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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

THERMAL HYDRAULIC PHENOMENA SUBCOMMITTEE

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WEDNESDAY,

FEBRUARY 28, 2007

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The meeting was convened in Room T-2B3 of Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., Dr. Sanjoy Banerjee, Chairman, presiding.

MEMBERS PRESENT:

SANJOY BANERJEE	Chairman
GRAHAM B. WALLIS	ACRS Member
THOMAS S. KRESS	ACRS Member
SAID ABDEL-KHALIK	ACRS Member

NRC STAFF PRESENT:

GREG CRANSTON

SAMUEL MIRANDA

TAI HUANG

ZENA ABDULLAHI

KULIN DESAI

ALSO PRESENT:

JOSE MARCH-LEUBA

ALLAN CHUNG

C-O-N-T-E-N-T-S

P-R-O-C-E-E-D-I-N-G-S

CHAIR BANERJEE: The meeting will now come to order.

INTRODUCTION

CHAIR BANERJEE: This is a meeting of the Advisory Committee on Reactor Safeguard, Subcommittee on Thermal Hydraulic Phenomena.

I am Sanjoy Banerjee, chairman of the subcommittee.

Subcommittee members in attendance are ACRS members Graham Wallis, Tom Press and Said Abdel-Khalik.

The purpose of this meeting today is to discuss the post staff revisions to the standard review plan, Section 15, introduction, and Section 15.9, BWR Stability.

The subcommittee will hear presentations by and hold discussions with the NRC staff; the contractors; and other interested persons regarding these matters.

The subcommittee will gather information; analyze relevant issues and facts; and formally propose positions and actions as appropriate for deliberation by the full committee.

Ralph Caruso is the designated federal

official for this meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on January 31st, 2007.

A transcript of the meeting is being kept, and will be made available as stated in the Federal Register notice.

It is requested that speakers first identify themselves and speak with sufficient clarify and volume that they can be readily heard.

I would also like to remind the members that the committee has determined that speakers should allow the first 10 minutes of presentation without questions from the members.

Now that's optional.

We will now proceed with the meeting, and I call upon Mr. Cranston of the staff to begin.

Mr. Cranston.

OPENING REMARKS

MR. CRANSTON: Good morning. My name is Greg Cranston. I'm the branch chief for the reactor systems branch.

And I just want to introduce Sam Miranda, the senior reactor system engineer, and senior technical reviewer for the reactor system branch.

We will discuss the proposed standard review plan, Chapter 15, transient and accident analysis, which introduces the standard review plan sections that deal with the accident analysis.

He will focus on the categorization of events; acceptance criteria; and their basis.

Sam.

SRP SECTION 15.0 - INTRODUCTION

MR. MIRANDA: Thank you.

My name is Sam Miranda. I'm a technical reviewer in the reactor systems branch in NRR. And I was working on the Chapter 15 introduction part of the standard review plan, along with several other reviewers in the reactor systems branch with Gene Hsii, George Thomas, Summer Sun and Lambros Lois.

I'd like to talk about the proposed revisions to Standard 15. And basically this was an opportunity for us to improve the standard, and was only one change that I think should be discussed here which I will get to later.

But in this revision, the 2007 revision, which is the first one since 1996, we have an opportunity here to make some accounting for the new reactor designs, and to add some content to this introduction.

Prior to this point Chapter 15.0 didn't have much of anything in there.

We also wanted to improve the links to the regulations, various acceptance criteria and guides for review. We wanted to make as close a link to the regulations as possible, and also to update the bases and the references, and finally, to make the text more readable.

MEMBER WALLIS: Are we free to talk about things other than the changes?

MR. MIRANDA: Well, if you want to. I'm here to introduce the changes. But if you have other questions.

CHAIR BANERJEE: I think it would be helpful to give a little background, fill us in.

MR. MIRANDA: Okay. In that case maybe we should go to the last slide.

This is a chronology of some related events to this section in the SRPs. And we begin in 1968 with the promulgation of 10 CFR 50 Part 34, which talks about the SRP.

And it also indicates in that section, a couple of paragraphs that appear also in the SRPs, which basically say that the SRPs are not law; that they are guidelines, and licensees are free to propose alternatives. That's in the regulations, and it's also in the SRPs.

And then the following year we have the birth of ATWS. In 1969 ATWS was conceived by an ACRS consultant named Dr. Epler who postulated an anticipated operational occurrence coincident with failure of a reactor trip to occur. And this would be a failure due to a common mode cause.

Then the GDCs, the general design criteria, appear in 1971, and you will see these referenced throughout the SRPs, and you will see bits and pieces of them throughout the acceptance criteria. So that occurs in `71.

In `72 the Standard Format and Content reg guide is issued, and in this Standard Format and Content reg guide we have a reference to the various events and how they are categorized, but we see more of that in 1973 in the ANS standard for PWRs.

This standard, 18.2-1973 sets up three classes of events, and they refer to them as condition two, three and four events.

Condition two events were anticipated operational occurrences. They were events defined by the ANS as events that can occur during a calendar year in plant operation.

Condition three events were slightly less frequent. They can occur during the lifetime of a plant.

And condition four events are the limiting faults.

Then in `73 –

MEMBER WALLIS: This is a time to ask a question about the first page here of the SRP. It appears that the intent of the standard you are mentioning was that all significant events would be investigated.

And yet on the first page of the SRP it simply says, a sufficiently broad spectrum of events. Now what is a sufficiently broad spectrum? That seems to be not very good guidance for some new reviewer who doesn't really know what to include and what not to include.

MR. MIRANDA: Okay. I think what they meant by that language is that the – of course all events, all possible events should get considered.

MEMBER WALLIS: If they're significant, yes.

MR. MIRANDA: But the sufficiently broad

spectrum would be those events that are limiting. So if we have a set of events, 100 events, we might choose a sufficiently broad spectrum –

MEMBER WALLIS: One includes the others, or limits the others in some way, that makes sense.

MR. MIRANDA: Yes.

MEMBER WALLIS: But there is no guidance here about what sufficient broad spectrum means. That's what troubled me.

MR. MIRANDA: Okay, well, hopefully we will be able to provide more information on that later on in the SRPs.

CHAIR BANERJEE: Are you going to – I mean there are going to be remarks made here. And are you going to appear in front of the full committee next week?

MR. MIRANDA: Yes.

CHAIR BANERJEE: So at the end of your presentation we should try to summarize your understanding of what remarks were made, and how we would plan to respond to them.

So as far as this remark is concerned, I guess, the issue lies in how do you define a sufficiently broad spectrum. And perhaps even how you define limiting as this was supposed to be guidance to reviewers.

MR. MIRANDA: At this point maybe I should mention that in addition to the SRPs there will also be a desk reference, which is going to be for internal use by the reviewers that's going to provide a lot more information than the SRPs.

CHAIR BANERJEE: As long as we know what's then in the desk reference, defining these terms, that will be fine.

MR. MIRANDA: In 1973 getting back to ATWS, between `69 and `73 there had been various submittals made by vendors of analyses of ATWS events, and they were showing some pretty bad results, usually pressures in excess of 4,000 psi.

And WASH-1270 was issued by the staff basically laying down guidelines for assumptions to be used in ATWS analyses, and calling for a new round of submittals by the vendors.

And I introduce ATWS in here because one of the changes we are going to make in the SRP, in Chapter 15 especially, is that we want to separate ATWS. ATWS has sort of bled into the other events, and ATWS was really in a class by itself. The history of ATWS is sort of intertwined with all of these others. But ATWS is not an AOO per se; it has to have a common failure in the reactor protection system – a very unlikely event. So it's outside the design basis of the plant, and including it in Chapter 15 with the design basis events seems a little bit out of place.

MEMBER WALLIS: So what is the criterion for deciding when something is design basis and when it is not?

MR. MIRANDA: Okay, we have some definitions in Chapter 15 at the end. And there is a definition for design basis event.

But basically a design basis event is an event that is used to size protection equipment. For example, the LOCA of the design basis event for the ECCS.

MEMBER WALLIS: But it seems to be a sort of circular thing. I mean it's what you use in design; it's not the basis of what you use in design. But there's got to be some – it seems to me – some critical philosophical reason for selecting certain things to be design basis events, and then used for design. You could exclude or include various things. Or decide – how do you decide whether or not to include ATWS in the design basis, for example.

MR. MIRANDA: Well, ATWS actually going back to the history of ATWS, ATWS was the first event that the staff wanted to approach licensing with a probabilistic safety goal.

And ATWS was supposed to be – I think the goal was something like 10^-6 core damage frequency per year, and then it was changed to 10^-7 and back to 10^-6, and that presented a lot of difficulties.

In fact it led to a 15-year long controversy about ATWS, which wasn't settled until the promulgation of the ATWS rule in 1984.

MEMBER WALLIS: Well, I guess this is related to my first question. When you've got a sufficiently broad spectrum to be looked at, and then you need a sufficiently broad spectrum of design basis events, too.

But when you are faced with, say, a new reactor design, how do you decide which of these accidents among the myriad which you can imagine should be in the design basis? I don't know how you decide that.

MR. MIRANDA: Well, the design basis are the accidents that can occur due to failures of components or systems. And some of these failures are more likely than others.

So these accidents are broken down into two categories.

MEMBER WALLIS: Well, ATWS isn't a failure of the system – the scram system, presumably.

MR. MIRANDA: It's a special failure of the scram system. The scram system itself is single failure proof, so in order to fail the scram system you need to have multiple failures or a common cause.

So that's what puts it beyond the design basis.

CHAIR BANERJEE: But are there scenarios which could potentially lead to this, like seismic events? Have you taken those things into consideration?

MR. MIRANDA: Well, yes, certainly there are external events. Yes, you could have seismic events. You could have a plane crash. You could have a number of different things.

When you start layering these events upon events, then you get into some very small probability space.

MEMBER WALLIS: When did LOCA become a

design basis event?

MR. MIRANDA: LOCA as far as I know has always been a design basis event.

MEMBER WALLIS: Before 1970 or so there were certainly people who spoke loudly both in and outside the agency as it was at that time saying that certain accidents were impossible, such as double-ended guillotine breaks, which we are now debating again, this transition break size thing.

So it's conceivable that large LOCAs would again be outside the design basis.

What's the basis for deciding that?

MEMBER KRESS: But would it be wrong to say that if the regulations require the design to accommodate postulated events, then those are the design bases which would in my mind include ATWS, because the regulations require that they do it.

Why is that not a design basis?

