things that you said.

MR. ROSENTHAL: Okay. It is also somewhat of a management challenge for us, which we will address, to face up to some of these issues, because they are truly interdisciplinary, and I will give you an example.

Yesterday, I was talking with a true

expert in thermal-hydraulics, and I said, you know, if you push harder on the generator and you have not changed the generator, you will get more power and fewer BWRs, and he said what is a BWR.

So I raised my right hand and I said a BWR is -- and he said, oh, I remember. Okay. And the point is that what we need to do in this search for interaction synergies is to go across disciplines, and I will get back to that specific example in a moment.

And what I am trying to do is describe in fact researcher's plans, and that we are not currently doing a project, although I do owe my boss a formal memorandum of plan with tasks, and I owe that this month.

We intend to be quantitative in our assessment, and we have the ability to run codes like TRAC and we have coupled three, or it is now a module of TRAC, and so we can do 3-D based on kinetics.

And we intend to use that capability for things like ATWS, and it is because we believe that when we do the analysis that we learn a lot by doing some quantitative work.

CHAIRMAN WALLIS: So when will you do this?

MR. ROSENTHAL: In Fiscal 2002 and 2003.

CHAIRMAN WALLIS: But they want an answer by November of this year.

MR. ROSENTHAL: This is a generic, and not a --

CHAIRMAN WALLIS: So it is a long term anticipatory research?

MR. ROSENTHAL: Yes, sir. We will start with boiling water reactors. I think if there are some questions on PWRs and again involving ATWS, where there is the potential for more positive MPCs that we would like to look at.

But to the extent that we are dealing with real boiling water reactors, we are asking for extended power uprates, and that is where we should look first. But we will do some PWR work later on.

We are going to not focus on the Chapter 15 analysis. The licensee, the vendor, and NRR are pressing those issues; but rather to at least have our focus being on success criteria in --

DR. KRESS: I think that is really a good choice for you guys, because I think you can rely mostly on this staff's review of the licensees for the design basis stuff, and this is added value here.

MR. ROSENTHAL: Thank you. And we also would like to look at some of the generic issues and severe accident issues that would be part of -- or may not be part of and addressed otherwise. As I said, this is a two year effort.

Farouk did speak before this committee several months ago, and we have been through a budget cycle, and it is now as we see it a currently budgeted activity. We do intend to do the work, and distribute it at least amongst three branches.

So how will I -- well, this is a search for issues, and there may not be any. I do not have a smoking gun, and if I did, it would be my obligation to notify NRR.

So if we could look at this list, and we will look at blackout and loss of heat removal, and I think we will look at loss of coolant, because it is of interest to us, even though we recognize that in most PRAs that loss of coolant actions are not scenarios.

We want to also -- and I will say review, less significant accident sequences, and ask ourselves the question could these sequences -- because the success criteria may change -- become more important.

And the example that I could use, and it is only as an example in my thought process, is large break LOCA and boiling water reactor is clearly not a risk dominance sequence.

If we were to somehow conclude that with the flatter power distributions, core spray now is very important, and the core spray distribution is very important, and if there is a problem with it, then --

DR. KRESS: How would you look at that? Would you just go in with your code and arbitrarily say or do some power metric studies on the distribution and see what it does to success?

MR. ROSENTHAL: It is a capability that we have developed with TRAC, and put in a flat power distribution which we think is representative of what is going on. We won't know anything more about core spray distribution.

DR. KRESS: No, but you could arbitrarily vary that.

MR. ROSENTHAL: Yes, sir.

DR. KRESS: And the bypass amount that you get is okay.

MR. ROSENTHAL: And see if it affects the results. And it is conceivable, although I don't expect, that there is some problems with the success criteria.

If it were, then it would make something that is not risk dominant, and make it very important. That is the type of search we would like to do.

DR. KRESS: I think where your problems are going to be are in the carryover term, and I don't know how you deal with that. When you increase and flatten out the profile, I don't know what that does to carryover. But that is the only place I see where that could make a lot of difference.

MR. ROSENTHAL: Yes. But we think we ought to be looking at those, and not just -- well, at least do some looking, and we will do definitely some quantitative analysis, and we will do some reviewing of the less sequence and think our way through it.

I think we want to also review some of the prior generic issues. We put in this power/flow stability issue in that category, but there were other things that the agency faced and resolved in the past, like the hydro-dynamic loads on the Torus, which would be different now.

And we would intend to go back and look, and in fact what I intend to do is go down the list of generic issues that we have resolved and think our way through which things might be different at the higher power.

CHAIRMAN WALLIS: Do you know you have the

-- coupled with the neutrionics code, does it predict flow stabilities? Do we know that yet?

DR. KRESS: I don't think it does.

MR. ROSENTHAL: I don't know.

DR. KRESS: I don't think it does.

MR. ROSENTHAL: As I said, what I have brand new is this 3-D spaced on kinetics capability that we now have.

DR. SCHROCK: What is the name of that?

MR. ROSENTHAL: Well, it is a module, and we have made it into a module of TRAC and its parts, and that is from Purdue.

CHAIRMAN WALLIS: So one success that you could establish would be that you could model power flow stabilities with these codes, that would be a success if it hasn't been done before. I don't know.

DR. KRESS: Well, they have models.

CHAIRMAN WALLIS: And if you have a model and the codes can't do it, that's not so good. It would be better if the code did it by itself.

MR. ROSENTHAL: Well, then you have to know whether you trust what you have got. But in that case, it is an area that we would like to explore and we think it is appropriate to explore this area.

I have a related area, and that is that

again it is ATWS, where the concern is to have a rewetting of the clad, and will the temperature of the clads go up. And for that, we are actually looking at -- we have a fuel code called PROCTRAN (phonetic), and we are working with of all things the Fins on a subchannel code called GENFLO, and that will allow us to look at that phenomena.

And we can couple that with the TRAC work, but we want to look at other potential generic issues.

DR. LEITCH: I assume -- and not to pick on the words, but when you say Torus, I suppose that applies to other kinds of suppression pools as well?

MR. ROSENTHAL: Yes, to the extent that it was an issue.

DR. LEITCH: And so pool snow and all those hydrodynamic effects are also in Mark Iis?

MR. ROSENTHAL: Yes.

DR. LEITCH: Okay.

MR. ROSENTHAL: And we would also like to go back and revisit some of what I will term severe accident issues. You have the Mark I liner melt issue, and you are now potentially putting down more material with more decayed heat in it, and will it move out further across the floor and affect the liner.

That is something that we ought to look at as an example of a severe accident issue that we put to bed and that we could take a look at.

DR. KRESS: That was put to bed by the peaponus (phonetic) methodology.

MR. ROSENTHAL: Yes. I doubt if you could factor into that the increase through the power level. It is well -- well, the uncertainties are well beyond what you get out of that. I don't know how you would do that, but that is your problem.

CHAIRMAN WALLIS: They can try.

MR. ROSENTHAL: I know what you are referring to, but I think we have an obligation to try to look at the sphere of consideration.

DR. KRESS: Well, you quantify how much melt is going to come down.

MR. ROSENTHAL: Right.

DR. KRESS: So you might change that by a ratio of 20 percent.

MR. ROSENTHAL: But once it is on the floor, it has got more decayed heat.

DR. KRESS: Yes.

MR. ROSENTHAL: And the severe accident, the containment venting size for certain power, and we can go back and look if it sized with greater power as being representative issues that we thought that we would rethink.

Now, to whatever degree that has already been rethought, we don't have to instill again. But that was the scope of the kind of places that we thought that we would look to identify issues within the success criteria, and within the previously resolved generic issues, and within some of the severe accident issues.

And let me go outside my branch a little bit, and some of these things I found interesting. Let me get back to the generator again. If I am pushing more power through VARS, and in fact I have a somewhat less stable system electrically.

And if I am tripping 120 percent power offline rather than a hundred percent offline, that potentially also affects the grid. So I discussed that with the PRA people, and they said, yes, those things are true, but we don't know how to quantify them, or at least now we don't know how to quantify it.

It would be something that we ought to look into, and that the risk may be dominated, a blackout, by harsh weather events, or external events, like seismic events in the past, and so these things may not be important.

But that is a good illustration of where the -- of the feedback between the electrical discipline and the thermal hydraulic systems.

CHAIRMAN WALLIS: VARS are reactive -- you have kept us in suspense by saying that some thermo-hydraulists don't know what VARS are.

MR. ROSENTHAL: We also would like to look at the possibility that just electrical equipment is going to be running hotter throughout the plant. So the division of engineering is interested in that.

And the division of engineering is interested in loads and vibrations, and fatigue, and thinning, and corrosion, although just as you heard just a little while ago, we don't have a good link between those issues and the ability to quantify them, which maybe be a capability that we would like to develop.

With the primary system, we will look at things like the vessel, and we will attempt to think our way through on piping loads. On containment systems is where I meant to have the cable, and where we already have experience.

I remember Pilgrim ended up baking a lot of cable up in the upper head and having to replace cable. Now, on one hand, just as you heard earlier from NRR, there were programs in place to monitor, and when people find that stuff no longer works, or it gets changed down, that doesn't mean that there is a safety issue.

But nevertheless we think there are going to be issues of thermal fluences and running hotter in containment. I meant to have a bullet under containment on the cables specifically.

And then of course we are interested in the higher pool temperatures and the effect on NPSH of equipment. There may be control systems issues that we didn't recognize, in terms of things like steam, to condensers, and if that fails, you are pulling more steam out and how does that affect the thermal-hydraulics.

And the PRA people will look at the human response times. So that is for the human error rate. So that is the scope of the considerations that RES would like to do.

CHAIRMAN WALLIS: It sounds big to me. It sounds like a large scope. What is the funding that is anticipated?

MR. ROSENTHAL: The scope of the FY '03 budget is not out yet.

CHAIRMAN WALLIS: Is this going to be done in-house or are you going to hire some consultants?

MR. ROSENTHAL: I have an FTE in the branch and some contract dollars that would be a little more outside than inside, but yes, we will do some of the work inside in-house, through the other divisions.

CHAIRMAN WALLIS: Do you have the capability to model these systems with your codes and computers and it is not a big struggle to get all the information that you need to do that?

MR. ROSENTHAL: There is always a loop around, and there is always the struggle to come up with DAECs.

CHAIRMAN WALLIS: Is G.E. going to give you DAECS, or is something going to give you DAECs?

MR. ROSENTHAL: We are planning on using an existing one, and for some of these other issues that involve that involve either the PRA group or the division of engineering, it is obvious that there are concerns, and I don't know how we are going to go about quantifying them.

CHAIRMAN WALLIS: I think you have a management concern. You have got so many issues that you might involve, let's say, a dozen people.

MR. ROSENTHAL: Yes.

CHAIRMAN WALLIS: And you are going to ask for a few hours of a dozen people to make an assessment which is not superficial, and which is then going to be coordinated by some people who can put it all together and figure out if it means anything.

DR. KRESS: Jack can do it.

CHAIRMAN WALLIS: So you are going to be the guy doing the work and not managing it?

MR. ROSENTHAL: Within the branch which I control, we do intend to do it. I have somewhat dedicated resources to work, on at least the thermal-hydraulic issues.

CHAIRMAN WALLIS: And when they come in front of this committee are they going to give crisp answers and not waffle?

MR. ROSENTHAL: The intent is to give yo numerical answers.

CHAIRMAN WALLIS: Good.

MR. ROSENTHAL: The last part, you had a discussion in terms of the source terms and consequence analysis,and we do have the capability to generate source terms, and we do have the capability to run consequence analysis using math and that was not in my mental larva of what we would do at this time.

CHAIRMAN WALLIS: I think we should keep this piece of paper.

MR. ROSENTHAL: And you are going to hold me to it?

CHAIRMAN WALLIS: Absolutely. I will put it up on my wall. When are you going to come and tell us, in 2002 or 2003, and we will have a reorganization by then, and you won't be in charge.

MR. ROSENTHAL: I would prefer that the next time that we would come before the committee would be sometime in late Fiscal 2002, when we had results of something to show you.

CHAIRMAN WALLIS: Yes, this is a very ambitious program.

MR. ROSENTHAL: As distinct from a -- you know, I can share the -- well, as I said at the beginning, I have to write a program plan, and that I would be perfectly willing to do.

CHAIRMAN WALLIS: Well, we see a lot of plans, and results are what really matter.

DR. KRESS: I would like to see your plans, too.

CHAIRMAN WALLIS: Oh, I know that we would like to see plans, but --

DR. CRONENBERG: But this is really one FTE, right?

MR. ROSENTHAL: No, no, no. My branch is one FTE, and --

DR. CRONENBERG: And so all the other branches have some money for this? What is the total program?

MR. ROSENTHAL: As Farouk said, it would be 850K and --

CHAIRMAN WALLIS: That's big.

DR. CRONENBERG: That is significant.