MR. MIRANDA: Well, ATWS from the beginning was defined as an event that was outside the design basis for the reasons I stated, that you need a very special set of circumstances to get into an ATWS.

MEMBER KRESS: Yes, but the design has to accommodate it.

MR. MIRANDA: And it does.

MEMBER KRESS: It seems like doublespeak to me.

MR. MIRANDA: The design is accommodated through the ATWS rule which requires special equipment.

CHAIR BANERJEE: What is your intent actually excluding this? Are there reasons to believe that the design cannot cope with ATWS, especially with the new designs?

MR. MIRANDA: Well, I have to be careful when I say excluded. We are not excluding ATWS. ATWS is in Chapter 15.8 of the FSAR.

But excluding it in terms of the categorization of events. ATWS is not an AOO, and it's not a postulated accident. It's something else. That's the exclusion I'm talking about.

MEMBER WALLIS: What's the large break LOCA going to be?

MR. MIRANDA: That's going to be a postulated accident.

The GDCs –

MEMBER WALLIS: Is it going to be outside the design basis, maybe, depending on how things go?

MR. MIRANDA: Possibly. I can't speak to

that.

As of now it's in the design basis. And LOCA is the design basis for designing the ECCS.

CHAIR BANERJEE: So is this a change with regard to ATWS?

MR. MIRANDA: No, it's not – the change is only in making this distinction. ATWS, I've noticed that in submittals and in SRPs ATWS has sort of been creeping into consideration with other accidents, accidents that for example could happen. And ATWS was never intended to be one of those accidents. ATWS was a special case.

MEMBER WALLIS: Why aren't all accidents just in the design basis? Because the plant has to somehow respond to all possible accidents.

MR. MIRANDA: Well, yes, that's one way of interpreting it. Yes, they are all in the design basis, but some are more limiting than others.

So you would design protection equipment for the limiting accidents.

MEMBER WALLIS: The worst of a certain class or something like that.

MR. MIRANDA: That's right. Right.

MEMBER WALLIS: But unless you covered everything –

MR. MIRANDA: That's right.

MEMBER WALLIS: But then if you start saying some are design basis and some are not, then you have to explain why you are giving different treatment to certain kinds of accidents.

MR. MIRANDA: Okay. ATWS, if you look at the ATWS rule, if you look at the ATWS systems, mitigation systems, unlike other accidents, mitigation of an ATWS is accomplished by equipment that is not necessarily safety grade.

The rule is that the equipment has to be highly reliable but not necessarily safety grade.

MEMBER WALLIS: Is that a good thing?

MR. MIRANDA: Well, this was the solution to the 15-year-long argument over ATWS. It was a compromise.

ATWS is not in the design basis, and the agreement was that therefore the mitigation systems for ATWS need not necessarily –

MEMBER WALLIS: If you put all these things into the design basis for future reactors we wouldn't have another 15-year argument then. Just put everything in the design basis.

MR. MIRANDA: Well, then that would be a change. That would be a different kind of a change.

Right now this is not a change. All I'm doing is –

MEMBER WALLIS: So the commission decides then what is in the design basis in some way, in some philosophical way?

MR. MIRANDA: The –

MEMBER WALLIS: Suppose we wanted the staff to reexamine this basis, particularly in the context of new reactors.

Should there be a design basis, and if so how should it be designed? How do we go about that? Is it best to do it in the context of new reactor regulations?

MR. MIRANDA: Are you talking about accidents in general or ATWS?

MEMBER WALLIS: Anything.

MR. MIRANDA: Anything?

MEMBER WALLIS: I'm taking a fresh look at regulations.

MEMBER KRESS: Should there even be a design basis?

MEMBER WALLIS: Maybe we should handle this as part of our new framework rather than attacking the decades old history.

MEMBER KRESS: The new framework talks about licensing basis again, which in my mind is the same thing as design basis. They just changed the name.

MEMBER WALLIS: Well, maybe we should move on. I just wanted to raise these points since we are looking at something very fundamental here, and maybe this is where we can have –

CHAIR BANERJEE: I'm sure that the main committee will debate this as well. So I think your answers on this need to be a bit crisper as to what you select as a design basis and what you don't.

It's not just codifying past history. There has to be some rationale for it.

MR. MIRANDA: Well, the rationale is identifying the limiting accidents. But those are accidents that require protection, and this protection is required in order to keep you within the acceptance criteria, whatever they are, for that accident, keeping the core cool for example.

And then designing and sizing your equipment in the mitigation system to deal with that accident. So when you've found the limiting accident, and you've design a system to deal with it, then that is the design basis.

CHAIR BANERJEE: Well, I think we should move on and revisit this later on.

MEMBER WALLIS: I just have another question. What is the stuck-open POVR in the design basis, the design basis accident, is a small-break LOCA at TMI.

MR. MIRANDA: The stuck-open POVRs in the design basis, has always been in the design basis –

MEMBER WALLIS: As a small-break LOCA, is that right, what it is?

MR. MIRANDA: Actually it's been in the design basis both as aan anticipated operational occurrence, and as a small break LOCA.

And the difference is, if you'd like to know, is that a stuck-open POVR as an anticipate operational occurrence is caused by a false electrical signal that operates the pore. It opens and it sticks open.

And in that case it relieves steam. And the stuck-open POVR as a small-break LOCA could be for example a mechanical problem; it could even be a stuck-open safety valve. It would be a broken valve. And it too would begin by relieving steam but eventually would relieve water. And the water relief would be small-break LOCA.

Okay now we get into the standards. The AMS standard which defined those three classes of events, conditions two, three and four, was issued in `73.

CHAIR BANERJEE: What did the standards say about ATWS?

MR. MIRANDA: It didn't. Nothing. In fact none of the standards that you see here say anything about ATWS.

WASH-1270 was issued. And then in `78 the standard for boiling water reactors was issued. And right guide 170 was revised. And then we had the first version of the SRPs issued in 1980.

And that refers to the regulation 50.34 which mentions the SRP. It's kind of a circular reference. One reference – each references the other.

1982 is a landmark year in which plants that are docketed after that, May 17th, 1982, are expected to follow the guidelines of the SRPs.

In `83 the ANS standards were replaced by newer standards. And at this point maybe I should mention the ANS policy on standards. When ANS issues a standard, it reviews that standard every five years, and either revises it or replaces it.

And if after 10 years they have revised

it or replaced it, then they withdraw it. And the standards that are mentioned that were replaced in `83 were withdrawn in 1998. They were reaffirmed in 1988.

The ATWS rule comes out in `84. And the ATWS rule specifies that certain equipment needs to be installed in plants, in certain plants. It doesn't really say anything about analyses, but we follow the bases for the rule, that the analyses that led to the rule.

And the reviewer is instructed, when reviewing an ATWS, to keep in mind how the rule was formulated, and how the analyses were made, the assumptions especially, in particular the moderator temperature coefficient.

In `96 we have the version of the SRPs that we are dealing with now. And then two years later these ANS standards are withdraw.

So what happens is, the condition two, three and four events that were established by these standards – and by the way, they were never endorsed by the NRC staff – but nevertheless, the licensees followed that classification of events, and submitted analyses based on that classification.

And the NRC staff reviewed those

analyses, and issued licenses based on those analyses. So whereas the NRC staff did not endorse the standards, there was in the act of issuing the licenses forms a tacit approval of that classification.

And the change that we are making, it's not really a big change, because the SRPs had not generally followed these three classes of events; the SRPs had always had two classes of events, and we are just formalizing that.

We are going to use the same names that the GDCs use. So whereas the SRP refers to events of moderate frequency and limiting faults, which correspond to condition two and condition four events, from now on they are going to say, anticipated operational occurrences of postulated accidents. And those are the terms used in the GDCs.

So basically what it does is, it lumps the condition three events, the infrequent events that can occur during the lifetime of a plant, it lumps them in with the condition two events to form the AOOs. And the AOOs are defined as events that can occur within the lifetime of a plant.

MEMBER WALLIS: That are likely to occur.

That are likely; it's all a probabilistic thing. You said that can occur. I mean I think that what you mean are likely to occur.

MR. MIRANDA: I see what you are saying. But the language it says can occur.

MEMBER WALLIS: Well, I think we have to be clear about some of those things. Because later on we get some criteria which are absolute and don't allow anything probabilistic, and then if someone is going to use a 95-95 criteria on something which is absolute, then that's a problem it seems to me.

It states that the maximum fuel element temperature shall not exceed 2,200; that is an absolute statement. It doesn't say with 95/95 confidence or something. It just says, shall not.

MR. MIRANDA: That's right. And that's what's in 50.46.

MEMBER WALLIS: It's quite a different from the interpretation of the stop.

MR. MIRANDA: We don't have any leeway in that.

MEMBER WALLIS: Well –

MR. MIRANDA: That's in the regulations.

MEMBER WALLIS: But then it's not being interpreted that way.

CHAIR BANERJEE: What was the word that "shall" has replaced?

MEMBER WALLIS: There are lots of "shalls" now on page seven for instance.

CHAIR BANERJEE: What was it before? Those "shalls" are highlighted.

MR. MIRANDA: Oh, yes, those "shalls" are highlighted. They were highlighted by the technical editor for the reviewers to consider whether we should be using "shall" or maybe some other word.

MEMBER WALLIS: What was used previously?

MR. MIRANDA: It was "shall."

MEMBER WALLIS: We'll get onto that page later perhaps. I have quite a few questions on that.

CHAIR BANERJEE: As Professor Wallis was asking, in practice was it interpreted as "shall," or was it interpreted in some other way by the staff?

MR. MIRANDA: I believe it was interpreted as "shall." If you have an analysis that indicates 2201 degrees, then that analysis fails.

MEMBER WALLIS: But the present Westinghouse method uses some sort of 95/95 probability, that is not a shall; that's with a high probability. And that's what the ECCS rule says. It doesn't say, shall. It says with a high probability. If you look at the actual 10 CFR, 50.46, it says with a high probability. It doesn't say shall.

There is something different there.

MR. MIRANDA: Okay.

MEMBER KRESS: If you could append that shall if the calculations are made according to the specifications in Appendix K. Then it becomes an absolute. I mean there is an implied probability in there somewhere.

MEMBER WALLIS: We can talk about page seven when we get to it. I don't want to interrupt your train of thought here.

CHAIR BANERJEE: So if you use the CSA methodology, and the best estimates –

MEMBER KRESS: Then you have to go to 95.

MEMBER WALLIS: There is no shall. There is a very strange criterion in number four on eight which says "might" instead of "shall." When we get to page seven, I think, are the details.

I don't want to interrupt your train of thought. You are leading us through the history which would be good. Then perhaps we can look at some of these details.

MR. MIRANDA: The reason I wanted to go through this history was that there was another criteria which we have not yet discussed, and that is the one that prohibits the escalation of an event from one class into the next higher class.

MEMBER KRESS: Prohibits is another one of those absolute words.

MR. MIRANDA: Yes.

MEMBER WALLIS: It prohibits.

MR. MIRANDA: Yes.

MEMBER WALLIS: That's a "shall."

MR. MIRANDA: That's a "shall," yes, shall not.

That criterion first appeared in the ANS standard of 1973 –

MEMBER WALLIS: But TMI was one of those where it started out as an AOO and it ended up as a LOCA, and then actually led to core damage.

MR. MIRANDA: That's right. That was in the ANS standard for PWRs in `73. It was repeated in the ANS standard for BWRs in `78. And it appears in licensing submittals that rely on the condition two, three and four event classification, and it was approved by the NRC staff, although the standard itself wasn't endorsed.

And I couldn't find any basis for that criterion in the regulations.

And then in 1998 the standards are withdrawn, so we would like to retain that criterion. We think it's an important criterion.

So in `98 the standards disappear, but we do have in 1999 10 CFR 50.59 which governs changes, tests and experiments. And in there there are a series of eight questions, and these questions seem to touch on this criterion.

MEMBER WALLIS: We talked about class two leading to class four. How about ATWS? Is there something that says ATWS shall not lead to a class four accident?

MEMBER WALLIS: ATWS is already worse than a class four.

MEMBER WALLIS: But it could lead to other things which are – you know – the ATWS sequence could lead to ejection of a control rod or something. The thought is that things could lead to other things.

MR. MIRANDA: I can see that. But ATWS is already –

MEMBER WALLIS: So bad already that you don't worry about it.

MR. MIRANDA: I don't know whether you are going to worry about these other things.

In fact, in ATWS in a PWR it would produce a very high pressure. And yeah, you could possibly end up ejecting a control rod. And I don't know what would happen then. In that you may have a relief path.

So this last item, this 50.59 has these eight questions dealing with, have you increased the possibility that an accident can occur? Have you increased the consequences of said accident? And so on.

MEMBER WALLIS: The whole stuff about minimal and nonsignificant and so on, hard to define.

MR. MIRANDA: That's right.

So if I want to keep that criteria that prevents one accident from leading to another, then that's about as close as I could come to it in the regulations.

Okay.

CHAIR BANERJEE: Does that have to be demonstrative by the applicant, that in some that –

how does the applicant show that it won't propagate from one class to another?

MR. MIRANDA: That's a good question. Applicants usually show this – there is only one sequence that I know of that can lead from one accident to the other, and that is, similar to the TMI scenario, the pressurizer is filled during some anticipated operational occurrence, for example, take a loss of feedwater, which is what happened at Three Mile Island.

You fill the pressurizer, and then once the pressurizer is water solid, pressure gets very high very quickly, and you eventually reach the PORV opening set point. The PORV opens and relieves water. And the PORV not being designed to relieve water is assumed to stick. And now you have your small-break LOCA at the top of the pressurizer.

So typically applicants have been shown that accidents such as loss of feedwater and other operational occurrences that can cause pressurizer level to rise – these are typically loss of heat sink type events – they show that they won't lead to a small-break LOCA by simply showing a transient that is over before the pressurizer fills.

MEMBER WALLIS: How about combinations of events? I mean the problem at TMI wasn't that the POVR stuck open; the problem was that there were two problems, and someone had left the valves closed on the aux feed. So that when they lost the feedwater, and asked for aux feed, it didn't come on.

And that happened, and then this POVR stuck open. Two things are going wrong simultaneously. So this classification of everything is one accident here, one accident there, one event here, one AOO, does that prevent looking at combinations of events?

MR. MIRANDA: You are touching now on the other change that we want to make to Chapter 15.0.

MEMBER WALLIS: That's I think why TMI – my explanation – why TMI confused the operators so much was that two things went wrong. And they fixed one, and sort of assumed that, you know, they fixed one so everything is fine.

MR. MIRANDA: Well, actually, more than two things went wrong.

MEMBER WALLIS: Yeah, but there is a sequence, a cascade of things. But there were two initiators in a way. There was the feedwater thing, then there was the aux feed problem. And then there as the POVR stuck open problem. Two things went wrong. Two systems failed.

MR. MIRANDA: Yeah, or maybe three, yeah.

MEMBER WALLIS: Maybe three. Is there some way to catch those kind of events in these reviews?

MR. MIRANDA: Well, for Three Mile Island there was a lessons learned, and that kind of thing – Three Mile Island you will find is scattered throughout the SRPs, and applicants have to show that they meet the requirements of the lessons learned report.

And one of those is the requirement to show that you are not going to uncover the core as a result of an anticipated operational occurrence like Three Mile Island.

MEMBER WALLIS: Well, somebody having left the aux feed valves closed during maintenance, is that an operating occurrence, or what is that? It's not an accident. It's a latent thing, something waiting to happen. It changed the state of the system. But it's not yet an accident. How does something like that get considered?

MR. MIRANDA: Well things like that are addressed through the tech specs, you have surveillance requirements; you these things things.

And you have surveillance periods. You test these things every 30 days or something like that.

MEMBER WALLIS: You change the whole course of action; that's the problem.

MR. MIRANDA: Yes, and when we do accident analyses, the assumption is that the plant is operating within the tech spec operating limits. And you are not in an action state.

MEMBER WALLIS: That is the problem.

I don't know how far you need to investigate that, but I think that's probably when plants are most likely to get in trouble when for some reason that maybe the operators don't know they are not in tech specs. And then there is some event.

The fact that they are not in tech specs somewhere changes the course of events, or it doesn't look like what they've been trained on.

MEMBER KRESS: I think you are mixing up two different spaces. You're mixing up design basis space with reality which is the PRA space.

MEMBER WALLIS: Well, reality is always a better space to be in.

MEMBER KRESS: The PRA space is reality as we know it. The design basis space is a sort of manufactured – they are not real accidents.

MR. MIRANDA: Then we don't need it if it's not reality.

MEMBER KRESS: They are descriptions of events, an event identified that could occur. But there are specifications going along with it, like how do you calculate the results? What kind of figures of merit you have to meet?

And do you have a single failure criteria? There are redundancy and diversity requirements for some of them.

These are all artificial type things that have been designed to use design basis space in an attempt to render the plant an acceptable level of risk.

But that connection is a little tenuous; I mean it's not a one-to-one connection. So we are kind of mixing up those two spaces when we talk about like the TMI; that's not a design basis event. That's a PRA thing.

MR. MIRANDA: Maybe we don't need design basis events if we have a good enough PRA.

MEMBER KRESS: Well, the designers like to have something to base their design on. And to base it primarily on the PRAs may be a little tricky. Because then you have to be very careful how you deal with the uncertainties.

Design basis space, there are no uncertainties.

MEMBER WALLIS: I guess we are going to revisit this again.

CHAIR BANERJEE: Tom, would the PRA space of sort of if you didn't know the answer now predicted that the TMI sequence could occur?

MEMBER KRESS: Yes. In fact it was predicted in WASH-1400 as the dominant accident.

MEMBER WALLIS: But that someone would leave –

MEMBER KRESS: That type of event. Well, the small-break LOCA.

MEMBER WALLIS: No, but the aux feed as well.

MEMBER KRESS: Well, that came out of WASH-1400. It was in there.

CHAIR BANERJEE: The plant could have an accident when it's out of tech spec.

MEMBER KRESS: Sure. That is a probabilistic event.

CHAIR BANERJEE: And what is the likelihood that a plant is out of tech spec?

MEMBER KRESS: Well, that is supposed to be covered in the PRA, the failure probabilities of certain things.

CHAIR BANERJEE: But the PRA should inform the design basis space.

MEMBER KRESS: That is my opinion. Now up to now we didn't have PRAs to inform design basis space. And that's why we end up with this sort of manufactured accident that covers the spectrum of what we think are identified occurrences.

But I think the new reactors, you ought to really inform design basis space by using the PRS. But I would rely on it completely, because then you have to be very careful about the uncertainties.

CHAIR BANERJEE: Sure. But nonetheless, we have this SRP now which doesn't consider the possibility that the plant is out of tech spec.

MR. MIRANDA: No, it's still in design basis space.

CHAIR BANERJEE: Yeah, strictly.

MR. MIRANDA: Design basis space to a large extent has not been fully informed of PRA.

CHAIR BANERJEE: If that's a fairly high probability event, then that should have informed the design basis space.

MEMBER KRESS: You would think so.

CHAIR BANERJEE: Do you have an answer for that?

MR. MIRANDA: I believe for the new reactor designs, they are using the results of PRAs to design new systems.

MEMBER KRESS: Yes, I think for new designs that's the case.

MEMBER WALLIS: We are talking here about a way to improve the SRP. It's our chance to change it if it's a good thing to change.

MR. MIRANDA: That's right, and we are trying to put in some provision in here for the new reactor designs.

And so that PRA-informed design could enter into the SRPs through that route. And as far as the older deterministic approach that has been around since 1973, we're – the improvements there are just in adding clarity and content, and linking it as closely as possible to the regulations that exist now.

MEMBER ABDEL-KHALIK: Back to the requirement of prohibiting one class of accidents from escalating to a higher class. Now if the plant is designed to handle the higher class event, what difference does it make how that event started, whether it started as a lower class event, or from time zero it was a higher class event?

MR. MIRANDA: The difficulty there is that we have events of moderate frequency, lower class events. They are more likely to occur, and therefore they have more stringent acceptance criteria.

This applies the principle of constant risk, you know, that if you multiply the probability of an occurrence by its consequences it should be about the same across the spectrum of events.

MEMBER WALLIS: I wanted to ask you about that. That's one of my questions.

This doesn't take into account risk aversion. The public has a kind of risk averse attitude. It's quite willing to tolerate a lot of things which are minor, but it's not particularly fond of the tremendous accident which is a very rare occurrence.

And when you say that the risk – in other words, probability times consequence – should be the same for sort of a minor accident and a major one is a big philosophical statement.

MR. MIRANDA: It's what we've been using all these years.

MEMBER WALLIS: I know, but is it right? Is that the way the public looks at nuclear accidents? I'm not sure that it is.