CHAIRMAN WALLIS: So it is going to be a big fat new Reg report that addresses all these issues?

DR. KRESS: Well, that can be decided later.

CHAIRMAN WALLIS: Well, there is the opportunity to do something like that, and put together some really authoritative report which addresses all these issues, and finds out the ones that are important and gives us some good answers.

MR. ROSENTHAL: I just hope that I have not been overly enthusiastic enough. The thermal-hydraulic analysis we can clearly attempt to do, and we will do it and get the results, and we will write the report on that.

CHAIRMAN WALLIS: Is that first?

MR. ROSENTHAL: On some of the other issues like if there is a small incremental change in the grid reliability can you actually ever quantify what that is, and can you put that back in your PRA, I can't make promises on that. That is really state-of-the-art.

And putting in pipe degradation back in the PRA is state-of-the-art stuff. So that is much harder for me to make promises on that.

DR. LEITCH: Professor Wallis, I think we can deal with additive things intuitively, but I would hope that if there are some subtle synergistic effects that come to light that we would be made aware of those prior to late 2002.

And if there are such things that surface, that we be notified, because we have been doing a lot of thinking about these things ourselves, and we have a concern, but I am not sure that we have identified any specific synergistic issues.

But should there be some, I for one would like to be aware of it as soon as you have a sense as he does.

MR. ROSENTHAL: At the beginning, I said

that I have no smoking gun. If we found a technical issue, we would feel obligated to --

CHAIRMAN WALLIS: Well, I don't know if it is a smoking gun. Smoking guns are usually after the event. It is more like a smoldering fire or something. It is something that could grow into something important.

So thank you very much, and you have helped us to get to go to lunch before 12:00 noon. So we will reconvene at one o'clock.

(Whereupon, the meeting was recessed at 11:58 a.m.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

(1:01 p.m.)

CHAIRMAN WALLIS: We are now going to hear a presentation by ACRS Fellow Gus Cronenberg, who has studied the matter of power uprates for a period of time and is going to give us some insights on his conclusions.

DR. CRONENBERG: Okay. I have two presentations, Graham. I went through this last week at a full ACRS meeting, and so what I plan to do is go through the margin reduction estimates fairly quickly, and then go to the review of some LERs operating experience for power uprates for a number of incidents, such as the Wolf Creek incident, and Maine Yankee, and some of the pipe ruptures that we saw.

And some safety implications of those operational events. So I will run through this fairly quickly, but this was a chart that ACRS gave me at the beginning of the year to try to figure out what are we talking about, and their concern about margin reductions for the significant power uprates that were coming in this year.

My overview is basically a little bit of margin reductions in the regulatory process, and I will go through that real fast; Estimates for power uprates, and estimates for renewal, and findings.

I think everybody here knows what we are talking about when we talked about margins, and it is always used in a general sense.

For example, when a design criteria in 10CFR50, it says reactor core and associated coolant, control, and protection systems shall be designed with sufficient margin to assure acceptable design limits.

And we have other various criteria throughout Appendix A of 10CFR50. Again, in containment also, including access openings, penetrations, et cetera, shall be designed without exceeding leakage rates and with sufficient margin.

So that basically the rule of law says that there shall be some margin that shall not be exceeded in nuclear power plant designs.

These margin requirements are more explicitly spelled out in regulatory guidance and the standard review plan, and basically the standard review plan for the construction permit essentially defines what the margin shall be.

Basically, there are pressure limits, pressure temperature limits, stress limits, ductility limits on cladding, and allowable materials that can be used, and then those go down into the ASME, for example, and --

CHAIRMAN WALLIS: Gus, limits are not the same as margin though are they? I always thought they were two distinct things.

DR. CRONENBERG: Well, basically there is allowable margin if you don't exceed these limits. It is basically what the regulatory inspection says, and that if you don't exceed a design parameter, then they say you --

CHAIRMAN WALLIS: Well, yes, that is one view of margin, that it is built into the limit, and the other view of margin is that even if you stay below the limit, then you have some extra margin, and that is the margin that is often discussed; is the margin between where you are and where this limit is, which itself has a margin.

DR. CRONENBERG: Well, maybe the best thing is by example then, and basically a licensee will come in with an application and say I have a pressure in this -- that my pressure in this piece of piping is a thousand psi, and the design limit for that by the ASME pressure vessel code is 1,250 psi. Therefore, I have adequate margin.

And that is basically all that he will say, and the same thing with ductility limits on cladding. I predicted for this amount of burnup and I will not exceed 14 percent cladding oxidation, and the cladding limits are 17 percent on station limit, and I have sufficient margin.

DR. KRESS: But I anticipate that they are going to come in and say that the design pressures -- I don't remember what number you said, but --

DR. CRONENBERG: Well, 1,250.

DR. KRESS: And I anticipate that they are going to come in and say that our calculations show that our pressure is 1,249. Therefore, we have adequate margin.

DR. CRONENBERG: Well, they will never get quite that close, but they will always say in the application that we have adequate margin.

DR. KRESS: But that is an example of what I think is going to happen, and what should be the response to that is that they probably do have adequate margin because it is built into the design limit like you said.

DR. CRONENBERG: Well, that is for you people and the staff to negotiate what that should be if it came that close. And I will show you an example where the margin was exceeded in the design.

DR. KRESS: And my own feeling is that

whether that is adequate margin or not depends on the uncertainty of the calculation. There is a large uncertainty in that calculation.

Maybe they don't have adequate margin, and I think the staff tended to agree with that view and said that's why they want to see more, and the closer you get to that margin, they want to see more uncertainty analysis.

Or the flip side of that coin is the design pressure for a piece of pipe that is 1,250 psi, and yet that piping broke at a thousand psi because it had the flow assisted corrosion or something.

So, you know, those things do happen, and we just passed Aconie, and said there was plenty of margin left in the control rod housing, and six months later they found cracks. So even when we think we know everything, sometimes we don't.

Okay. Impact of power uprates on plant operating conditions and margins. Basically, for a power uprate, you have a coolant enthalpy changes, and flow rates, and coolant temperatures, and fuel temperatures, and then you have usually some major changes to operating conditions on the secondary side.

Here are some examples, and as I said, I am going to run through this quickly because ACRS has already seen this. What we are talking about here is a fleet of aging plants, 25 or 30 years old, that are coming in for major power uprates.

So this is why the ACRS asked me to look at this question of what we are talking about as far as pushing these plants further out for license renewal, and power uprates, the same fleet of plants that have been around for quite a while.

And what are we talking about in terms of margins. I used as a case study, and I only looked at one, and I am not talking about Duane Arnold today.

I looked at a case study, the Hatch, because the Hatch had two power uprates. Hatch is under current review for license application, and Hatch was also a lead plant, Monticello and Hatch, for the G.E. extended power uprate program.

It is an older plant, an early '70s vintage plant, BWR-direct cycle Mark-I containment, two power uprates in '95 and '97. And it is also under current review for license application.

So I looked at what the impact of those two separate actions on the plant, and basically we have a direct cycle plant, and so what I did was march around the primary system, and the secondary system, and see what I could see as far as design parameters, and changes in design parameters, and therefore changes in margins.

For recirculation, piping, the feed water piping, the primary steam piping, and that sort of thing, and what was the impact of the power uprates and the license renewal on those kinds of systems.

Okay. Here is -- and I don't know if you can see that clearly, but these are the powers for unit one and unit two. They are sister units, and essentially the same power, and what was changed. For example, the steam flow rates were increased from an original 10 to 10.6, to 11.5; and steam dome pressure, the original was 1015 and then it jumped to 1050, and then a constant pressure type of uprate to 1050 again on the second power uprate.

The temperatures changed from the first to the second, and of course the feedwater flow rates and temperatures increased progressively as you went up in power.

There were two types of margins, and I wrote down operational conditions, and then also what are the changes in margins for design basis LOCA conditions; and that I also looked at fatigue estimates for the license renewal from the time limited aging analysis.

My margin was based on what I would call a definition of -- well, it doesn't say there shall be adequate margin, and that is what the rule says, 10 CFR 50.

Basically, I said that you can't exceed the design limit from the ASME pressure vessel code. So the operating parameter scaled to the design pressure, or design temperature, or whatever.

Okay. The main steam line pressure, we saw that increase from 1015 to 1050, and the design limit for that piece of piping is 1250 psi. So we had a margin of 18 percent when we built the plant, and reduced to 16 percent.

So there is a 2 percent degradation in margin, and one would say that is not much of a decrease in margin. The same with steamline pressure. The design pressure or design limit for that piece of piping is 1575, and we go from 546 to 551.

So we go from 5 percent to 4 percent margin, and of course, from what Dr. Kress said, there is also excess margin above the ASME allowable design parameters.

Feed water piping, and 1650 is the design limit, and we go from 1130 down to a lower pressure, and then the feedwater piping temperature we increase.

So we go from 30 percent margin to 28 percent margin.

So nothing major so far here as far as operational conditions. However, if we start looking at LOCA conditions, things change a little. The reductions in predicted margins become greater, and when I get into my next set of slides, we will look at, for example, the Maine Yankee experience, which was not a very pleasant experience.

But that was as you know related to a power uprate for Maine Yankee. They could not quite satisfy their LOCA conditions, and I will get into that story in a little while.

DR. SCHROCK: And when you are talking about percentages, they are based on what?

DR. CRONENBERG: Just the design limit over the value, and how the value changed as a function of power. We went from whatever it was -- well, from 392 to 4000.

DR. SCHROCK: And do you need sort of an absolute number denominator?

DR. CRONENBERG: Yes, it is. It is the 562. It is the design limit.

CHAIRMAN WALLIS: And we could make it degrees --

DR. SCHROCK: Yes, that is what I was

getting at. You can get a different answer if you use --

DR. CRONENBERG: Oh, I see. I just used -- it is specified in terms of degrees fahrenheit, the design limits, and so that is what I used it as.

DR. SCHROCK: You probably shouldn't express it as a percentage.

DR. CRONENBERG: Well, this is just a signature. I am trying to give a feeling for what things are changing, and --

DR. SCHROCK: I know what you are trying to do, but the significance of the number should not be dependent on an arbitrary choice in the system of units that you want to use.

DR. CRONENBERG: Well, margin is in and of itself kind of an arbitrary term used in the regulatory process, and we will never find a definition of you can't exceed a parameter by .2 percent or something.

You do have things in terms of allowable dose limits, and that sort of thing.

The only things that we have are design parameters in the boiler and pressure vessel code, or curies, or dose, or something like that.

Okay. Here is some predictions for the

Hatch plant on the design of LOCA calculations. For example -- I wanted to go to the primary system first -- here is one for the vessel shroud and support weld, the vessel shroud and head bolts, and the access cover plate.

All right. The vessel access cover plate, et cetera. Now, all these numbers I got from the licensee's own submittal, okay? The safety analysis report, the SAR, and the SER. I didn't go beyond that. I just used the licensee's own numbers.

And, for example, the predicted stress at the original power at the support welds was 8.9 kilopounds per square inch, and it jumped to a 9.05. So not much change in margin there. The same for a head bolt.

Now, this access hole cover plate is an interesting comparison, because it looks like with an 8 percent power uprate; that between the first uprate and the second uprate that there was an 8 percent power increase.

The predicted stress jumped from 64 to 90, but that is a little unclear because -- and one of the conclusions that I am going to make in my presentation today is that I don't think either the safety analysis report, nor the NRC's safety evaluation report, the SER and the SAR, give you enough detail and enough information to do a good job on margin assessment.

I don't know if it is the number one bolt in the first calculation, and the number six bolt in the second calculation. I don't know if you had superimposed loads. I don't really know if one was a seismic induced and one was not a seismic induced.

You don't get in the SAR a picture of the EISO bars for the stress predictions for all the components. All you get is a little summary table saying that these were my predicted stresses for these 5 or 6 components.

And then the SER basically says that we had no problems or we requested information on this particular number.

So if ACRS is asking for a detailed assessment of the impact of a power uprate on margins, I can't pull it out from the data that I worked out from the historical FSARs.

And there is no defined criteria; that this piece of information shall be given for this component every time you do an uprate, so that you can compare apples and apples, and so you can get an historical picture of what is happening to this reactor over time, and for the various licensing actions

Also, you change models and you change calculational procedures, and there is not enough detail in what we get I believe from the applicant, or what I can find out in the evaluation report by the agency.

So I don't know how we are going to get a good handle on margins if that is what this committee is concerned about, and that will be one of my conclusions. The information base to me is sketchy.

DR. FORD: Just to go back through that, did you ever resolve the question of whether the --

DR. CRONENBERG: No, I looked back and I couldn't tell which bolt it was for, and I couldn't tell the exact details of the boundary conditions on the stress calculation. There was not enough detail.

What I can tell you is, and what I told you before, that access plate was replaced because of what was found at Peach Bottom. They found stress corrosion cracking in the welding of that plate, and then the NRC required that they do inspections at each outage.