I hear a lot from George and others about risk averse public.

MR. MIRANDA: Well –

MEMBER WALLIS: You have to make the risk of the major accident less than the risk –

MEMBER KRESS: Once you depart from the risk averse curve, you open up an infinite number of curves. And you have to decide on which one you want.

And I know of no criteria, other than poll the public and say which one of these do you prefer.

MEMBER WALLIS: Okay.

MEMBER KRESS: But you know that's uninformed. Those people don't know. They may be risk averse, but we have to choose something that we think is reasonable.

I think the non-risk averse curve is probably the most reasonable one to choose.

MEMBER WALLIS: Well, that's what you

think.

MEMBER KRESS: Yeah, I know, but this is a policy issue. You can't decide – I don't think there is a technical basis to decide on how much risk aversion to put in on a regular basis.

MEMBER WALLIS: I want to make the point, though, that assuming that the risk is constant across the spectrum of accidents is a policy decision.

MEMBER KRESS: Sure.

MEMBER WALLIS: You say it's a policy decision. You say it's a principle. It's not a principle of nature.

MR. MIRANDA: It's a design criteria.

MEMBER WALLIS: Someone has decided it.

CHAIR BANERJEE: Has it actually been formulated as a policy decision?

MEMBER KRESS: They are looking at it – no, there is nowhere in the policy statements that you can read that says that.

MEMBER WALLIS: So where did it come from? Why is it a principle?

MEMBER KRESS: Well, I think they just made it a principle.

MR. MIRANDA: Well, actually, that

principle, I've seen it in print in the BSR standard of `78.

MEMBER KRESS: I see. It actually goes up there.

MR. MIRANDA: I think so, yes.

MEMBER KRESS: I didn't know that.

But anyway there is an infinite number of choices you can make. But I know of no technical basis to make a choice.

MEMBER WALLIS: So when you make this statement in the SOP there is no reference to some policy statement by the commission or something that justifies it?

MR. MIRANDA: No.

MEMBER WALLIS: So it's just sort of stated without any –

MR. MIRANDA: It's the way things are. It's why we have more stringent acceptance criteria for the more frequent accidents.

And getting back to your question –

MEMBER WALLIS: Well, I guess the problem is with the more severe consequence. There is a lot more uncertainty about both frequency and consequence. So maybe one should be more cautious about these relatively rare accidents, because there is much more uncertainty about both the frequency and the consequence.

CHAIR BANERJEE: To actually give some credence to this, I have seen numbers on pipe breaks, probabilities which exceed the age of the universe. So I mean – and age of the earth by a factor of 10 or 100.

MEMBER WALLIS: You mean one over the age of the universe.

CHAIR BANERJEE: Yeah. One over. So I mean these numbers are highly speculative.

MR. MIRANDA: I agree. And there are accidents that we postulate are not going to happen that actually have happened. So this is just a general statement. It's about constant.

MEMBER WALLIS: Okay. Well, when we get to new reactors, I'm going to challenge this statement.

MEMBER KRESS: That's what's being put into the new reactor framework.

MEMBER WALLIS: I know. It seems to be being put in without explicitly stating it. Sort of implied by it.

MR. CARUSO: Remember also how this policy gets determined. The staff is proposing guidance, and it's coming to the technical committee for its comments. You are going to CRGR with us?

MR. MIRANDA: No.

MR. CARUSO: Sometimes CRGR gets to look at it, and then put it out for public comment, right? So the public gets to take a whack at it.

So that's how these policies aren't in the policies – this process. So this is the committee's chance to stick its foot in the water on this policy.

MEMBER KRESS: I think we're going to get a disagreement.

CHAIR BANERJEE: I think one of the probabilities should be limited to one-tenth the age of the earth.

(Laughter)

MR. MIRANDA: Or one-hundredth, what would you prefer?

MEMBER ABDEL-KHALIK: I guess if I go back to the question I asked earlier about the escalation requirement, my concern there is that by putting this requirement, you are actually excluding – possibly excluding a whole group of initiating events that you are excluding from eventually becoming design basis events just simply by the fact that they are part of the lower classification of events.

MR. MIRANDA: The criterion is there to prevent the possibility that you can have a limiting fault, a very serious accident, with the same probability of occurrence as an AOO.

MEMBER ABDEL-KHALIK: No, that is not the concern. The concern is similar to the issue that Professor Wallis raised earlier, that you have a sequence of events, and the probability of that sequence of events is quite low so that it would fall in the higher category, higher classification category; but the very first event in that sequence is a lower classification event.

MR. MIRANDA: Okay, now I think we are getting back to the differences between the PRS deterministic approaches. Because for example the scenario described earlier, the stuck-open POVR, what I mentioned before was, a POVR relieving water is assumed to stick open. In real life it may not. It probably will not. But for the deterministic accident analyses it's always assumed to stick open. The probability is one.

In that case you have a small-break LOCA with the same probability of occurrence as the original opening of the POVR. And now you have an accident with serious consequences postulated to occur fairly frequently.

And that's the difficulty in the deterministic side. And all of these SRPs that follow in Chapter 15, they are all deterministic analyses.

MEMBER WALLIS: Okay, thank you.

CHAIR BANERJEE: That's been very useful.

MEMBER WALLIS: I think we can probably go through these fairly quickly now.

As I said before, we were going to try to put in some provision at least for the new reactor designs, at least put in a placeholder. We expect there will be more changes.

MEMBER WALLIS: What's going on with the bottom one? The bottom one seems to be more - go back to the TMI thing. There is a failure of aux feed, and then there's also an AOO. You don't often allow that. You don't have to consider that.

MR. MIRANDA: I'll get to that.

MEMBER WALLIS: Okay.

MR. MIRANDA: So we are defining the two categories, and we're separating out – we are not changing anything in ATWS, but we are making the distinction that ATWS is a separate category.

We want to retain this –

MEMBER WALLIS: What does prohibit mean? Do you mean by design you make it impossible to happen. Or is it you prohibit it in design basis space? Is it a physical thing you are prohibiting or a regulatory thing?

MR. MIRANDA: This is a design criteria. So if you are going to make, for example, if you have a design such that the pressurizer will always fill, then you need to design the POVR to relieve water. If that's in your design, if your POVRs are going to open and relieve water, then they should be designed to relieve water and then reclose after that.

MEMBER WALLIS: And there is no probabilistic thing? You must absolutely prevent an AOO from becoming an accident with any probability whatsoever, like one over the age of the universe?

MR. MIRANDA: Yeah, that's right.

MEMBER WALLIS: Hard to do with design.

MR. MIRANDA: There are six plants, for example, in the U.S. that have designed their POVRs to relieve water.

MEMBER WALLIS: Then they only relieve

water with some probability. I mean you have to consider. Prohibit is a bit of a strong statement.

MR. MIRANDA: For our purposes, in a deterministic analysis, if they are safety grade POVRs, and they are designed to relieve water –

MEMBER WALLIS: They always work?

MR. MIRANDA: – they always work, yeah.

MEMBER WALLIS: Even if they are allowed to deteriorate over months?

MR. MIRANDA: Well, that's what tech specs are for.

MEMBER ABDEL-KHALIK: How do you sort of reconcile that with the leak before break?

MR. MIRANDA: I don't. Leak before break I think falls into the space between – leak before break is recent compared to these. These have been around since `73.

So leak before break, I put it in the space between the deterministic and probabilistic approaches.

MEMBER ABDEL-KHALIK: But still, I mean physically, we are talking about something that will start out as a minor leak; then it evolves into a small-break LOCA, and possibility propagate into a large-break LOCA.

So you are covering the entire spectrum. So how do you reconcile that with the requirement that an anticipated occurrence cannot, or should be, prohibited from becoming a possibility of an accident?

MR. MIRANDA: I can address that by playing with the definition. I can say, for example, that a leak for example in the pipe, a leak in a pipe is a mechanical fault, and therefore, not very likely to occur in the first place.

MEMBER KRESS: It's not an AOO.

MR. MIRANDA: It's not an AOO, right. So it's a limiting fault of different dimensions.

CHAIR BANERJEE: Is that consistent with actual experience? I mean we've had a lot of leaks.

MR. MIRANDA: Well –

CHAIR BANERJEE: I mean shouldn't you really keep your feet on reality here? It has occurred during the lifetime of plants, right?

MR. MIRANDA: This is true.

CHAIR BANERJEE: Each time we get a surprise, and we say, oops, didn't think of this material problem.

Every 10 years roughly there is a new problem that arises, Bill Shack says that, that we haven't thought of, and we get a leak.

MR. MIRANDA: That's true. And what you are saying is, that when we classify these events, that the boundaries are not that clear. Sometimes what we think is a limiting fault, we may really have the likelihood of an occurrence of an AOO. Things like that have happened.

MEMBER KRESS: They are covered in the other category.

MR. MIRANDA: They are.

MEMBER KRESS: They are covered. It's just that we decided if it's not an AOO, it ought to just be in the other category.

CHAIR BANERJEE: So the decision is not as we discussed informed by any probability. It is simply arbitrary to classify something as – more or less arbitrary to classify something as an AOO –

MEMBER KRESS: Well, the frequencies are implied.

CHAIR BANERJEE: They are implied, yes.

MEMBER KRESS: They are not off the top of your head. Just talk about occurring over the lifetime of a plant versus some other.

CHAIR BANERJEE: Perhaps we should reexamine those in the light of experience and see what should be reclassified as AOOs. I mean we have a lot of experience now.

MEMBER KRESS: Yeah, I don't know why we got rid of events that occur over – within years past. I would have kept those, I think. I mean that's just finer division of the things you look at.

MEMBER ABDEL-KHALIK: I think perhaps what we ought to do is try to understand the implication of misclassifying an event.

In the very beginning, when the ANS-1973 standard came out, steam generator two were considered class four events. And then later on they were reclassified as class three events.

The question is, what changed?

MEMBER WALLIS: They happened more often.

MEMBER ABDEL-KHALIK: Well, that's why they were classified as class three rather than class four.

But from a practical standpoint, what did that reclassification result in?

MR. MIRANDA: From a practical standpoint probably very little. Because class three events has always been an ambiguous. The criteria for class three has been some level of fuel damage which was defined by offsite dose limits.

It was – events have always been class two or class four. Class three has been very hard to define.

But you are right, the reclassification occurred because we had better experience, and we knew that steam generator tube rupture is something that is going to occur during the lifetime of a plant.