And the licensee, because the inspection program was going to cost them so much, they decided to just replace that access cover plate. I don't think it resulted from these kinds of numbers.

But from my reading, I couldn't get a good indication of what are the boundary conditions in the stress calculations. They are not discussed in the submittal, and they are not really discussed in the evaluation report.

But all I saw was tables and these are the numbers, and it is probably hard to go back to something in '95 and ask for that contractor report. Sometimes it is not even the licensee.

The licensee will go to G.E., and G.E. will go to Structural Analysis Associates, and I will show you some of what you have to backtrack to pull the information out when we get to the time limited aging analysis.

It was not easy to pull information to get these numbers. And then we had the same thing on the margins on the LOCA conditions for the containment, and for the drywell pressures, we go from a 14 percent margin down to a 10 percent margin.

In some cases the peak drywell gas temperature exceeds the design limits, but you look at the calculations, and it is for a short period of time. So the NRC says that's fine.

It is only for a short period of time, and it is basically a few seconds in this calculation during the flow-down, and the exemption is still granted, and you can't go up in power.

And then the same suppression pool temperature, of course, and the temperature goes up because you have higher power, and the margin goes down.

But there is nothing major here so far, except for what we saw for that access cover plate. Since I am interested in the license renewal, I think you can get a better handle on margins. There is more requirements that go into a license renewal application going from 40 to 60 years operation conditions.

We have a standard review plan that is based on several years of agency efforts between the staff and ACRS going back and forth on what will be required for an adequate submittal on license renewal.

And there is a lot of calculations there, and you can calculate margin, and it is more clearly documented. It is easier to pull out something on margin reductions if it is more clearly documented.

Basically, I looked at the time limited aging analysis, and we talked about this this morning, and the cumulative usage factor for the questions of fatigue that Peter was bringing up.

And we heard a response from the NRC staff that for these uprate applications that the staff is requiring some cumulative usage factor estimates.

And then I said that was the first time that I had seen from the applications that I looked at in the past, and I never saw any cumulative usage factor estimates for pipes or any real components.

And this was new to me, and I think it is a good way to at least get a handle or a feeling for degradation and the effects of increased flow, and increased vibration, aging, and that sort of thing.

And accumulative usage factor is just a fatigue estimate, and basically it is based on historical data, and then projecting that out in time.

And we can see what the estimates are for the heat removal suction piping at 40 years, and basically you can't exceed one, and if you calculate one, then you have to do something for that component.

It is essentially from the agency's point of view it has filled up its bucket as far as fatigue in Ralph's analogy of a bucket. So we have some buckets for irradiation induced embrittlement, and we have buckets for fatigue, and so forth.

We have some buckets that we fill up for pressure temperature limits, and for license renewal, I don't know how many buckets we look at for the power uprate. It is not as clearly defined for me.

And then you can estimate it for 60 years, and so your residual margin here went from 43 to 23, and feedwater piping has a margin of 39 percent down to 17 percent.

It looks like if this is an accurate prediction of what is happening over time, then you did increase your fatigue on that piping, and you reduce margin.

It is something anyway, but to get these estimates, these cumulative usage factors will not or are not part of the licensee submittal. They are not a part of appendix material.

This was referenced in Appendix C of the license submittal. I asked for these numbers from the staff, and we couldn't find them. I had to go back and go through Brent Busher, and he had to go back to the licensee.

And the licensee had to go back to the subcontractor, to G.E., to get these numbers. That's why I am saying that sometimes it is hard to pull this information out.

If this committee wants to know something and this agency wants to know something about margins, it is going to have to define what is required and what kind of information we are going to keep. Right now we don't have a clear definition of that.

The pressure temperature limits were in the Appendix E of the license renewal application for the Hatch plant, and we did have those numbers in-house.

And basically that if you have a certain pressure of a piece of piping, you have to have a certain temperature to keep that pipe ductile enough.

And because of irradiation embrittlement the ductility is going down with irradiating dose and time, and so the temperature has to get and higher, and higher, and higher. So these are estimates in Appendix E of the license renewal for 36 effective full power years, 40, 44, 48, 50.

We go from a margin of say about 30 to half that at 60 years. So to me there is a clearer indication of margins and how they are affected for the license renewal, because we thought about it, and we thought it through over a number of years, and we know something about aging, and fatigue, and flow assisted corrosion.

And we asked the licensee this is what you have to submit to us to show that this plant will be good for another 60 years, and have we clearly thought that through for significant power uprates for an aged fleet of plants, and that is the kind of question that I think is really before this committee. What does this agency need to be looking for.

Okay. These are just data sources. Again, I wanted to really indicate to you that you have to look at a lot of different data sources. It is not easy to pull all of this together, because every licensing action is an individual action.

We look for a power uprate in an individual way. We look for extended fuel burnup as an individualized licensing action. We look for a license renewal in that individual licensing action.

No one puts this all together in terms of margins for the plant as a whole. The point of this slide is that this is all the information that I got out and it was proprietary information as an appendix to the LOCA calculations for the Hatch SAR, and these were the stress calculations.

It is a summary table and very little is told you about the boundary conditions, the models, and so forth that I used in there. So it is hard to predict from one power uprate to another, because they will give you different components or different bolts, or whatever.

So the task that you asked me to do was almost an impossible task to give you a clear answer, because we don't have clear dictates on what is required on calculational results.

It is just tell me what the maximum stress is for a couple of components, and that is basically what you get in a summary report. The analogy to me is when we went to the IPEEE process. We didn't ask for the dependency tables in the PRA.

All we asked for is a summary report, and then we tried to glean information out, and it was hard to pull, and then we started asking questions. Well, what does this mean. Well, we only have summary reports and we don't have dependency tables.

DR. FORD: So do the stresses change?

DR. CRONENBERG: The loads are different because the blowdown loads are different because of the power increase. The coolant enthalpy is increased and the blowdown loads are increased.

DR. BOEHNERT: Gus, you should probably pull that slide. That is proprietary material and we are in an open session.

DR. CRONENBERG: Okay. Sorry. And a lot of this information is also proprietary. All right. Summary and observations to date. Safety margins are used in a very broad sense and in the regulatory process.

And there is a lot of difficulty in getting consistent data to assess the margin impact. Different models change, and things that are looked at change from one uprate to another.

There was some success nevertheless from Hatch, and that's why I titled my talk "Signatures of Margin Estimates and Margin Reductions." We get some sign posts here and there of what is going on but we don't have a good integrated assessment of what the margin impact is for that whole plant.

You can't tell if it is a synergy and you get it for a piece of pipe or a bolt, or something, but it is not the plant as a whole. Generally though as you might expect from the start before we even looked at this, that there is some reduction in margins because you increase power and you increase LOCA based stresses.

And you increased pressures and temperatures on piping and that sort of thing. So there is some indication of a degradation in margin from design limits.

And also I believe the SARs, and what we are requiring in the SARs and the SERs do not appear to be of sufficiency, detail, and consistency to make a good assessment of a margin impact on this particular licensing action.

I think that the data is too sketchy to give you a good feeling for margin. Basically you will see in the SER and what -- and basically all the agency is required to do is to assess the current regulations are satisfied. That is what we regulate.

The kinds of concerns that this committee has, you go, well, will we be caught in the Maine Yankee situation, and you look at it in a little broader sense.

What is the real safety impact, and so the questions asked by this committee are probably a little different than the questions asked by the staff.

And to answer the questions that the committee has asked me to look at is -- well, you can't get a clear answer as to that. I do have some suggestions on power uprates, and these are observations, personal observations and suggestions that tell me what should be asked for.

Basically, the NRC uprate review process centers on the assessment of current regulatory requirements are satisfied. There is no requirements for risk impact, margin reductions, or impact of multiple licensing actions and synergies.

It is just that the current regulatory requirements are satisfied, and that is rightly so what the staff should be looking for. Nevertheless, I endorse prior recommendations from the Maine Yankee lessons learned report.

You know about the Maine Yankee history here, and one of the principal conclusions of the lessons learned was that we need a standard review plan. We need some sort of guide post, and the G.E. uprate and extended power uprate is one step in that direction.

And basically for the PWRs, the last thing we had on the power uprates was for guidance, and we never had a guidance from CE, and we never had guidance from BWR, and we only have a W-Cap report from 1984 for the Westinghouse.

And that is the last time that we had guidance come in from vendors on what it takes to do a power uprate for a PWR. PWRs still follow the W-Cap guidance from 1984 that Westinghouse provided, which is a very minimal -- it is like a 10 page report. It just lists the kinds of things that you might look at.

Also, Scitech did a review for research, or it was for NRR or research, but it was a contractor report, and to do a review of the uprate applications to that time, and the Scitech conclusion also concluded that this agency would be better served if it had a standard review plan.

It looked at large variances for one upgrade application to another, and the review procedures, and there was no clear definition of acceptance criteria, and why you looked at this control rod drive.

In one case, you didn't look at control rod drive calculations, and on another you looked at fuel behavior effects, and on another you did not. Scitech's conclusion was basically that there was no clear guide posts for a review of uprate applications.

And they also endorsed a standard review plan, and the same with my 1999 recommendation, I also thought that this agency would be better served if it had a standard review plan in place for power uprates.

DR. LEITCH: In spite of all those recommendations, we seem to be moving forward without such a standard review plan.

DR. CRONENBERG: Partly because most of them, I guess, are for G.E. so far, and G.E. is ahead of the other plants.

DR. LEITCH: Yes, but the recommendations stemmed largely from Maine Yankee, which -- and as you said, it is more applicable to BWRs.

DR. CRONENBERG: Again, an uprate standard review plan might include a standardized listing of all system structuring and components subject to an uprate review. It kind of mirrors the kinds of things that we have in a license renewal application.

Assessment of impact on system structures and component margins for both operational and DBA conditions. A clear definition of methods to be used and acceptance criteria that the staff will review that application.

That is the kinds of things that we have in the license renewal application. We don't have a clear definition of, for example, acceptance criteria for the staff to review.

We have input from G.E. on what they will submit, but do we have a clear definition that this committee is comfortable with as far as acceptance criteria for the review of that application.

I also talked about something that I

called the legacy tables, and it is some sort of time line or history of what is happening with that plant as you go on in time, and as you uprate power.

Right now we don't have that a licensed application for an uprate will include what was on the prior power, and what was on the original FSAR, and what changes were made as far as fuel burnup, and how that might have impacted the same components, and structures, and systems that are impacted by the power uprate.

And a standardized table for DBA predicted loads. We do have these kind of standardized formats that one has to follow in our license renewal process. We don't have it for the proper uprate process.

So that is basically what I wanted to say about margins, and then I have a second talk that I was asked to do on looking at uprates, and past uprate applications, and events that occurred for plants that had received uprate approvals.

And so are there any questions at this point on margins? Now, this work I did back in '99, and again I was asked to review uprate applications and see if there was a potential synergistic safety issue.

And the way I approached that is that I

looked at operational events for uprated plants. I will review some of those applications and NRC review procedures, and altered plant conditions, events noted for uprated plants, potential synergistic safety issues, and observations and recommendations.

And some of this I guess I can skip here. These are the uprate applications up until the early or mid-1990s. I think there was something like 21 uprates, and most of them are 4 or 5 percent power.

Those are the kinds of applications we used to see in the mid-1980s and early '90s.

DR. FORD: You have Oyster Creek there and there are three really quite big ones. Any reason why those are big ones and how they got through at that time?

DR. CRONENBERG: Well, Maine Yankee was one, and Indian Point.

DR. FORD: Indian Point was PWRs and that was 10 or 11 percent?

DR. CRONENBERG: Some of them, and I am not sure, because it has been a while, Peter. But some of them were asked to go to a certain power level, even though the design base or the FSAR calculations were all based upon higher power levels.

And I would have to go back and look and see which of those plants were, but some of them -- all the FSAR calculations were done at a certain power level, and their original operating license was for a lower power level than their design basis calculations, and they are allowed to step up to those.

DR. BOEHNERT: Certainly Oyster Creek was one of those, and I bet you that the other two were as well. Indian Point was the other one, and Maine Yankee.

DR. CRONENBERG: I don't need to go through that plant. Okay. What I am going to concentrate on are the power uprate events. Now, maybe I shouldn't use this term, but these events that happened for power uprated plants, whether they were due to the uprate or something else.

It is not always an easy story to pick out. The first one you know about, the Maine Yankee one, and that went for two power uprates. There was a deliberate faulty LOCA analysis submitted by the licensee that involved the critical heat flux and alteration of the decay heat models.

It was a whistle blower type of notice that came before the agency. The whistle blower went to the State Agency, and the State Agency came to the

NRC after the uprates had been approved. There was two of them.

Both incorporated faulty analysis, which was not caught by the NRC and only after we received insider information from the whistle blower.