And when these classifications were first set up in 1973 I believe they were done according to the knowledge that was available at that time. And it's only right and proper to modify these as we get more experience.

CHAIR BANERJEE: But is that taken into account in the documents? Experience.

MR. MIRANDA: Well, the SRPs are guidelines, and licensees can propose alternatives. And if a licensee comes in and has some experience, data, operating experience, and wants to classify an event into another category, and can back it, we would have to consider it.

CHAIR BANERJEE: Right, but that is putting the onus on the licensee.

MEMBER KRESS: If you want to impose new

requirements on existing plants, by reclassifying one of these things, then you have to do a backfit analysis. So it may not be imposable on them. But it could very well apply to any new plant.

MEMBER WALLIS: The last bullet you just alluded to, is that something new?

MR. MIRANDA: The last bullet is something new, and we will discuss that.

MEMBER WALLIS: What was it before?

MR. MIRANDA: Before there was a requirement in the SRPs that said, you take an AOO, and you consider it for – for an AOO you consider it a single active failure. Any single active failure criteria is AOO.

MEMBER WALLIS: And this has been removed? You're going to talk about it later.

MR. MIRANDA: It's already come up a couple of times, so I guess we should do it.

I call it the combo AOO requirement. And this is the language in the SRP, an incident of moderate frequency, or an AOO, in combination with any single act of component failure, or single operator error, shall be considered, and is an event for which an estimate of the number of potential field failures shall be provided for radiological dose calculations.

What this says in effect is that a moderate frequency event, an AOO, if you combine it with another failure, has now bumped into a next class. Now, because the acceptance criteria for an AOO don't allow any fuel failures. But now you are allowing fuel failures.

So it's a way of – they are combining accidents. And when they say any single act of component failure, that could be – that's any single act of failure.

That could be – that's any single act of failure. That could be another AOO. That could be something that is not related to the original accident.

MEMBER KRESS: It seems to me that we are losing some of the conservatism; you are losing some margin here.

MR. MIRANDA: I don't believe that. And the reason is that this requirement is hard to meet. It's ill defined, because you can postulate any combination of AOOs or accidents.

For example it's a loophole. I can take an accident, an AOO, and postulate a single act of failure with it that has nothing to do with the accident; that doesn't aggravate the accident. But now I've just relaxed my acceptance criteria.

MEMBER KRESS: I don't see that that follows.

MR. MIRANDA: Why have you done that?

CHAIR BANERJEE: That sounds like gamesmanship.

MR. MIRANDA: Yes.

MEMBER ABDEL-KHALIK: I'm sorry, could you explain what you just said?

MR. MIRANDA: Okay. Take an AOO, I don't know, loss of feedwater, okay. And loss of feedwater, and I combine it with another accident, for example, operator turns off safety injection, or doesn't turn it off, it never goes on, but he disables safety injection, so you don't get safety injection. That's a lot –

MEMBER KRESS: Would that be a single failure?

MR. MIRANDA: That's a single operator error.

MEMBER KRESS: Those are included in single failures.

MR. MIRANDA: According to this language, it says –

MEMBER WALLIS: Then this leads to a high cause accident which is something that you have already forbidden; is that what you are saying? That's why it should not –

MR. MIRANDA: No, what I'm saying is, if I want to play this game, I can postulate any active failure, and that active failure could be something that doesn't affect the original accident. It could be something totally different.

And since it doesn't affect the accident, all it's done is, it's bumped it, according to this requirement, it's bumped it into a more relaxed acceptance criteria. Now I can take some fuel damage –

CHAIR BANERJEE: Has this actually ever occurred?

MEMBER WALLIS: Why does it have a more relaxed acceptance criteria?

MR. MIRANDA: Because an AOO by itself, the acceptance criteria for that is no fuel damage. But if I combine that AOO with a single act of failure, now I'm allowed to have some fuel damage.

So if I'm free to choose any single act of failure or operator failure, I can choose one that has no effect on the accident, and in doing so

I have a more relaxed acceptance criteria.

MEMBER ABDEL-KHALIK: But that doesn't remove the original AOO requirement from being met by itself.

MR. MIRANDA: By itself, yes, it does not.

MEMBER ABDEL-KHALIK: So your argument is incorrect.

MR. MIRANDA: Well, my argument – yes, that's right, the AOO remains and you have to meet those acceptance criteria; that's right.

And this requirement, also, this requirement then has no effect. Why have it in the first place?

MEMBER ABDEL-KHALIK: Well, because, let's go back to your example of a loss of feedwater, and if the operator disables safety injection. That is not the only single failure that needs to be postulated in conjunction with a loss of feedwater event. And there is possibly another single failure that can be postulated that would make this event more severe than the loss of feedwater in and of itself.

MEMBER KRESS: You have to design around that.

MEMBER ABDEL-KHALIK: Correct.

MEMBER KRESS: That's why I say it seems to reduce the margin.

MEMBER ABDEL-KHALIK: Absolutely.

CHAIR BANERJEE: I think this is something we need to discuss with the full committee. This is a significant change.

MR. MIRANDA: Well, this requirement by the way, when we discussed it in the active systems, no one could figure out where it came from. It's not in the regulations. And the only reference I've seen to it anywhere was one line in the 1970 BWR standard. It didn't appear in the PWR standard.

And the way this is written it's not well defined, especially if I take any active single failure. I mean we discussed this already.

MEMBER KRESS: The problem I have is in our deterministic regulations, part of them is always the single failure is part of it. And now we are taking that way from one class of accidents for some reason I don't understand.

MR. MIRANDA: No, there are two single failure criteria. And there's been some confusion about this. We have had a lot of discussion about this.

There is the single failure criterion that is specified in standards like IEE-279. It's specified in the GDCs. This is the single failure criterion that says, a protection system has to be able to perform its function despite the worst single act of failure.

MEMBER KRESS: Yeah, that's what I believed. That is a different kind of single failure.

MR. MIRANDA: Yeah. The single failure of this one, the one I'm talking about, is, the single failure is also – it's an accident. It's an AOO. It can be anything. It can be a reactor trip. It can be an operator error. It can be a valve opening or closing.

MEMBER KRESS: It seems like we need to sharpen our definition of what a single failure is. Because I was thinking this first definition you gave is what the -

MR. MIRANDA: Yeah, a lot of people are thinking that. It's not. It's – that's why I call it the combo AOO. We've got two AOOs at the same time now. We've got two accidents at the same time, and it says so. Two simultaneous AOOs.

And this is like –

MEMBER WALLIS: That's in PRA space presumably.

MR. MIRANDA: Yeah, that's right, or three AOOs if they are sufficiently likely to occur. Yeah. This is similar to looking at an accident occurring during a tech spec action statement. You've already got a system that is out of service, and now you've got an accident.

MEMBER ABDEL-KHALIK: I still think we have to tread here very carefully. Because I would consider this a part of the defense in depth. And therefore just simply eliminate it, just because it doesn't exist in any written document, is probably a decision that has to be made with care, a lot more care.

MEMBER KRESS: I think the person I would ask, given this change, what does that represent in terms of changes, possible changes to the plant? That's where the rubber meets the road.

I don't know what it means.

MEMBER WALLIS: Well, we use a PRA to show that the risk is climbing.

CHAIR BANERJEE: Maybe you could address the question that Dr. Kress has as to what it really means in terms of changes to the design or whatever.

What are the practical consequences of this likely to be?

MR. MIRANDA: Well, one practical consequence that I've seen as a reviewer is that some licensees submit analyses of AOOs, assuming single active failures in combination AOOs. Some of them do submit analyses like this, and others don't.

And –

CHAIR BANERJEE: Does it reduce the conservatism? Because they still have to meet the AOO criterion.

MR. MIRANDA: That's right. So when I see analyses like that, I don't really know what to do with that.

CHAIR BANERJEE: Where does the confusion arise?

MR. MIRANDA: The confusion arises in several places. One is in your choice of analyses, your choice of active failures, the combinations that they decide to analyze. And the other is the acceptance criteria that they say they need to meet.

CHAIR BANERJEE: Do they still meet the AOO acceptance criteria?

MR. MIRANDA: Certainly.

CHAIR BANERJEE: That, and then when they do this combination they can choose whatever they like? What are the consequences of them bumping it up? Is there any consequence of that?

MR. MIRANDA: I don't see any practical benefit. They do the analysis. They choose the combination of failures as they arise. And then the acceptance criteria that they need to meet, this business about allowing some fuel failures, that's kind of ambiguous. How much fuel failure is allowed?

Now we have acceptance criteria for AOO, and we have them for limiting events, limiting faults. Those are well defined.

But in between, for combinations of events, I don't know what to do with that.

MEMBER WALLIS: There is no acceptance criteria?

MR. MIRANDA: Well, there is, and you saw it. It says that – it says there will be an estimate of the number of potential fuel failures –

MEMBER WALLIS: Provided – that's the only criteria.

Mr. BANERJEE: Bring it to the judgment of the reviewer.

MEMBER WALLIS: Then presumably these

dose calculations have to meet the dose criteria.

MR. MIRANDA: Well, they don't say that, do they? About the only firm criterion you'll see there is that there will be no less of function to any fission product barrier other than the fuel cladding. So that means that the vessel remains intact, and the containment remains intact.

MEMBER WALLIS: But in all of this, you have to consider this, but then you have a weaker criterion for some reason.

Well, maybe the whole thing needs to be straightened out, not deleted. Just because it's awkward doesn't mean you get rid of it. You have to consider how do you meet the intent of this original advice here.

MR. MIRANDA: So then I would ask you, what is the intent?

MEMBER WALLIS: I don't know; I didn't write it.

MR. MIRANDA: Well, neither did I.

MEMBER ABDEL-KHALIK: The intent perhaps is to provide some reasonable connection between design space and –

MEMBER KRESS: Risk space.

MEMBER ABDEL-KHALIK: Right, and the real world. That's the intent of this.

MR. MIRANDA: I would say that that's what tech specs are for. That's what action statements do, that if something occurs, and a system is not operating at full capacity, then you are required under action statements to repair it within a certain period of time. And that is determined probabilistically.

MEMBER WALLIS: How long has this been in the review plan, this statement?

MR. MIRANDA: Well, at least since `96. As a matter of fact –

MEMBER WALLIS: That's not so long ago. You could probably find somebody who wrote it.

CHAIR BANERJEE: But let me ask you, I mean the impression you are giving, which may be unintended, is, this is being done to provide clarity and some ground to the reviewer. That can be done in different ways.

I mean if you specified what the radiological dose calculations of potential fuel failures would be, you are attempting to limit that. That could also provide some clarity, as Professor Wallis said. You could just improve the language there so you would make it a little bit more deterministic.

MR. MIRANDA: And what would be my basis for that?

CHAIR BANERJEE: I don't know.

MEMBER ABDEL-KHALIK: The word, any. That's the basis for that. I mean you say that the licensees come up with analyses in which they do these calculations, and they pick and choose whichever component they assume to fail.

They do that maybe because there is no guidance as to what the word, any, means, in this requirement.

And if you provide them with that guidance, if you specify the range of additional single failures that they have to consider, that would eliminate the uncertainty.

MR. MIRANDA: That's one side of the uncertainty. That's the definition of the event. And then we have the uncertainty of the acceptance criteria.

MEMBER WALLIS: And you clarify that too.

MR. MIRANDA: But then –

MEMBER ABDEL-KHALIK: Well, there is a clear definition of – at least a part of the acceptance criteria. It is that the only failure as far as fission product barriers would be just the fuel cladding. The other two barriers would remain intact. That's a clear acceptance criteria.

MR. MIRANDA: Okay, in that case I could argue that the combination AOO requirement is bounded by ATWS. I would say that ATWS is an AOO with probably the most serious event, which would be the failure of the reactor trip. And the acceptance criteria for ATWS is that you have an intact vessel, an intact containment.

So this, if you do an ATWS analysis, then you have covered all possible combination AOOs.

MR. CARUSO: Well, I could argue that for ATWS you don't really have reactor coolant pressure boundaries. It doesn't maintain its integrity. Because to mitigate ATWS you have to blow down the reactor vessel quite a bit in order to relieve the pressure.

So you're throwing a lot of – if you have lost sufficient fuel cladding integrity, you have lots of fission products that are getting out of containment.

CHAIR BANERJEE: You are not maintaining that last –

MR. CARUSO: Well, you're going from –

for ATWS you are going from two barriers to one barrier. And if you look at pressure inside BWR containments, I think they get pretty high in an ATWS, don't they?

MEMBER KRESS: Yes, sir. That's one of the problems.

MR. CARUSO: So it's not clear to me that that's a good thing.

CHAIR BANERJEE: We have seen that before. I mean it's one of these upgrades.

I think that what you are looking for is some clarity with the "any." Of course I think that Professor Abdel-Khalik pointed out, that you can probably take care of. You are talking about some clarity with the radiological dose calculations.

MR. CARUSO: Yes, and I'm also – there is the issue of clarify, and definition of acceptance criteria. But there is also the issue I had when I first looked at this. I didn't know where it came from, and I didn't know why we needed it.

CHAIR BANERJEE: Well, it's surely redundant. If you can really show it's redundant, and I don't think you've quite shown that to us, then that would be a good enough argument, too. Because you also said it's redundant, I think.

MR. CARUSO: Yes, because you have the whole class of AOOs. You consider those individually, and none of them can result in fuel failures. So you do that.

CHAIR BANERJEE: The redundancy I think is your strongest argument, is that it doesn't add anything. It's already there. What you intend to do is already done by the regulations without this, whether by the guidance, without this.

MR. CARUSO: Then I could also argue reduction of regulatory burden.

CHAIR BANERJEE: That's a difficult one to argue. If it's redundant, then that's a good one. If it's just an imposed burden that achieves nothing, that's okay. But the redundancy I think is the best argument you have. If you can really make that one.

MEMBER KRESS: If one looked at this principle of constant risk across the frequency, non-risk events, and used as your consequence the quantity of radioactivity released for example, then the AOOs have a range of frequency to them.

But generally they are limited to – you know, they are set. They happen every year, and there are some that happen over a lifetime.

But it seems to me like one could have a criterion that relates the frequency, at least AOO, to the quantity of fission product released. As your figure of merit for acceptance criteria. You could have associated with that a failure of a single active combo. That would just be another specification in how you –

CHAIR BANERJEE: But are you going to require this additional failure as well, then?

MEMBER KRESS: You could. I mean that's generally what's been done with the design basis of this.

Now I don't know about this second single failure definition I heard.

CHAIR BANERJEE: Are there frequencies of this combo of the order of the LOCA?

MEMBER KRESS: No, not generally. A LOCA is something that happens over the lifetime of the plant. So most of these AOOs are not that frequent – are more frequent than that.

CHAIR BANERJEE: Right, but I mean the combo.

MEMBER KRESS: The combo? Probably is the same order as the LOCA. I don't know. You'd have to look at the PRA.

CHAIR BANERJEE: Maybe we've said enough. This is clear a point that has to be adjusted –

MEMBER KRESS: Anyway it looks like this one is one that we worry about.

CHAIR BANERJEE: You've got the message. It is going to come under scrutiny.

So if you were flagging items to bring up in front of the main committee, and not the whole talk. Because they are going to want to know the real issues, this will be a real issue.

MR. MIRANDA: This is the issue that I'm here about today actually. This is the change I wanted to bring up today.

CHAIR BANERJEE: You want us to agree to it?

MR. MIRANDA: Well –

CHAIR BANERJEE: Our opinion on it, right? Or then you can really show it's redundant with conclusive arguments, then I think I would buy it. If you can show that it's taken care of already by something else. Then you don't need it.

MR. CARUSO: I think it was probably put in there because someone discovered a sequence that wasn't covered that someone gamed. So this is to plug a hole.

CHAIR BANERJEE: Maybe it's a post-TMI thing.

MR. CARUSO: Maybe post-TMI. But somewhere some licensee or vendor figured out a creative way to define an event in a certain way. And this was put in there to plug a hole. The language strikes me as open.

MR. MIRANDA: The hole-plugging is with chewing gum.

MR. CARUSO: Well, since we don't know what's behind the hole, I mean –

MR. MIRANDA: This requirement has been followed in the submittals by CE plants by not by Westinghouse plants. And we have reviewed both. Not only is it a requirement I have a problem with, but it hasn't even really been followed.

CHAIR BANERJEE: But that is not the licensee's fault. If you have a requirement that people don't follow, and you don't call them on it, then they got away with something. I mean it's your job to do it.

MR. MIRANDA: That's why I said earlier that I don't know what to do with this. When I see analyses that come in with these combination events, I don't know what to do with them. I don't know how to judge them. I don't have any acceptance criteria.

CHAIR BANERJEE: Because this is just basically guidance to the reviewer. And it has to be based on a regulation of something somewhere.

And what you are saying is, there is no basis for it anywhere.

MR. MIRANDA: The only basis I could find is one line in a 1978 BWR standard.

CHAIR BANERJEE: That may be sufficient.

MEMBER ABDEL-KHALIK: So where is this requirement defined? Where is this language that you are coding gone? Where does this come from?

MR. MIRANDA: This comes from the current 1996 SRPs. I can get you a copy.

MEMBER ABDEL-KHALIK: I think that would be a good idea.

CHAIR BANERJEE: We don't have a red line version, do we?

MR. MIRANDA: No, we don't have a red line version. I'll provide copies of the old SRP.

CHAIR BANERJEE: Do you have a red line version for us.

MR. MIRANDA: Of this language?

CHAIR BANERJEE: No, of the SRP. I mean

we don't – it's going to – reading two SRPs and comparing them is hard. So if you have a red line version that would be a lot easier for us; edited version.

MR. MIRANDA: You asked this before, didn't you?

MR. CARUSO: I don't think I got it. What I was told was that it was so rewritten it wasn't worthwhile to put together a red line.

CHAIR BANERJEE: Well, that's why we should give a lot of consideration to it, then, if it's a new document.

MR. CARUSO: That's what I was told was that it was so different than a red line wouldn't make any sense. If I have one, I'd like to know where it is.

MR. MIRANDA: That's true for the ATWS standard. The ATWS standard before was only three pages; now it's more like 15. But you are talking about in general, the SRPs, right?

MR. CARUSO: No, no, just the 15.0.

MR. MIRANDA: 15.0?

MR. CARUSO: 15.0, yeah.

MEMBER WALLIS: Okay, well, if we've got to red line them, I'll provide it to the members.

CHAIR BANERJEE: If changes have been so large that a red line version doesn't exist. Our changes we've shown are not that many.

MR. CARUSO: I have an old version of 15.0. I have the 1996 version, and I have the new version that you are proposing. But I don't have a comparison.

MR. MIRANDA: Okay. I don't think I have seen that one. But I have with me the old version and the new version.

MR. CARUSO: What I'm saying is, I do not have a compare.

CHAIR BANERJEE: Well, that's something you can work out. Either you find a red-line version, or you make a comparison yourself and let us know the results.

MR. MIRANDA: All right.

MEMBER WALLIS: Can we move on? We've obviously highlighted it.

MR. MIRANDA: That's all right. Don't worry about it. We will get it later.

MEMBER WALLIS: Is that okay, Sanjoy?

CHAIR BANERJEE: Yes.

MEMBER WALLIS: There may be some more questions, too.

CHAIR BANERJEE: Right. And we are also over time. So.

MEMBER WALLIS: But I think this is an important thing. This is Chapter 15. It's a major part of the regulations. This describes the Agency's advice about how to make them work.

MR. MIRANDA: You are right. And I think probably we should have spent more time on this one requirement. Because this is the requirement I wanted to bring up before the committee. This is the major change. The others were editorial.

MR. CARUSO: Can I ask you a question?

I notice in all the discussion that we talk about active failures. And this is for advanced reactors, and we all know the advanced reactors use a lot of passive systems. And I wondered, did the staff consider how to deal with passive system failures, as opposed to active failures, and if not, why not?

MR. MIRANDA: I haven't worked on the new designs, so I don't know if there is any different approach that has been taken for passive failures.

The question itself has been considered in the past in depth. There has always been this distinction between active and passive failures.

And I can't answer the question, because I don't know whether the new reactor designs would change that approach at all.

MEMBER WALLIS: Well, let's consider, there are filters, debris filters in the passive systems. There's a big tank, and there's a pipe that goes and cools the reactor.

There's a filter in some of those things. Now if it should be that there is some debris clogging that filter for any reason, that's built up over the years or something; then you have a passive system that failed when called upon, because it blocks the flow of water. It doesn't flow as much as it should. The passive system fails, like a pump failing in effect. But it's not a pump; it's gravity.

MR. MIRANDA: Okay, you can look at it that way. You can say it's a passive system that failed. Or I could say that it's a system that should be operating but has not be surveilled properly.