Wolf Creek and North Anna, both of those had uprates, and there were control rod insertion problems noted in high power hot, and high burn up assemblage. And we will go through that.

There was the Callaway and Susquehanna, which were pipe ruptures, and a long history of all kinds of pipe ruptures in nuclear power plants, and I will go through some of that.

Brunswick was a faulty use of DBA criteria, and then we have Limerick instability problems. Okay. In Maine Yankee, we had allegations of a deliberate faulty LOCA analysis submitted by the licensee.

The DBA declared limit of 2,200 was exceeded for uprate conditions, and the LOCA analysis was performed for altered decay heating critical flow models.

The NRC did not question the licensee's analysis, and there was no really audit calculations using our own audit codes of the licensee submittal.

However, after the allegation was submitted to the agency, we did an internal study and we verified that indeed there was a faulty analysis submitted by the licensee.

Maine Yankee was shut down and never operated again. The lesson learned from Maine Yankee was a need for independent staff analysis or audit calculations, some of which Ralph talked about this morning, and that the NRC at this time is aggressively doing some audit calculations for these type of power uprates, and which was not done during the time frame of the Maine Yankee.

DR. LEITCH: Just one point of fact. When you say it was shut down and never operated again, it was reduced to the pre-uprate power level and did operate at that power level for quite some time.

DR. CRONENBERG: Okay.

DR. LEITCH: And for quite some time I mean a year perhaps.

DR. CRONENBERG: A year, and then they had to upgrade their ECC and they decided not to do it for one reason or another and the plant was shut down.

DR. UHRIG: I thought it was steam generators.

DR. LEITCH: There were a number of

issues.

DR. CRONENBERG: And I think that the injection system was not adequate for the LOCA.

DR. LEITCH: Yes.

DR. CRONENBERG: Wolf Creek and North Anna. Wolf Creek had a --

MR. ROSENTHAL: Can I just interrupt for just a moment, please. Jack Rosenthal. I was on the Maine Yankee independent safety assessment, and I led the team at Yankee Atomic while most of the team was up at Maine Yankee.

And we reviewed all different sorts of analyses, the higher scope of Chapter 15 analyses, and were generally satisfied with a broad range of analyses.

And I believe, or from what I understand, that the reason that Yankee did not ultimately continue operation were questions concerning its steam generators, and it had done a hundred percent plugging of the sleeving of the steam generators.

And they were faced with a financial question about replacing the steam generators, and cable separation issues that dated back a long period of time, and they were faced with a large cost of replacing the steam generators.

It was in a State in which there had been referendums in the past on whether the plant would be allowed to run a lot. So there was a great deal of financial uncertainty associated with the plant, and so they made a business decision to shut down the plant.

And in fact if it was only the LOCA analysis, that would have been readily overcome by either them doing the analysis or going to still a third party.

And their large break LOCA analysis was always a combustion evaluation model. It was a small break LOCA issue. So I think in the characterization of Yankee, it would be fair to say that they ultimately made the decision to shut down the plant for commercial reasons.

DR. CRONENBERG: My point was that the small break LOCA calculations were submitted, and we accepted them, and then after we had the allegation, we audited those calculations and found that, yes, indeed the models were altered.

And we didn't catch that in the review, and that was my main point. The Wolf Creek and North Anna, we had an uprate in 1996, and this is PWR plant, with Advantage 5H type of fuel assemblies, and

basically they had a control rod insertion problems for the high power, high burn-
up assembly, and basically the thimbles swelled due to irradiation growth mode, and then the control rod couldn't be placed down into those thimbles again.

I would like to read you what was -- well, because it happened in high power, high burn-up assemblies, it could have been reviewed as part of the power uprate application and I just wanted to read here what was in the SER on the control rods.

The only thing that was looked at was the control rod drive mechanisms as far as the documentation of the review. The licensee evaluated the adequacy of the control rod drive mechanisms by comparing the design basis input parameters with the operational conditions for the proposed uprate.

The licensee stated that he uprate conditions would have an insignificant impact on the original design basis analysis for the control rod drive mechanism.

The staff has reviewed the licensee's evaluation and concurs with the licensee's conclusion that the current design of the control rod drive of the control rod drive mechanism would not be impacted by the uprate.

That is the only thing on control rods themselves, and at least from the review procedures the thimbles the irradiation growth. There is nothing telling me in here, and it just says the staff reviewed the licensee applications.

I had no idea of what the acceptance criteria of that is. It just said we reviewed it and find it acceptable. I think with a little more tightened review procedures, where we define what the acceptance criteria are, just like we do on a construction application.

And that we would be better served, and that the staff will have a better guidance as to what is acceptable and what isn't acceptable. So we had an incident at Wolf Creek, and all you can say that it did happen, and with the high power assemblies it might have been a review question, but we looked mostly at the control rod drive mechanism.

We didn't say anything about irradiation and induced swelling of zurcoroid guide thimbles. And maybe if we had a standard review plan we would say that this is what you have to look at, and these are the kinds of calculations that you have to make with fluence.

And you have to monitor and this is the

acceptance criteria, and you shall not have such swelling, and so forth, and so on. On North Anna, we had -- and this is again a PWR, and we couldn't insert new rods into assemblies that were being stored in the spent fuel pool.

They tried to bring in some new control rods, and insert them into the assemblies that they had in the spent fuel pool, and those guide thimbles were also warped, and we couldn't temporarily store the new control rods into those assemblies.

Neither uprate SER addressed changes in fuel rod or control rod performance for high burner, high power conditions. The lesson learned here again is that maybe we need something -- a tighter review process for power uprates.

Okay. Pipe ruptures. We talked about corrosion and erosion problems, flow assisted corrosion. We had many pipe ruptures. We have 53. There is an IPEEE report, a detailed IPEEE report on pipe ruptures, and we have 53 pipe rupture events for pipings greater than 2 inches in diameter.

Most of those were attributed to an erosion/corrosion mechanism as Peter noted this morning, and erosion is a flow, a flow synergism, and corrosion is an aging phenomena, and here we have a synergism or a linkage with enhanced degradation of flow assisted corrosion process.

Empirical evidence for flow/aging effects, lessons learned, is a need for a staff review of potential synergisms, and this is --

DR. FORD: The 53, is that 53 between how many plants?

DR. CRONENBERG: I have a table coming up on that. Basically, I just took that from an EPRI report. It is not anything that I did.

Nucleonics Week. I just wanted to talk about the Susquehanna shutdown, and this just came up this morning, and there were some statements that it was more than just maybe a flow associated vibration effect.

But I just wanted to quote the headlines from Nucleonics Week with respect to Susquehanna. "A recent Susquehanna-2 forced outage could be the result of weld fatigue from increased vibrations from a power uprate in 1995, and NRC is looking at potential generic implications for other uprated BWRs."

"BWR uprates have increased the speed of recirculation pumps and caused increased vibrations in the recirculation systems, said the NRC resident inspector at Susquehanna."

The reason that I put this slide up is that this is the only time that I see anyone really stating what they believe is a direct linkage between an uprate and a pipe rupture.

MR. KLAPPROTH: This is Jim Klapproth with G.E. I would like to comment on that. We saw that article come out and we do not agree with that position. Really, there was an increase of flow, and Susquehanna moved to an increased core flow concurrently with the power uprate, but it was not specifically a power uprate issue. It was increased core flow.

DR. CRONENBERG: Okay. But the --

DR. FORD: Well, 53 is an astounding number.

DR. CRONENBERG: And 53 isn't just from flows. I put this up because this was a statement by an NRC official that an event, an LER to uprate.

MR. KLAPPROTH: I understand, but I would just like to go on record as saying that G.E. does not agree with that position.

DR. CRONENBERG: I understand, but you do agree that it was a flow enhanced flow, but the flow was not dictated by the power uprate?

MR. KLAPPROTH: It was not due to power

uprate, yes.

DR. CRONENBERG: And here is a piping rupture mechanisms through 1995, and basically EPRI did this for the Swedes. The Swedes wanted some information on pipe ruptures, and what are the mechanisms.

And so they did it for a range of piping sizes. It was according to small piping, larger than 2 inch piping and that sort of thing. Erosion and --

DR. LEITCH: This surely isn't primary system.

DR. CRONENBERG: No, this is all piping in the plants.

DR. LEITCH: This is piping in nuclear plants that ruptured?

DR. CRONENBERG: Yes. And the EPRI report is a real detailed report on pipe ruptures in nuclear power plants, but you can see the highest here for vibrational fatigue and erosion/corrosion, both of which one might expect vibrational fatigue for increased flows, and erosion/corrosion for higher powers and higher flow rate that might accompany a power uprate.

To me, this indicates that most from our experience to date, that most of our ruptures for large piping, and this is 2 inch and above piping, are for kinds of phenomena that we would see in an uprate; vibrations due to flow, and flow assisted corrosion.

DR. KRESS: If I have got a hundred plants out there, and I look at vibration frequency, and there is one a year?

DR. CRONENBERG: Yes, one a year.

CHAIRMAN WALLIS: I am trying to relate to your previous thought. You said it was erosion problems, and presuming it was carbon steel pipes, right?

DR. CRONENBERG: Yes.

CHAIRMAN WALLIS: And yet you said there were 53 events of erosion/corrosion of carbon steel plants.

DR. CRONENBERG: Well, 53 events for pipe ruptures greater than two inches. That could e all types of ASME type designations of all kinds of piping. Basically, it is steel piping, but 53 large pipe breaks. Now, on this slide --

DR. LEITCH: And worldwide presumably, because you have a foreign plant listed there.

CHAIRMAN WALLIS: That's right.

DR. CRONENBERG: Yes.

DR. KRESS: And if I add up all of those

listed over there, I don't get 53.

DR. CRONENBERG: This is just the breakdown of where you see these breaks, okay?

DR. KRESS: But those are just U.S. plants.

DR. CRONENBERG: I have to go back. I don't know if they are just U.S. plants, Tom. I have to go back into the EPRI database. They did it for -- I can get you a copy of that. They did it for the Swedes. It might have included other plants.

DR. KRESS: But if you add it up and multiple it by a hundred plants, it doesn't add to very many.

DR. CRONENBERG: No.

CHAIRMAN WALLIS: Three a year.

DR. KRESS: I forgot about multiplying it by the number of years.

DR. FORD: Previously, you said that Callaway and Susquehanna, and I assume you are referring to erosion/corrosion problems in the carbon steel pipeline, and you said Guillotine pipe failures?

DR. CRONENBERG: Yes. Well, no. Did I say Guillotine?

DR. UHRIG: Yes, you did.

DR. CRONENBERG: Sorry. Susquehanna was

not a Guillotine. Susquehanna was on a line to the recirculation system. Callaway was a large pipe -- somehow will have to help me. Do you know what the Callaway was again? I will have to go back and give you an answer on Callaway.

DR. FORD: Maybe you could relate to how many gallons per minute you are losing in heat.

DR. UHRIG: It is Callaway and Susquehanna guillotine pipe rupture.

DR. CRONENBERG: Yes, Guillotine should be out of there. And in the DBA analysis of the wet weld design limit is 220 and NRC did not challenge the licensee's evaluation at 220. However, the real number should have been 200.

So it was just an oversight that got through, and the licensee then came back and said, sorry, it should have been 200 and not 220. It is just an example of something that we didn't catch.

Where if we had a more detailed or checklist, and again I am trying to say that we would be better served if we had a tighter process, a standard review plan, and maybe these kinds of numbers would be in there, and we would not have been caught in this type of situation.

And where we didn't catch it and the

licensee had to come back and say that we didn't catch it, and you didn't catch it, and we did catch it.

And then Limerick, and we have these -- well, when we restart, we have these instabilities that we see for BWRs, where the predicted Delta-K over K is different from the measure, and it gives the operator a little bit of heartburn when he sees that.

And then we have to back off on power, and then find out what was wrong with our calculations, and then start up again.

DR. UHRIG: I didn't understand that. They are not determining a design limit are they?

DR. CRONENBERG: Which one do you have questions on?

DR. UHRIG: On Brunswick. You had licensee based on wet weld design limit of 220, and NRC did not challenge the 220. I thought the NRC would set the limit.

DR. CRONENBERG: In the FSAR, the design limit for the wet weld for that plant was 200 degrees F. The analysis was based at if the design limit was 220, and it was submitted by the licensee.

We believe that our design limit for a wet weld is 220, and NRC went and said, yes, we reviewed the application, and you are below 220. It is fine.

A couple of months later, the licensee came back and said, oh, sorry, I told you the wrong number for the design limit. The design limit was 200.

What I gleaned from looking at some of these LERS, license events for uprated plants besides the generic implication of a need for a tightened review process, and a standard review plan, is that maybe there are synergisms.

For example, rod fretting, and flow induced rod vibration, leading to contact wear with adjacent structures, and increased core flow at uprated powers, and zry-irradiation growth. We know that there is irradiation growth, which may lead to some fretting problems.

Axial power offset. We know about the axial power offset problem, and boron added to compensate for excess reactivity for high burn up and high enrichment, crud buildup for long fuel duty times. And boron is gettered.

There seems to be evidence of boron gettering by the crud, and we have an axial power offset. The effect is compounded, and it seems to be the evidence that it is compounded at high-power core locations.

DR. UHRIG: Where is that evidenced? I

have not heard that before.

DR. CRONENBERG: The boron?

DR. UHRIG: No, the effect that it is compounded by high-power.

DR. CRONENBERG: Mostly, they find it at the high-power central locations and don't find it at the lower power assemblies. It is something that we look at for high burn up assemblies.

Other synergisms, and Jack talked about these, and looking at cable degradation, insulation breakdown due to irradiation effects, and that is exacerbated by elevated temperatures.

We do have cable aging type of things in our license renewal requirements. However, if we are talking about higher temperatures for power uprates, and for plants that are 30 years old, maybe we should be looking at those sort of things on power uprates, too.

And so forth and so on. And of fluid mechanical components, and degradation of elastomers at higher temperatures, and those are the kinds of things that maybe if we had a more detailed assessment of the impact of power uprates on a checklist, or a standard review plan, we might need to look at it.

So I had some recommendations which are

not too dissimilar from looking at margins, and looking at licensee event reports, and current application review processes, and reevaluation of design basis conditions, and uprated conditions, and there is essentially no requirements to look at synergistic effects.

We review based upon current regulatory requirements. Events show indirect evidence of potential synergisms, and the agency, I believe, would be better served if we had a standard review plan for power uprates for BWRs.

And G.E. goes a long way to that goal, and the NRC needs to do something on acceptance criteria, I believe, for the PWRs. It has been a long time since a licensee or a vendor did anything on power uprates, and basically we are still dealing with the 1984 W-CAP report. And that is basically all I want to say.

DR. LEITCH: Gus, your third bullet down there says that that standard review plan for power uprates is in progress. These slides are a couple of years old. Is that still true?

DR. CRONENBERG: The standard review plan is still an on-the-burner sort of issue that -- well, at this point, the agency is not doing a standard review plan, and maybe the staff can answer that.

CHAIRMAN WALLIS: Did you have a comment on that, Ralph?

MR. SWAYBE: This is Mohammed Swaybe again. No, we are currently pursuing a standard review.

DR. KRESS: I am intrigued by your bottom bullet, and intrigued by the fact that you added QHO in parentheses there. Do you have any ulterior motive for that?

DR. CRONENBERG: I just put that in for you, Tom.

DR. KRESS: Thank you. I appreciate that.

DR. CRONENBERG: We don't have any requirements for license renewals particularly, but anyway something about that. PRAs can give you -- well, you know, you believe in PRAs, and it gives you some sense of a holistic integrated assessment of what things are.

We talked about a raw risk aversion LERF, and not a risk aversion LERF for a component, but a risk aversion LERF for a system, and all these issues are before the ACRS. And some thinking needs to go into how we get a better assessment of how systems behave as a whole, rather than components, or how the plant behaves as a whole.

DR. KRESS: You know, the reason that I wanted that QHO over there is you are actually talking about power uprates, and you ought to refer back to the QHO itself rather than LERF, because what we are doing is changing the source term.

And LERF is dependent on the source term, and of course I think there is enough site dependence of things that we really ought to revert back and see what we are really doing instead of using LERF.

DR. CRONENBERG: Well, maybe we should like at something like a QHO, and the source term is changing, but core damage frequency doesn't tell you always the whole story as you know. It doesn't tell you anything about consequences.

DR. KRESS: And I don't think that LERF tells you enough of the whole story.

DR. LEITCH: I have heard a couple of times today that the G.E. topical reports are to perhaps stand in place of the standard review plan. Yet, there are a number of the issues that you talk about here as being potential effects that are really behind G.E.'s scope of supply; electrical cables, and cement control systems, and so forth.

So I guess I just don't understand that.

Also, I don't understand why the real recommendation coming out of Maine Yankee is that there be a standard review plan for power outrates, and why aren't we doing that.

You know, we are looking at a whole bowel wave of power uprates here, and what are we going to do to them? Is it on an individual basis, and looking at them as though each one is a new case?

Isn't there some benefit that could be achieved by having a standard review plan, rather than considering each one as a separate issue?

MR. SWAYBE: This is Mohammed Swaybe again. I can't speak too much on a standard review plan, but I know that was considered and right now we are not pursuing a standard review plan.

However, as far as future power submittal applications, and what we are doing, and the ones that are ongoing right now, for the major extended power uprate applications, we are considering the Quad Cities, Duane Arnold, Dresden, as first of a kind.

We are going through those and we will be having a public workshop after the completion of those. We are also going to be looking for ways to get information out to industry, in terms of how they should be submitting these applications, and format, and getting the information that we need out to industry so that they know what to submit.

It is not a standard review plan, but it will provide some guidance.

CHAIRMAN WALLIS: What form will it take then?

MR. SWAYBE: I am not sure at this point. We are considering several options. It may be a RIS, and it may be through workshops, and it may be through webpage. We are not really sure at this point.

DR. LEITCH: It just seems to me that we all learned some pretty painful lessons at Maine Yankee, and we are kind of flying in the face of that experience.

MR. SWAYBE: I think one of the recommendations may have been a standard review plan, but there have also been some other lessons learned.

And I remember in working in the reactor systems branch that there was guidance given down to the reviewers, in terms of the kinds of things to look for that came out of Maine Yankee.

I mean, there was more than just a standard review plan recommendation for that. There were some letters that came down from management that said that this is what we learned from Maine Yankee, and be sure that you are looking for this kind of information when you do your reviews.

DR. LEITCH: Yes, that is good for those specific things, but what I am saying is that the way that we improve is by institutionalizing some of this experience, and capturing it, and getting smarter as we go along; a little bit like we have down in the -- well, at least I think we have done and are maybe continuing to do in the license renewal process.

But here it seems like we are starting each one kind of with a blank sheet of paper.

MR. SWAYBE: Well, I think on the first few that you are probably right. We do think of them as first of a kind, the first few. You know, 15 or 20 percent. But I think after that, that you will see that we will provide some guidance and hopefully things will be a little more standard.

CHAIRMAN WALLIS: This will be a sort of lessons learned from Duane Arnold, Dresden, and Quad Cities.

MR. SWAYBE: Okay.

CHAIRMAN WALLIS: Anything else? If not, it is probably better if we take our break now before we hear from G.E. so we don't interrupt your presentation.

Well, I guess we will do your introduction first and then we can take our break. Let's do that.

DR. FORD: Mr. Chairman, I have to say that I have a conflict of interest here, being an ex-G.E. member, and as I understand the rules of the game, I am allowed to comment, but not judge.

DR. KRESS: Only on factual matters and not expressing opinions.

CHAIRMAN WALLIS: You can ask questions and we can judge the answers. It would be very useful if you would ask the right questions. So let's proceed with the open part of G.E.'s presentation.

MR. KLAPPROTH: Okay. My name is Jim Klapproth, and I am the manager of engineering and technology in San Jose, and I would like to thank the committee for an opportunity to come and give an update from our perspective on power uprate.

We have not been in front of this committee since 1998, and I think that as we have seen here there is a lot that has transpired in the last 2 to 3 years, especially with the extended power uprate sitings.

And it is very timely for us to have an opportunity to have this discussion. I have two ot her individuals here with me that I would like to introduce.

Israel Nir is on the far left, and he is the power uprate process project manager at G.E., and he will be speaking primarily about the constant pressure power uprate approach, which I believe the committee has had an opportunity to at least look at.

And also to my immediate left is Gene Eckert. Gene is the engineering fellow for transients and reactor systems control, and he will be speaking primarily to a lot of the issues that have come up today relative to the special topics and synergistic effects.

As an aside, I would like to note that this is Gene's 65th birthday today, and I couldn't think of a better present than to have him here today.

So, anyway, I will run through a quick introduction here. We will have some opening remarks and then I will turn it over to Gene to kind of go through an introduction and give you a little history.

We have heard a lot today about the G.E. topical reports. I want to step through the five percent stretch power uprate, and then move to the mid-1990s and to the extended power uprate in the 5 to 20 percent uprate.

The third step in our progress has been

the thermal-power uprate program, or thermal-power optimization, which takes advantage of the improved water flow on certain need characteristics so we can realize a 1-to-1-1/2 percent power uprate.

And then finally the constant pressure power uprate, which we will focus on. Then we would like to go into closed session and really get into more details and specifics about what the impacts of power uprate are.

And before I turn it over to Gene, just a couple of opening remarks, and basically these five bullets are the key messages of our presentation. First of all, there has been an extensive amount of experience with extended power uprates.

And there are five plants, and it says four here, but there are four utilities, and actually five plants that are currently operating under extended power uprate conditions; three domestic and two overseas.

And in addition, we have completed the analysis and it is currently under staff review, of power uprate programs for an additional five plants.

DR. KRESS: Who reviewed the overseas plants?

MR. KLAPPROTH: KKL.

DR. KRESS: Was their review as extensive as the ones that our staff does?

MR. KLAPPROTH: I believe so, yes.

DR. BOEHNERT: Were those 20 percent or higher uprates? What was the uprate on those?

MR. KLAPPROTH: I think it was 117.

MR. ECKERT: KKL did a five percent somewhere to our original uprates, and then they did this additional 14-1/2 percent. So they are close to 120. And the KKM plant is up around 114, above the original.

DR. SCHROCK: Is that the way that you calculated it; that it is based on the percentage of the original?

MR. ECKERT: That is the way of keeping it in our books for sanity since they are going in different steps here, yes. These are the numbers that they give you and they are right around 119. something. They are not above 120 from originally.

They were 104.2,. and then 114, or something like that.

CHAIRMAN WALLIS: And was that the Leibstadt one?

MR. ECKERT: Yes, that was the Leibstadt one, the bigger one, yes. A bigger uprate.

MR. KLAPPROTH: In fact, I think we have a chart later in the presentation.

MR. ECKERT: We have information from their program.

MR. KLAPPROTH: The second major bullet, we have had a lot of discussion today about margins, and from our perspective, the safety margins are maintained.

And both Ralph Caruso, who I think back in December when he was in front of this committee, the deterministic licensing criteria are maintained for power uprate. There is no request for any relaxation of the deterministic licensing criteria.

In other words, we believe that all the safety margins are maintained. I think a lot of the discussion we have been having previously is relative to performance margin, and operating margin, and there is a slight impact in some cases on operating margin, and we understand that.

And relative to safety margins, we believe that there is no impact on safety margins for power uprates, especially under the constant pressure power uprate approach, which is a no pressure increase.

And you will see as we go through the presentation in the closed session the impact on plant systems, and on plant response to events, such as design basis accidents, and transients, is fairly benign relative to prior pressure increase power uprates.

So again we believe that the safety margins are not impacted for extended power uprates. and power uprates.

DR. CRONENBERG: When you say that, what about, for example, like the feed water line? Do you view that as a non-safety impact, and design loads, and even the operating conditions are higher flow rates and higher temperatures on the feed water lines.

MR. KLAPPROTH: We have a specific example, and we will discuss that in the closed session, but basically our position will be that as long as you stay under the 1250 limit, anything underneath that is additional margin over and above the safety margin.

DR. CRONENBERG: Okay. So you are defining safety margin as anything above the design limit?

MR. KLAPPROTH: Exactly. And I believe that is consistent. I think if we go back 10 years, I believe -- and, Tony, you can help me on this, but in the improve tech spec role, I think NEI and others took a very close look at what the definition of safety limits and safety margins are.

And I think there was some guidance put together by NEI which was accepted by the staff on what the definition of safety margin is relative to operating margin.

MR. ECKERT: And all the appropriate code equations were checked again for the new operating conditions, and any temperature change that took place, and the flow changes that took place, and in compliance with all the appropriate code equations for the piping was done for each small uprate or big one.

DR. CRONENBERG: So when we see something in an SAR that says the safety margin is not changed, what we are really talking about is that you are below the design limit?

MR. KLAPPROTH: Right.

CHAIRMAN WALLIS: Could you say more about Bullet 3?

MR. KLAPPROTH: The constant pressure power uprate bullet?

CHAIRMAN WALLIS: Yes, without getting into something which is proprietary. It is not just constant pressure. You get your power uprate by flattening the power distribution of the core without changing to the maximum temperatures and all those things which -- well, if you had just taken and raised the power everywhere, you would be changing those things.

But you have done some clever engineering to keep other things constant other than just pressure. Can you talk about those now or is that something that is more proprietary?

MR. KLAPPROTH: I think we would prefer to talk about that in the closed session.

MR. ECKERT: Well, on the pressure side, we control pressure independent of power. I mean, they interact, but we have a pressure controller that keeps the pressure where we want it, and that this plan for our uprate, we make sure that when we get to the new higher power level that we have the same reactor dome pressure that we had before.