MEMBER WALLIS: Or is outside the tech specs.

MR. MIRANDA: That's right. It's a failure that will go undetected until you have gone through your surveillance. And that way it would not be any different from a diesel generator that's in its 29th day on a 30-day surveillance schedule.

CHAIR BANERJEE: So shall we flag this and move on? I think you have a basis for – to come to the main committee.

So we now are up to the constant risk principle, are we?

I didn't mean to stop. I think we should –

MR. MIRANDA: I thought we were over time.

CHAIR BANERJEE: There are lots of things; I'm going to give you a little more time.

MEMBER WALLIS: Shall we ask questions? Or will you move on with your presentation?

CHAIR BANERJEE: I think we should move on with the presentation.

MEMBER WALLIS: And I will try to fit them in as they are relevant.

CHAIR BANERJEE: You have already made a comment on this, and so has – we've had a brief discussion on this.

Now this is a very philosophical policy issue. So perhaps, I don't know if we need to debate this as part of this RP. It's a much larger debate that you are talking about.

So what is the opinion of the members here? Do you want to address this here or is it a larger policy issue?

MEMBER KRESS: I think it's a larger policy issue.

MEMBER WALLIS: I think we can flag it.

MEMBER KRESS: Our committee ought to discuss it among ourselves.

MEMBER WALLIS: We ought to discuss it.

CHAIR BANERJEE: All right.

MEMBER KRESS: Because it doesn't need debate back and forth with the staff. We ought to decide ourselves.

MEMBER WALLIS: But if we think something else should be done, we should say so.

MR. MIRANDA: This is a very basic principle. If we change it now, we will have to change a lot of other things.

MEMBER WALLIS: But do you know where it came from? Is it another one that is shrouded in the mysts of antiquity? Someone wrote it sometime, and –

MR. MIRANDA: I haven't seen it written

anywhere except as I said in the passing reference in a BWR standard –

MEMBER WALLIS: Well, this one is also like the last one, the combo.

MEMBER KRESS: It shows up in the Palmer curve, where I first encountered it.

MEMBER WALLIS: If it's a principle there ought to be somewhere where it's defined, and sort of on tablets or something.

CHAIR BANERJEE: It's not part of any regulation.

MR. MIRANDA: If you read the GDCs, and there are 60 GDCs, if you read them, you come to a sense that underlying all of them is this thing.

MEMBER KRESS: It is implicit perhaps.

CHAIR BANERJEE: It is a little bit like interpreting the Constitution.

MEMBER WALLIS: Constant risk inference.

MEMBER KRESS: And in fact if you look at the technology mutual framework, they established a series of frequency ranges and the consequences. If you draw a straight line to that, it follows this principle pretty close.

Those were derived from the current regulations. They were trying to be consistent. So it's implied in the regulations.

MEMBER ABDEL-KHALIK: It's sort of implied in the categorization process itself.

MEMBER KRESS: Yes.

MR. MIRANDA: Exactly, yes. And all we are doing is, we are sort of coming to terms with this difficulty of categorization, and some accidents maybe ought to be – one category or another, depending on experience. And we are reducing it from three categories to two, because I don't think we can get any finer than that.

CHAIR BANERJEE: And that is based on the regulations.

MR. MIRANDA: That's right, the GDCs have only two categories.

CHAIR BANERJEE: That's why I understood is your rationale for doing that.

MR. MIRANDA: Yes.

CHAIR BANERJEE: And so what is the feeling of the members here about this? Should we discuss it amongst ourselves at a different time?

MEMBER WALLIS: I think it's something that should be presented like this to the full committee, and the full committee wants to say this is something we'll take up with new reactors or something, then we can do that.

I'm not sure we are going to change this now, but it's something that we –

MEMBER KRESS: I will guarantee it will be discussed at the next meeting.

MEMBER WALLIS: So you should show this slide to the full committee and see what happens.

MEMBER KRESS: It is definitely on the agenda for the next meeting.

CHAIR BANERJEE: You better give a lot of time for this.

MEMBER WALLIS: We will take it from the formal hydraulic –

CHAIR BANERJEE: I hope so.

All right.

MR. MIRANDA: Okay. We talked about this. We are going to follow Appendix A, Part 50 –

MEMBER WALLIS: Anything is possible, it should say likely to.

CHAIR BANERJEE: I guess that is the language there already, right?

MR. MIRANDA: Yes, that is their language. The only thing it says, that we have on this slide, is for new plants and any operating plants that choose to do so, we would use the two categories of the GDC's appendix A, and for operating plants that have submitted their analyses according to the condition two, three and four event scheme, you just continue to apply that system.

So there would be no back-fitting here.

CHAIR BANERJEE: Where did that ANS category three come from? What was the reason for them to invent that?

MR. MIRANDA: They made a distinction between events that can be expected to occur during a calendar year of operation, and events that are not expected to occur, but may occur during the lifetime of a plant, during the 40-year lifetime of a plant.

So they drew the line there. Can it occur in one year? If not, can it occur during the lifetime of a plant? If not, then it becomes a postulated accident.

CHAIR BANERJEE: But there was no basis in the regulations for that, right?

MR. MIRANDA: No, there wasn't.

CHAIR BANERJEE: It was arbitrary?

MR. MIRANDA: I don't know if it was arbitrary. I can tell you that there were other versions of standards from the ANS that appeared after that that further talked about accident categorization.

There was one standard I looked at that had something like five categories. And it was a BWR standard, 1983 standard, for example, that had many different plant conditions, they called them. And these were accident categories, and they combined them with external events such as earthquakes or other events, and they had a whole scheme of categories. I think it was in excess of five or six categories.

But that was never adopted.

CHAIR BANERJEE: Was there any reg guide or anything?

MR. MIRANDA: The reg guide that comes closest to this is reg guide 1.70, the standard format. And you will see that on the last slide. And that reg guide talks about moderate frequency events, infrequent events, and limited faults. It doesn't use the same names, but they line up pretty closely.

MEMBER KRESS: In essence it seems to me like this changes – actually it goes more in a conservative direction. And it adds margin.

The reason is, if you had divided AOOs

into different frequence ranges, like a year or two years or five years, 20 years, whatever, then you could have different acceptance criteria for those, to follow the principle of costs and risks.

But what this does is say, oh, if it's going to happen during a lifetime, then we are going to have the same acceptance criteria. So we are going to treat those things that happen very infrequently over a lifetime the same as other frequencies. So this to me adds a level of margin and conservatism, and makes it more consistent with the regulations as they are anyway.

So I don't have any real problem with this.

CHAIR BANERJEE: I don't either.

MEMBER ABDEL-KHALIK: Well, I mean, this reclassification into two categories would make it more conservative if you retain –

MEMBER KRESS: If you retain --

MEMBER ABDEL-KHALIK: – from condition two. But the question is, what is the acceptance criteria now.

MEMBER WALLIS: That's right. That's a good point.

MR. MIRANDA: That's right, and that's

exactly what we wanted to do. What we are doing is, we are folding the condition three events into condition two, and condition two is an AOO. And condition two does not allow for field failures.

MEMBER KRESS: So it adds some conservatism.

MEMBER WALLIS: Correct.

MR. MIRANDA: And that's also why we are allowing plants that currently have condition three events to retain them.

CHAIR BANERJEE: So you don't have to reanalyze any plants, nothing. They follow this, it's fine.

Let's move on.

MR. MIRANDA: This is a little comparison of what we were just discussing. Reg guide 1.70 is what the licensees were following, and this is what the – and also some of them talk about moderate frequency events; others talk about condition two events. But basically that's what they were following.

But the regulations, the GDCs, had only the AOOs and the postulated accidents. And this slide will show you that the infrequent events, the condition three, are going to have to meet the same criteria as the AOOs.

And this is a little discussion about ATWS and why it's a separate category. It's outside the plant design basis, and the regulations for ATWS were found in 50-62.

The non-escalation criteria, the important – we need to retain this criteria, and we need it to prevent the possibility that you could create an accident, a postulated accident, that has the same frequency of occurrence as an AOO.

CHAIR BANERJEE: I guess the issue was brought up that how do you actually show that this doesn't happen?

I mean I guess it's up to the applicant to do it.

MEMBER KRESS: And he has to use approved calculations in their design, and they have to show that their system will not lead to any fuel failure –

MEMBER WALLIS: It's a bit extreme to say this still has the frequency of an AOO. Because there is a conditional probability of it developing into a possible accident.

An AOO could have a probability of 10 to the minus one per year, but the probabilities have been developing into a postulated accident could be another 10 to the minus five or something.

MR. MIRANDA: That's true.

MEMBER WALLIS: So that what is important is this probability of developing into a postulated accident, not excluded.

MEMBER KRESS: But that's implied in the calculational methodology that they have to use. They are given a methodology that has conservatisms in it, and these are reviewed and approved, and there are figures that have to meet –

MEMBER WALLIS: It's not as if –

MEMBER KRESS: And so if you follow all that, and you don't develop into a postulated accident, then there are some implied probability in it.

MEMBER WALLIS: What I object to is your statement, you imply that if it could develop into a postulated accident, then the postulated accident has the same probability as the AOO itself.

MR. MIRANDA: I made that statement based on the rules of the deterministic analyses, which say that if a POVR is not qualified for water relief it's going to fail; the probability there is one.

The same thing with fuel rods. If they

into DNB, they fail. The probability is one.

MEMBER WALLIS: I understand that. Now I understand. So this seems reasonable.

CHAIR BANERJEE: Yes. Let's move on.

MR. MIRANDA: We talk about this, trying to find a regulatory basis for retaining that criterion, and the closest I could find is in 50.59 which seems to touch on the same questions that this criteria deals with.

MEMBER WALLIS: And you talked about that one.

MR. MIRANDA: That is an open item.

MEMBER WALLIS: Will you talk about the criteria sometime? I have questions on page seven, which is called analyses and acceptance criteria. Are you going to talk about that?

MR. MIRANDA: Okay.

MEMBER WALLIS: Or can I ask questions?

MR. MIRANDA: Go ahead.

MEMBER WALLIS: All right.

At the top of the page, it says, lists of basic criteria to meet the requirements of GDC postulated accidents. And it lists them. It says, pressure in the RCS should be maintained below – fuel clarity will be maintained. These are sort of slightly different things, should be, will be and shall be.

But then you have some extraordinary thing, which says, a postulated accident might cause sufficient damage to preclude resumption of planned operation.