CHAIRMAN WALLIS: Well, if we had that, it would just draw out more water at the same pressure.

MR. ECKERT: Basically, yes. And we have a control system that will hold it where we want it.

CHAIRMAN WALLIS: And you achieve that by not -- without raising this sort of maximum fuel temperatures and things like that. So there must be some engineering done to distribute the load more evenly across the core.

MR. KLAPPROTH: Well, we will talk about that.

DR. KRESS: When you say constant pressure, you are talking about the pressure in the dome or --

MR. ECKERT: The reactor dome pressure, yes.

DR. KRESS: Which means that you are blowing more steam, and so the resistance between there and the turbine has to be less?

MR. ECKERT: Well, it is built already. The resistance is there, and so at the turbine, we actually drop pressure a little bit at the higher flow rates.

CHAIRMAN WALLIS: So you need an even bigger flow rate to get the power uprate?

MR. ECKERT: We have to build the turbine, and the MODs get a little tougher by holding this pressure philosophy. But inside in the primary part of our system, and the whole pressure boundary, it becomes much simpler, and that is what we will talk about.

DR. KRESS: Okay. We will wait until then.

MR. KLAPPROTH: And in general, for example, on the LOCA analysis, we will show that the power uprate, really the effects of LOCA, the effect of power uprate is very minimal on LOCA analysis.

CHAIRMAN WALLIS: And you still have the vessel at the same pressure and so you make a hole in it?

MR. ECKERT: It is the same sized pipes.

CHAIRMAN WALLIS: And that sort of overview needs to come forward so that someone who is looking in from the outside can understand how you achieve it without it being too proprietary.

MR. KLAPPROTH: Okay. The fourth bullet, the high volume EPU review request anticipated. There was a question this morning on how many do we anticipate over the next year or so.

Right now the staff has Dresden and Quad Cities, and Duane Arnold reviews in progress. We anticipate between now and the middle of next year that there will be another five plants submitting for power uprate, and extended power uprate applications, using the constant pressure power uprate approach.

And beyond that our projections are over the next several years that we would expect at least another four plants per year coming to the staff.

That's why we think it is appropriate to move to a streamline approach, which is again linked to our constant pressure power uprate.

And actually we will be meeting with the staff tomorrow and getting the initial feedback on the topical report that I believe the staff has seen on our constant pressure power uprate, and hoping that we would have a safety evaluation issue by the end of the year.

DR. KRESS: Do you think we have reached the limit of power uprates, or is there a potential another round? How far can we go? I know that there are different things that limit --

DR. SCHROCK: Isn't it limited by your radial peaking? I mean, all you are doing is taking advantage of the fact that the older plants are more peaked, and now you are flattening it.

But there is a limit to what you can get if you spread it uniformly --

MR. KLAPPROTH: Well, at this point, we are really where we want to go at this point, which is 20 percent. We have not really looked beyond 20 percent in the NSSS environment to say what is the next limit.

Ralph mentioned this morning a limit.

However, that is based on current licensing analysis, and I think we have moved to more realistically track the analysis, and we will find that we have some additional margin that may allow us to go higher.

There may be some related issues that we need to worry about when we go above 20 percent, but we frankly have not done a study to say, well, we can go to 129, or we can go to 142.

DR. KRESS: That is something that we don't need to worry about right now. We are not faced with that.

MR. KLAPPROTH: So, with that, I will turn it over to Gene to walk through some of the background information if there is no further questions.

CHAIRMAN WALLIS: I think it will be interesting. Maybe it is not G.E.'s job to look at one of these things and say with a pressure vessel, and core geometry, what do you do to get more power out of it, and presumably we circulate more water and things like that.

And maybe you are not asking for it and so you don't want to get into the details, but it is kind of interesting for some HD student or someone to look at one of these things and say, well, here are all the things that we could do.

We could get a hundred percent more power out or what, and I would be interested to see that. Please go ahead.

MR. ECKERT: And we may be asked to answer that question as good engineers by our managers. This is a brief run through, and we have been with you before, and especially connected with the extended power uprate power program, and it is one of those generic topical reports that were put together back in June of '98.

We had some follow-up meetings with you in July, answering some questions that you asked. It was built off to 5 percent in an earlier program, and keeping as Jim was saying the criteria for acceptability of the plant was to be kept the same, and that we were not changing the criteria that we had to meet.

We expected this to be handled pretty well, and it has been holding up pretty good, and we can see that we are getting close to some things, and that's probably it is not an automatic answer that we go beyond 20 without some changes in the NSSS.

The balance of the plant did need significant changes, and we recognize that, and the utilities struggle with what is it worth, and is it worth that investment at our plant, and many of them are deciding, yes, it is.

I have this bullet about MELLLA. We are throwing acronyms out here. This is a term that G.E. has used over the years to describe the operating domain that we use on our map.

We call it a power versus core flow map, and we have defined the range of operability at which we call normal operation, and it has expanded over the years up to this title called, "Maximum Extended Load Line Limit Analysis."

Load line meaning the rod line, flow line, and that if we change core flow power, it moves up and down with core flow, and that is a common way we change power in the plants.

We don't change our rod patterns up at high power generally. We change core flow to do that, and we will see some pictures of it in the rest of the presentation.

CHAIRMAN WALLIS: Are you going to show us the stability and instability region?

MR. ECKERT: We will talk about which region is most at risk for stability considerations and what happens there. When we went to extended uprate, we constrained ourselves in the utilities not to go above the previously licensed boundary, and that was an important term relative to the stability question, because we did not want to push ourselves at that time, or now, beyond that line for these basic extended upright plants.

And so there may be some plants that were not licensed all the way to this line before, but the fleet had examples of every product line that had gone up to this boundary, and so some plants are moving up to the previously licensed boundary, but none of them -- and what we are calling the extended power uprate program -- are going beyond this previously licensed boundary on the power flow map.

And you can think about it as a power flow ratio kind of boundary that we have agreed to remain constrained within. There is a combination of things that came out of this effort, which is partly generic, and partly plant specific.

And that was differentiated and defined as we went into our topical reports that tried to establish the guideline that this is needed to be done plant by plant because it has some unique features.

And that these are things that need to be done even cycle by cycle, which is pretty costly coupled to our GESTR effort for reloads, and there were some things that we could handle generically and say that all BWR4s are bounded by this one analysis, or all BWR6s can be bounded by this one analysis. And wherever possible that was included in our generic material.

CHAIRMAN WALLIS: So this mellow boundary is independent of the fuel or the flux distribution?

MR. ECKERT: It is applicable to all of our fuel types, and plants operate up to that boundary, and we will look at it in detail.

CHAIRMAN WALLIS: And the boundary is somehow independent of fuel and so forth?

DR. KRESS: When you decrease flow, if you had the same power, you would increase the void fraction?

MR. ECKERT: Correct, which unbalances the reactivity.

DR. KRESS: And so the reactivity comes down.

MR. ECKERT: It pushes you back down.

DR. KRESS: And this MELLLA line is the description of that effect?

MR. ECKERT: And it is almost -- you know, for the first rule of thumb, it is a constant void fraction line. It is not perfect, but it is basically that the reactor forces us to stay at the said void fraction when we have the same rock pattern.

DR. KRESS: So it is a natural --

MR. ECKERT: It is a basic physical characteristic.

DR. KRESS: -- physical characteristic of all the reactors?

MR. ECKERT: Of our wonderful machine, yes.

DR. KRESS: I think that is useful for this committee to understand.

MR. ECKERT: We will have more detail later, Tom.

DR. KRESS: So it would depend on your fuel in some way wouldn't it?

DR. KRESS: Well, it really does depend some on that, yes.

MR. ECKERT: We calculated for different fuels, and it is amazing how close it follows, because it has got the thermal-dynamics of the constant void fraction built into this.

DR. KRESS: It is really the effect of void fraction on the neutrons, and it is almost independent of the kind of fuel it is. Not quite, but almost.

MR. ECKERT: All of our fuels have strong negative void reactivity characteristics, and so it forces us back to very close to identical void fraction, which is --

CHAIRMAN WALLIS: Which shuts itself down, and moves it around.

MR. ECKERT: We submitted two different topicals basically. One we call ELTR1, and that had followed our previous generic document LTR1, which was the 5 percent uprate, and this is the bigger uprate, but it was basically a guideline document.

Here is the scope of what needs to be looked at and here are the key criteria that we are going to commit ourselves to. We reviewed that with the staff, and we reviewed it with you, and we reached agreement on that.

And then ELTR2 is the place where we have documented generic topical material that can be used by different plans, and as generic, we think that this issue can be settled this way, and a plant simply has to confirm that we are within the generic package that you have submitted before.

For the big uprates, obviously there were a few less generic things that we could do than we did for the smaller uprates, but we still had this advantage to the total program.

We presented this and reviewed it with you, and coupled very closely with the Monticello extended uprate. So it was a BWR3 and then it went up 6.3 percent above what they had started operating their unit at.

And then very closely coupled after that were the Hatch 1 and 2 submittals that followed this program. And we had questions from you, and tried to and did resolve that, and have received acceptance of that program. And that has led to all the activity by the utilities.

CHAIRMAN WALLIS: And this concluded -- you are saying that ACRS concluded or you concluded?

MR. ECKERT: Well, mutually we concluded it, and we are moving ahead.

DR. KRESS: We actually had a letter on this.

MR. ECKERT: The staff has given us approval.

CHAIRMAN WALLIS: Well, we certainly approved it, and so I was wondering if we used these exact words?

MR. ECKERT: I think these are my words. And I am not too much of a salesman, but I have a little. There is some terminology that we wanted to make sure that you understood, and we have probably since then, by using the term stretch power uprate a little more than we did back then.

And that meant this early program that was up to about 5 percent uprate, and it was basically already built into most FSARs, and it was just that we were not licensed there immediately, and we just went up to it.

And it is based on percent of original licensed in most of our discussions. Extended means the step that could up to the 20 percent level above the original license.

All plants are not choosing to go that far based on what their economics are for their turbine generators, or whatever their system might be. It might be that they don't have room for another pump to go in, or would need it, or whatever.

So economically each customer will look at that, and pick a point to shoot for. And just recently you are seeing the ones that are coming close to saying, hey, we think we can get darn close to 120.

DR. LEITCH: Gene, just a terminology question here. If I say the term extended power uprate, that generally means that there is an increase in pressure; and if I say the term constant pressure power uprate, I understand what that means.

MR. ECKERT: That's a good question. In the past, our EPU program included the potential to go up in power and pressure, depending on the balance of design trade-off's that would go on.

And by going up in pressure, we could save a little bit in our turbine MODs and things like that. So the general program in 1998 had the option of pressure increases, as well as power increases, and you will see those topicals discussed it.

The CPPU, constant pressure power uprate, fresh stuff coming at you now, is to constrain ourselves to keep that dome pressure constant, even though we may be going up as much 120 in power.

And that is the more recent path, and even the ones that have done power uprates we will talk about in a little bit. Many of them, if they have gone up in pressure, they haven't gone very far, and then they decided to do most of their uprates without raising pressure because of saving lots and lots of extra considerations for the primary boundary.

CHAIRMAN WALLIS: Do you have figures for the cost per installed whatever, megawatt or whatever, whatever the capital cost is for this uprate? I mean, you are not buying a new reactor. You are just buying some balance of power.

MR. ECKERT: You are asking the wrong guy.

CHAIRMAN WALLIS: Well, that is the motive for this isn't it?

MR. ECKERT: Yes, it helps. It helps. Some of it is avoiding just calculational costs, and lots of paper, but there could well be some real hard work changes, too, for the pressure change.

And that is these extra bullets here, the different phases of uprate that have been coming at you. There is one that we call thermal power optimalization, and you may know it better just as an Appendix K uprate.

In the sense where the better feedwater measurement and equipment could get another 1 or 1-1/2 percent power by sneaking up closer to the analysis that was done traditionally at 102 of the rated power.

And we have a parallel program for the BWRs, and the staff has received a generic topical that tried to scope out what was involved in doing that type of uprate. That is not our main discussion here today, but we wanted you to know that was also coming along.

DR. BOEHNERT: Does that mean that someone can go to 121.4 or 5?

MR. ECKERT: Well, that is a good question, and we haven't really faced it. In theory, the answer would be yes, but in practice, most of us are being pretty cautious about saying that.

In reality, it says that if my license is here, and my safety analysis is here, can I creep closer to it because I have less power uncertainty, and in theory the answer is yes.

I already have it basically. I do a 120, and it says that I am going analysis at 123-1/2 already. So I would vote yes, but I have more cautious people behind me.

And we are not forcing you to say, yes, you can go beyond 120 that way. Some day somebody may come and ask for that.

DR. BOEHNERT: So you have not made a decision one way or the other, I guess?

MR. ECKERT: The topical that we have submitted says that if a plant is already upgraded five percent or whatever, they can abide this thing. So in theory if somebody had really gone all the way to 120, we would say it is theoretically possible. We don't have a project pushing for that at this point.

DR. BOEHNERT: Okay. Thank you.

MR. NIR: We recommend that the customer will analyze and perform the analysis at 122, or 2 percent above 120.

MR. ECKERT: All of the new ones are being done under the old rules with respect to power uncertainty, and none of the new submittals to you or the staff at this point are saying we are going to an uprate, and we are only doing it with this tiny uncertainty factor.

And in the constant pressure one, we will talk about more during the presentation, and we have already touched on that; that it just involves being constrained, and constraining ourselves that dome pressure does not go up with the power, which we can control.

That is our common control system for all our plants, and it is constrained by our tex specs. We will talk a little bit about on-line implementation, which is something that maybe wasn't as actively on our table with you when we were here in '98.

And that we have now come up with some of the better ways to implement uprate as we go through the licensing approval process, as well as the practical parts of doing plant MODs, and so forth.

CHAIRMAN WALLIS: You don't just suddenly throw a switch and the power is 20 percent bigger?

MR. ECKERT: Right. These give you more details about these different parts of the program, and what was called the stretch, and the five percent one, and it introduced this idea of LTR1, and LTR2.

And there was good communication between us and the staff, and I thought a good exchange, and a good challenge to each other. The standard was similar and built on it, and here are some dates at which these things were submitted, and when our plants, the lead plants for this program made their submittals.

I think Fermi-2 was the lead plant at the five percent part of it, and Monticello and Hatch were the lead plants on the larger ones, even though they didn't go all the way to 20 percent.

On the so-called TPO or the small uprate, this gives you a few details on the way that we were doing this, and we are in the process of reviewing. We have received some RAIs from the staff and are responding to them and moving toward approval of this half we hope.

I think there will be some plants that

follow this lead, or a couple that are submitting such submittals to you independent of our topical approach, and in some manner this will be merged together as the staff reviews the process.

Basically, we are trying to take advantage of everything that was already done at the 102 or more above today's license, and to identify pretty clearly what ought to be reviewed because it was done back at a hundred percent.

Things like ATWS were agreed upon to be done back at a hundred, for example, and so we talk about what happens if we were up a percent or a percent-and-a-half above that.

MR. KLAPPROTH: I think the only other point that we should make here is that last bullet. We do expect three submittals by the first quarter of next year on a TPO approach.

CHAIRMAN WALLIS: And that involves some different instrumentation then?

MR. KLAPPROTH: Better instrumentation and measuring feed water flow, which is a primary element in our power uncertainty calculation.

CHAIRMAN WALLIS: And is there certain technology being used for that flow rate, flow measuring?

MR. ECKERT: The technology has been reviewed by the staff and has gone through the ringer. Caldon is one of the suppliers, and I think ABB has a system.

CHAIRMAN WALLIS: So anyone who can prove itself is?

MR. ECKERT: Yes, and we are saying that based on whatever they claim, you can creep ahead following this guideline of scope of work.

DR. UHRIG: This is with the original single pass system from Caldon, and the newest X system?

MR. ECKERT: We have written our work that says that we are not claiming what the improvement is. We have said that if you can defend a claim of a percent improvement, here is the safety work that would be needed.

The CPPU you will hear us talk about quite a bit today, and we hope that it facilitates the future applications. It takes a lot of work out of the process because we aren't pushing temperatures and pressures harder in lots of the equipment.

It remains functioning at the same pressure temperature conditions that it is operating at today. It gives us another vehicle to work with, and our utilities to accomplish the uprates without extra work involved that the pressure change would have.

We have submitted this topical generic approach to this earlier this year, and so we are in the process of that review. Tomorrow is a meeting to discuss this, and keep communicating about what needs to be done to reach agreement on what should be included in this approach. We will hear more later and it involves some other recommended improvements just in the process of going through the uprate programs.

This little chart talks about the on-line implementation IDF, which is trying to decouple the moment we actually have approval on an SER from the staff, and to say, yes, we agree, and you can go up in power.

And from when outages are for a given plant, and so the outages give the utility the time to do any MODs that are needed, and they will do that in a series of changes maybe for larger uprates.

But they would introduce some MODs and an outage in anticipation of getting approval during the cycle, and having submitted it to the staff for review and resolving questions, and getting approval midcycle.

They are prepared to at least take advantage of part of that approved new power level during this first cycle that the approval is received.

The approval doesn't have to come immediately at the time of a start up from an outage, and that helped quite a few ways. There are some things that you have to wait to get changed out here perhaps.

But part of the uprate can be taken advantage of right away, and it helps in the scheduling of all this stuff with utilities and ourselves, and with the staff.

It takes a little bit of heat off the staff, and they don't have to be right there on the day they want to pull rods and come out of an outage. And so it made it more practical for all of us.

This chart -- we keep showing you these with the list of plants, and the list keeps growing. The column on the left are the plants that have basically done uprates in the past and have included some pressure increase in their plant.

And part of our discussion with you today is especially aimed at helping you understand the constant pressure path that we think that everybody else will be on.

Some of the plants on this column even might have uprated or had increased pressure during part of their uprate, but not all of it. Like this plant in Switzerland, the Liebstadt plant, when they did their first 5 percent uprate, they did the uprate and pressure as well, and it was 20 pounds or something. It was some amount.

But then when they went to the big uprate that followed, they adopted our constant pressure thing just for practical reasons of their own. So they have gone the last 15 percent or 14 percent without raising pressure.

But they did some analysis with the pressure increase, and they looked back and said, hey, I would rather try to do it without all those set point changes, and all the other changes that are needed, and they also have gone a long ways without it for the second half of their uprate.

It is a pretty big list over here of plants that have already or are planning to go up in power using the constant pressure approach. And the starred ones are the ones still in process, and including the ones that we talked about before.

And Cofrentes is a plant in Spain that has done a small amount of uprate and are going to bigger uprates in the process of that. We show the Brown's Ferry units on here that weren't on the previous list, but we have been working with them and aiming at a target up here, and they are present in the crowd here today.

And they are very interested in seeing the same program, and there are others that we are talking to. The last chart there is the real benefit for all this that we are all seeing as an industry, and we are trying to accomplish wisely and safely.

There are pretty big numbers starting to add up here. Completed uprates in the neighborhood of 1,250 megawatts. There is some differentiation in the charts here. The first block are the five percent uprates, and then there is the little chunk on top of here that are the EPUs, the bigger uprate programs starting to be shown on the map.

CHAIRMAN WALLIS: I don't understand that. Are you referring to total megawatts of?

MR. ECKERT: This is the added megawatts to the fleet. It is not an individual plant, but this is the sum of the plants that have uprated. And these are the ones in process, and these are almost totally the extended uprate plants that are part of our plan.

We are estimating from the year 2001 to 2003 that we will get these additional uprates and a little bit coming in as part of what we are calling thermal power optimization. Not as big, but still vital power for these people.

DR. KRESS: Now, going from the second column to the third column, does the third column include the bottom of the second column that are in progress?

MR. ECKERT: No. These are contracts in hand, and --

DR. KRESS: They are expected to be finished before you get to this other?

MR. ECKERT: Yes. And this would be even our estimate out further.

DR. KRESS: So those are all new megawatts?

MR. ECKERT: Yes, each column is independent.

DR. CRONENBERG: And is Brown's Ferry in the forecast?

MR. NIR: I believe it is in the third column, 2001.

MR. ECKERT: Yes, at the time that this chart was made.

CHAIRMAN WALLIS: And that is equivalent to five new plants?

MR. ECKERT: Five, 930 megawatt plants.

CHAIRMAN WALLIS: And the problem is that the 930 is so close to the 960 and the 1100, do you think that you are talking about individual outrates?

MR. ECKERT: Yes, that is what is sounds like, but it was just a way of expressing it. We believe that we are consistent in supporting what the staff requirements are in terms of supporting the plants for additional power.

CHAIRMAN WALLIS: And this is your contribution to the 10,000 --

MR. ECKERT: We just need some longer extension cords to reach California though, and we can't avoid the fact that this is giving high volume work here through the process to the staff, and as well for us, and for the utilities, too.

CHAIRMAN WALLIS: Are we through with the open session?

MR. KLAPPROTH: That is the end of the session, yes.

CHAIRMAN WALLIS: So let's take a break and I think we can come back at five after, and that will give us a 12 minute break.

(Whereupon, the Open Meeting was recessed at 2:54 p.m. and the proceedings resumed in Closed Session at 3:05 p.m.)

**CERTIFICATE**

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

Name of Proceeding: ACRS Thermal-Hydraulic Subcommittee

Docket Number: (Not Applicable)

Location: Rockville, Maryland

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Paul Intravia

Paul Intravia
Official Reporter
Neal R. Gross & Co., Inc.

# Review of Power Uprate Applications and Potential Synergistic Safety Issues

**August W. Cronenberg**
**ACRS Fellow**

# Outline

- Power Uprate Overview
  Applications, NRC Review Procedures, Altered Plant Conditions
- Events Noted for Uprated Plants
- Potential Synergistic Safety Issues
- Observations & Recommendations

# Summary of Power Uprate Applications

| Plant | Reactor Type | Year Startup | Original Power(MWt) | Year Power Uprate | Uprated Power(MWt) | % Power Increase |
|---|---|---|---|---|---|---|
| Oyster Creek | BWR | 1969 | 1690 | 1971 | 1930 | 14.20 |
| Calvert Cliffs-1 | PWR | 1977 | 2560 | 1977 | 2700 | 5.46 |
| Main Yankee | PWR | 1972 | 2440 | 1978 | 2630 | 7.79 |
| Millstone-2 | PWR | 1975 | 2560 | 1979 | 2700 | 5.47 |
| Fort Calhoun | PWR | 1973 | 1420 | 1980 | 1500 | 5.63 |
| St. Lucie-1 | PWR | 1976 | 2560 | 1981 | 2700 | 5.46 |
| Cook-2 | PWR | 1978 | 3391 | 1983 | 3411 | 0.56 |
| Duane Arnold | BWR | 1975 | 1593 | 1985 | 1658 | 4.08 |
| St. Lucie-2 | PWR | 1983 | 2560 | 1985 | 2700 | 5.47 |
| Salem-1 | PWR | 1977 | 3338 | 1986 | 3411 | 2.19 |
| North Anna | PWR | 1978 | 2775 | 1986 | 2893 | 4.25 |
| Callaway | PWR | 1985 | 3411 | 1988 | 3565 | 4.51 |
| Main Yankee* | PWR | 1972 | 2440 | 1989 | 2700 | 10.65 |
| Indian Point-2 | PWR | 1974 | 2758 | 1990 | 3071 | 11.35 |
| Fermi-2 | BWR | 1987 | 3293 | 1992 | 3458 | 5.01 |
| Wolf Creek | PWR | 1985 | 3411 | 1993 | 3565 | 4.51 |
| Vogel 1&2 | PWR | 1987 | 3411 | 1993 | 3565 | 4.51 |
| Peach Bottom-2 | BWR | 1974 | 3293 | 1994 | 3458 | 5.01 |
| Susquehanna 1&2 | BWR | 1983 | 3293 | 1994 | 3441 | 4.49 |
| Surry 1&2 | PWR | 1972 | 2441 | 1995 | 2546 | 4.30 |
| Nine Mile-2 | BWR | 1988 | 3323 | 1995 | 3467 | 4.33 |
| Hatch 1&2 | BWR | 1975 | 2436 | 1995 | 2558 | 5.00 |
| Limerick-2 | BWR | 1988 | 3293 | 1995 | 3458 | 5.01 |
| Limerick-1 | BWR | 1985 | 3293 | 1996 | 3458 | 5.01 |

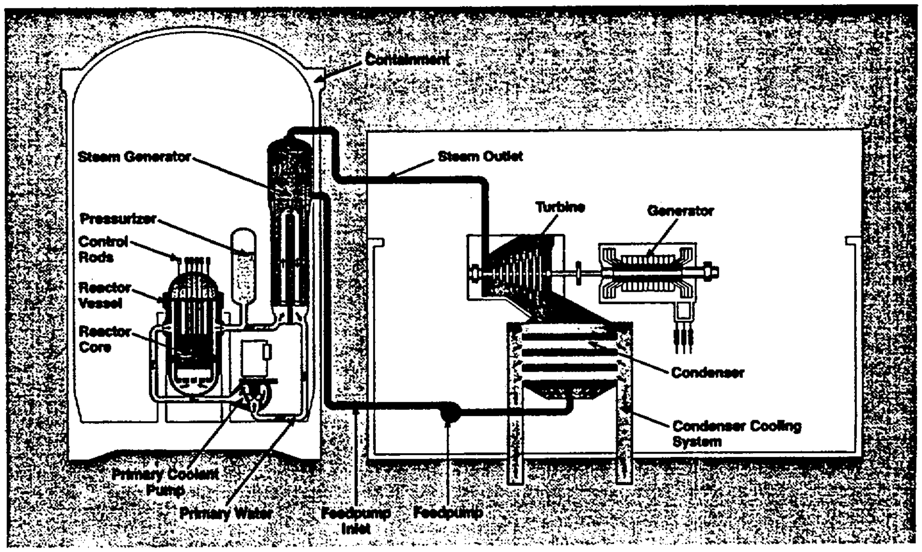
* Denotes second power uprate, percent power uprate based on original power level.



# Licensee Uprate Responsibilities

- Uprate Application takes form of License Amendment Request
- Application Must Include Power Uprate Safety Analysis Report (SAR)
- SAR Generally Follows GE-BWR Generic Guidance (Series of Licensing Topical Reports through-1996) or W-PWR Generic Review Plan (WCAP-10263, 1983)
- SAR Centers on Re-evaluation of Design Basis Accidents, No Significant Hazards Assessment, Changes to Plant Conditions and Technical Specifications

# Plant Characteristics Impacted by Power Uprates




**Primary Coolant System (PCS)**
Core Power
Core Inlet/Outlet Enthalpy
Vessel Outlet/Inlet Coolant Temperatures
Fuel Temperature
Primary Coolant Flow Rate

**Secondary Coolant System (SCS)**
Steam Generator Steam Flow Rate
Feedwater Flow Rate
Feedwater Temperature
Feedwater Pumping Requirements



# NRC Uprate Responsibilies

- NRC staff reviews licensee's uprate SAR
- NRC reports findings in Safety Evaluation Report (SER)
- NRC review centers on an evaluation of the impact of power increase on plant operations and safety
- No agency uprate Standard Review Plan or standardized acceptance criteria
- No agency requirements for independent code analysis of plant uprate conditions

# Power Uprate Events

- Maine Yankee: Deliberate/Faulty LOCA Analysis by Licensee
- Wolf Creek/North Anna: Control Rod Insertion Problems
- Callaway/Susquehanna: Guillotine Pipe Ruptures
- Brunswick: Faulty use of DBA Criteria
- Limerick: Predicted Δ-K/K Less Than Measured



# Maine Yankee

- **Allegations of deliberate/ faulty LOCA submittal, DBA clad limit of 2200°F exceeded for uprate conditions.**
- **LOCA analysis performed with altered decay heat & critical flow models.**
- **NRC-SER did not question licensee analysis. No independent analysis performed by NRC staff.**
- **Subsequent investigations concurred with allegations.**

**LESSON: Need for independent NRC staff analysis (code calculations) for uprate reviews.**

# Wolf Creek / North Anna

**Wolf Creek: 4.5-% Uprate 1996**
**Control rod insertion problems for 5 high burnup rods (47 GWD).**

**North Anna: 4.3-% Uprate 1986**
**2 control rod assemblies fail to fully insert in high burnup (47-49 GWD) assemblies in spent fuel pool.**

**NRC-SER: Neither Uprate SER addressed potential changes in fuel or control rod performance for high-burnup/high-power conditions.**

**LESSON: Need for NRC staff review of potential synergistic high-burnup/high-power effects.**



# Pipe Ruptures

- Susquehanna, Callaway, Tsuruga, etc
  (53 rupture events pipe Diam. > 2")
- Erosion (flow)/Corrosion (age) mechanism is major cause of pipe ruptures
- Empirical evidence for synergistic flow/aging effects
- LESSON: Need for NRC staff review of potential synergistic flow/aging effects

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NUCLEONICS WEEK

Vol. 40 No. 51 December 23, 1999

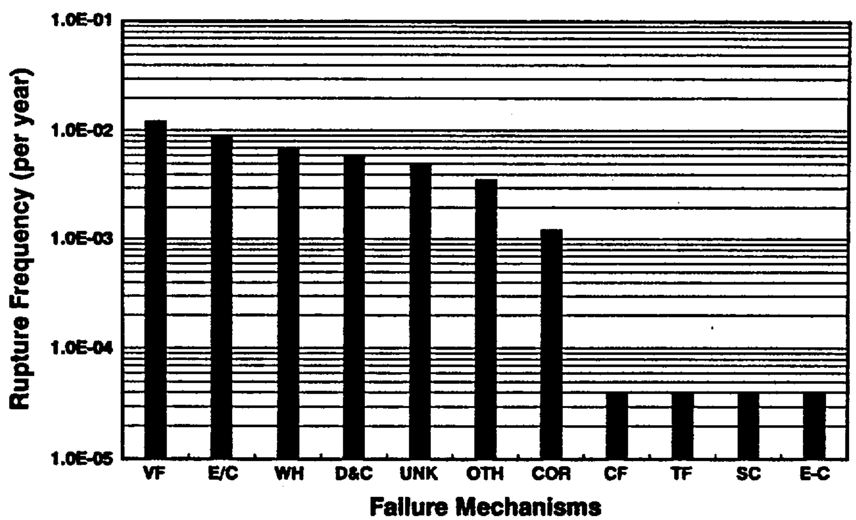
## SUSQUEHANNA SHUTDOWN MAY SIGNAL NEW GENERIC PROBLEM FOR BWRs

" A recent Susquehanna-2 forced outage could be the result of weld fatigue from increased vibrations from a power uprate in 1995, and NRC is looking at potential generic implications for other uprated BWRs..."

" **BWR uprates have increased the speed** of recirculation pumps and caused increased vibrations in the recirculation systems, said Sam Hansell, NRC resident inspector at Susquehanna."



## Frequencies of Pipe Ruptures Mechanisms Through 1995




| | | | |
|---|---|---|---|
| **VF** | **Vibrational Fatigue** | **COR** | **Corrosion Attack** |
| **E/C** | **Erosion/Corrosion** | **CF** | **Corrosion Fatigue** |
| **WH** | **Water Hammer** | **TF** | **Thermal Fatigue** |
| **D&C** | **Design & Construction** | **SC** | **Stress Corrosion Cracking** |
| **UNR** | **Unreported Cause** | **E-C** | **Erosion -Cavitation** |
| **OTH** | **Others** (human error, frozen pipes, etc.) | | |

# Other Events

Brunswick 1 & 2 (BWR)

- Licensee DBA Analysis based on wet-well design limit of 220°F.
- NRC did not challenge 220°F analysis.
- Correct value of 200°F (Licensee).

Limerick-1 (BWR)

- Code predicted $\Delta K/K$ for restart less than measured for high-power/high-burnup core.
- Code inadequacies for high-power/high-burnups.

LESSON: Need for agency uprate SRP and assessment of adequacy of core physics codes for high-power/high-burnup/high enrichments.



# Potential Synergistic Effects

High-power/High-Burnup Synergisms

Rod Fretting: Flow induced rod vibration leading to contact wear with adjacent structures. Increased core flow at uprated power and Zry-irradiation growth for high burnup may lead to fretting.

Axial Power Offset: Boron added to compensate for excess reactivity of high-enrichment/high-burnup rods. Crud buildup for long fuel duty times. Boron gettered by crud, leads to axial power offset. Effect is compounded at high-power core locations.

# Potential Synergistic Effects

High-Power/Ageing Synergisms

Electrical Components: Insulation breakdown due to irradiation effects, exacerbated by elevated temperatures.

Fluid -Mechanical Components (pumps, piping, valves): Subject to flow assisted corrosion (FAC). Elastomer seal degradation at high temperatures.

Instrumentation & Control Systems: Ageing of I&C exacerbated at elevated temperatures and fluid velocities (vibration).



# Observations & Recommendations

- Current uprate application/ review process largely centers on re-evaluation of DBA conditions at uprated power. Nil consideration of potential synergistic effects.
- Events show indirect evidence for synergistic power-uprate/ageing and power-uprate/burnup effects.
- NRC Standard Review Plan (SRP) for power uprates should be issued (in progress). SRP should include acceptance criteria for synergistic effects.
- NRC uprate reviews should include staff T-H and core physics code calculations to verify licensee analysis.
- NRC uprate reviews should include comparison of safety measures (CDF, QHO, LERF) for prior & uprate power.

# ACRS BRIEFING

# ON

# THE POWER UPRATE PROGRAM

**June 12, 2001**

**J. Hopkins, Senior Project Manager, NRR**

# AGENDA

- Introduction ........................................................ J. Hopkins, NRR
- Duane Arnold Audit ............................................ R. Caruso, NRR
- Risk Informed Review Considerations .................. D. Harrison, NRR
- RES Research Program ....................................... J. Rosenthal, RES
- Concluding Remarks ........................................... J. Hopkins, NRR

# EXTENDED POWER UPRATES (15 - 20%)

| Plant | Uprate | Submittal Date | Review Completion |
|---|---|---|---|
| Duane Arnold | 15% | 11/20/2000 | 10/15/2001 T |
| Dresden, Units 2&3 | 17% | 12/29/2000 | 11/30/2001 T |
| Quad Cities, Units 1 &2 | 17.8% | 12/29/2000 | 11/30/2001 T |
| Clinton | 20% | 06/18/2001 T | 03/30/2002 T |

# RES Plans to Assess Synergistic Effects of Power Uprates

## Presented to ACRS Subcommittee on Power Uprates

## June 12, 2001

Jack Rosenthal

Safety Margins and Systems Analysis Branch
Division of Systems Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research

# RES Assessment

Consider potential
- synergies
- systems interactions
- phenomenological interactions

Quantitative assessment

Consider Boiling Water Reactor "Extended" Power Uprates first

Focus on Probabilistic Risk Assessment Success Criteria

Focus on Severe Accident Issues

Fiscal Year 2002 -2003 Effort by multiple branches within RES

# Identification of Issues

**Quantitative Analyses at Extended Power for Risk Dominant Sequences**

- Anticipated Transient Without Scram
- Station Blackout
- Loss of Heat Removal
- Loss of Coolant

**Review of success criteria at extended power for range of sequences in PRA**

**Review of Generic Issues**

- Power/Flow Stability
- Torus Hydro-Dynamic Loads

# Identification of Issues (Continued)

## Quantitative Analysis of Severe Accident/ Accident Management Issues

- Mark I liner melt
- Containment vent capacity

## Electrical Systems

- Grid Stability- more power, less VARS
- Accelerated ageing due to temperature

## Plant Systems

- Potential increase of failure rates due to loads, vibration, fatigue, thinning, corrosion

# Identification of Issues (Continued)

Primary System

- Reactor pressure vessel- higher fluence induces embrittlement
- Pipe loading

Containment Systems

- Higher suppression pool temperatures correspond to reduced NPSH

Control Systems

- Pressure and flow control, turbine and steam bypass

Human Actions

- Response time

# Duane Arnold Power Uprate
# Audit Results

**Ralph Caruso**
**Chief, BWR Systems and**
**Nuclear Performance Section**
**Reactor Systems Branch**
**US Nuclear Regulatory Commission**

**June 12, 2001**

# Background

- DAEC Power Uprate
- Staff Performing Review for Compliance with ELTR2 Topical Report
- Staff Review Includes Audit of Various Licensing Calculations in Support of Uprate Conditions
- Audit Performed on March 26-29 by Team of 4 Staff Members

# Audit Scope

- SAFER/GESTR LOCA Methodology
- Long-Term Stability Option I-D
- GEXL14 Correlation
- Reactor Core Design
- Methodology and Uncertainties for Safety Limit MCPR

# Findings

- SAFER/GESTR

  - Analyses for Rated Conditions Complied with SER Conditions and the Codes Were Appropriately Applied.
  - Analyses of Single-loop Conditions Used Uncertainties Derived from TRAC and Full Power Operation, Which May Not Be Directly Applicable to Off-rated Conditions.
  - However, Conservative Penalties Are Applied to Single-loop Operation, and Plants Rarely Operate in this Condition.

- Long-Term Stability Solution
  - Option I-D still Applicable to DAEC
  - Power Uprate and Change of Licensing Methodology Will Increase Operator Reliance on SOLOMON On-Line Stability Monitoring System

- Recommendation that DAEC and Fuel Vendor Work Together to Increase Operator Confidence in Ability of SOLOMON to Predict Instability

- GEXL14
  - Staff Review Identified Use of COBRAG-generated Data in GEXL14 Database
  - Staff and GE Discussing Appropriateness of COBRAG to Generate Data

- Reactor Core Design
  - Methods Continue to be Used Appropriately

- Safety Limit MCPR
  - Methods Continue to be Used Appropriately

# Conclusions

- Approved Methods Continue to Be Used Appropriately at Uprated Power Levels

- GEXL14 Correlation Database Evaluation Continues to be Discussed with GE

- Staff Will Continue to Perform Audits of Analysis Methods and Results for Upcoming BWR Extended Power Uprates
  - Dresden 2,3, Quad Cities 1,2
  - Clinton