This isn't a criterion. It should read something like, a postulated accident shall not cause sufficient damage – it's not a criterion the way it's written. It simply says it might happen. That's not a criterion. You need a shall or a should or something in there instead of a might. Or should not.

MR. MIRANDA: I think if you look at the ANS stated or that defines the condition two, three and four events, or if you look at the definition of an AOO, an AOO is an event that occurs that will not result in fuel damage.

MEMBER WALLIS: This is for postulated accidents.

MR. MIRANDA: I know. I know. It will not result in fuel damage, and the plant can be returned to operation shortly after the fault is corrected. That is what an AOO is.

So the postulated accident here, it says might cause sufficient damage.

MEMBER WALLIS: But that's the definition of a postulated accident. It's not a criterion for acceptance. A description of what you mean by a postulated accident.

MR. MIRANDA: That's right, it is a definition.

MEMBER WALLIS: So you are going to put it somewhere else?

MEMBER KRESS: Well, you know if you are a reviewer, this is a review plan –

MEMBER ABDEL-KHALIK: But this relaxes the acceptance criterion, then, the acceptance criteria for condition two events say that there is no damage to the plant that would preclude the plant from being restarted once the cause of the malfunction has been identified and corrected.

MEMBER WALLIS: We're talking here about postulated accidents.

MEMBER KRESS: In terms of postulated accidents –

MEMBER WALLIS: This is a criterion for postulated accidents, okay.

MEMBER KRESS: If the analyst makes an analysis of a postulated accident and it shows that there is significant fuel damage, but it still meets all the criteria, the reviewer must say, well, is this acceptable or not? And I think what he's saying is, even if there is fuel damage it could be acceptable.

MEMBER WALLIS: But then you have to have some criterion for acceptability of damage.

MEMBER KRESS: I think there is; there's dose criteria.

MEMBER WALLIS: But then you have to say it in the form of a criterion. This isn't a criterion.

MR. MIRANDA: This is – you're right, it's a definition. It serves to distinguish a postulated accident from –

MEMBER WALLIS: You are going to fix that? It should be in the text and not a criterion.

MR. CARUSO: Actually I think it's appropriate here. Because remember this is providing guidance to the reviewer. And it says to the reviewer, when you do the review, when you find this accident, it's going to be really bad, and it's going to make a really bad mess. And they will probably never operate this plant again. That's okay for this accident.

MEMBER KRESS: That's what it says.

MR. CARUSO: It says to the reviewer, if you review this accident and you find that it's going to make a real bad mess and they are going to lose their investment, that's okay.

MEMBER WALLIS: Then you need to say it. But this sort of "might" is a strange thing. You say that if the criteria would clearly say that fuel damage is allowed, and there is no criterion limiting it or something, that would be clear.

But saying it might cause damage, that isn't a criterion at all.

MR. CARUSO: Maybe it can be revised.

MEMBER WALLIS: You're going to fix that anyway. You will fix that so I don't have any questions about it next time.

MR. CARUSO: As I understand it, this is a definition.

MEMBER WALLIS: It's not a criterion as written.

Now we get down to loss of coolant actions, LOCAs. It says the calculated maximum cadmium shall not exceed. There is no probability at all.

CHAIR BANERJEE: I guess that is the

regulation.

MEMBER WALLIS: No, the regulation says with a high probability.

CHAIR BANERJEE: Oh.

MEMBER WALLIS: So I don't quite know how this squares with the regulation and the allowable probabilistic approach to this which the current stuff now permits.

CHAIR BANERJEE: Well, I think it should echo the regulation.

MEMBER KRESS: The trouble is, there are two sets of regulations to choose from.

CHAIR BANERJEE: Clarify that.

MEMBER WALLIS: 10 CFR 50.46 says, with a high probability –

CHAIR BANERJEE: I think you should clarify that.

MEMBER WALLIS: It says with a high probability.

Anyway I know that this is now being done with probabilistic stuff, and it seems to be in conflict with this statement.

MEMBER KRESS: Yes, I think you're right.

MEMBER WALLIS: That needs to be fixed.

And then – you're going to sort that

out? And then this statement, calculated changes in core geometry shall be such that the core remains amenable to cooling, really means nothing. TMI was cooled. Anything can be cooled eventually.

MEMBER KRESS: Yes, but they go on to specify what coolability is.

MEMBER WALLIS: Well, they don't. This is a separate criterion. Really the coolable geometry is defined by this 2-21 rule.

MEMBER KRESS: That's the amount of hydrogen generated.

MEMBER WALLIS: But this statement is a very empty statement.

CHAIR BANERJEE: Isn't there some guidance as to what coolable geometry means?

MEMBER KRESS: It means you don't exceed a certain energy, you don't exceed a certain hydrogen generated, and you don't –

MEMBER WALLIS: That's different, because –

CHAIR BANERJEE: No, I mean that's a separate thing here, right?

MEMBER WALLIS: Because the core can balloon and still not exceed 2,200. It could be at 2,000 for a very long time, so other things happening to it.

(Simultaneous voices)

MEMBER WALLIS: How do you interpret a coolable geometry?

MEMBER KRESS: The fuels people are working on this to revise this regulation, to give a crisper definition of coolable.

MEMBER WALLIS: I know. We've debated it quite a bit.

MEMBER KRESS: We've debated it quite a bit. Right now it's still the 2,200 and the 17 percent –

MEMBER WALLIS: Well, that's one, two and three, but what does four mean? One, two and three says 2,200, 17 percent and one percent. Four has an additional criterion, core shall remain amenable to cooling.

(Simultaneous voices)

MEMBER WALLIS: Doesn't it?

MEMBER KRESS: No.

MEMBER WALLIS: Amenable to cooling.

MEMBER KRESS: No, no, it means its geometry is still maintained pretty much.

MEMBER WALLIS: Well, then you have to explain that in some way.

MEMBER KRESS: Well, I don't know where you explain it.

MEMBER WALLIS: Well, I've raised the question. I think it's doesn't mean anything, then, this statement.

CHAIR BANERJEE: Well, the problem is, it's in the regulation.

MEMBER WALLIS: Is it?

MR. CARUSO: Yes, it's part of 50.46.

CHAIR BANERJEE: But there is no guidance as to how to interpret that.

MEMBER WALLIS: So maybe your hands are tied on this one.

MR. MIRANDA: We'll have to discuss that at the LOCA.

CHAIR BANERJEE: Is there a reg guide or anything that says this is an acceptable way to interpret coolable geometry?

MEMBER WALLIS: No, I don't think there is.

MR. CARUSO: I'm not sure there is any particular regulatory guide. But it's in the methodologies that are used to calculate performance during a scenario, and that's where this gets captured.

MEMBER ABDEL-KHALIK: I mean the implication is that if you meet conditions I, ii, and iii, that the four condition would be met. That's the current interpretation.

MR. CARUSO: That's the current – but the fourth criteria is there to cover all the situations that may not be covered in one, two and three.

MEMBER WALLIS: But the tubes, they all buckle and –

MR. CARUSO: Ballooning for example, or something weird happened. And that's in there for the staff –

MEMBER WALLIS: Well, there should be – is a calculated change in the core geometry the accumulation of debris in the spaces? Is that –

MR. CARUSO: That could be considered, yes.

MEMBER ABDEL-KHALIK: Boron precipitation?

MR. CARUSO: Yes, it could be.

MEMBER WALLIS: Boron precipitation, yes.

MEMBER KRESS: That is exactly the sort of thing that –

MEMBER WALLIS: What is your criterion to determine that it is coolable?

MEMBER ABDEL-KHALIK: That's part of – I shouldn't be involved in this. That's part of the dialog that occurs between the staff and the industry in establishing whether a particular fuel design or system is acceptable.

MEMBER WALLIS: So there isn't a clear definition of a coolable geometry?

MEMBER ABDEL-KHALIK: No.

CHAIR BANERJEE: Is there any references to documents and things where they have interpretations of what coolable meant?

MR. MIRANDA: I don't know; I'll have to check on that.

MEMBER KRESS: If you look into FSAR, look under the LOCA calculations.

MS. ABDULLAHI: There is an SRP section on this.

This is Zeyna. Isn't there an SRP and a desktop for ECCS LOCA?

MR. MIRANDA: Yes, there is.

MS. ABDULLAHI: That would define more –

MR. MIRANDA: Does it have practical measures to determine whether or not the core is in a coolable geometry?

MS. ABDULLAHI: No, but I think each

licensee, like Ralph pointed out, each fuel vendor has to show how they meet those criteria, and they define exactly how they meet coolable geometry, and when that process, like Dr. Kress said, is approved, then you have that criteria approved. And subsequently every plant would have to meet that.

CHAIR BANERJEE: Well, it would be useful, because I'm sure this issue will come up – I mean we've debated this at ACRS a number of times. So if you have any sort of backup.

MEMBER WALLIS: The cladding could disappear. You'd have a pebble bed reactor. It might still be coolable.

CHAIR BANERJEE: All right. So how is it being interpreted now? This is a pragmatic thing.

MEMBER WALLIS: Okay, I don't want to prolong that discussion.

There are an awful lot of GDCs at the end of this, I notice.

CHAIR BANERJEE: Is there anything else we should know?

MR. MIRANDA: No, I believe that the subcommittee had questions on what is sufficiently broad spectrum of events, and the definition of a design basis, and questions regarding the LOCA acceptance criteria, whether all those shelves really belong there. And whether or not – I don't know what to discuss about the constant risk principle, but I will bring it up again so you can debate that.

MEMBER WALLIS: I think you've done a very good job of answering our questions and explaining things.

MR. MIRANDA: Thank you.

MEMBER WALLIS: We have tried, I think, to bring up some of the basic questions, because this is a very important part of the SRP.

MR. MIRANDA: As far as I – the open issue here is the criterion that we want to remove, the combination of the AOOs. I'll try to provide more information on that.

CHAIR BANERJEE: That was probably the most significant issue.

Let me just look through my notes.

MEMBER WALLIS: So this is a question of like sufficiently broad spectrum, are you going to address that?

CHAIR BANERJEE: For example, that is another issue that you might want to clarify what you mean by that.

MEMBER WALLIS: We want to leave it vague for the staff so they can figure out what's a reasonable number.

CHAIR BANERJEE: Whatever it is, you should have some justification for using that wording.

MR. MIRANDA: Yeah, I don't even know if that's wording that was changed from the old revision.

CHAIR BANERJEE: Now, I understand that there is a mock up version on ADAMS which somebody will let you know, Ralph.

MR. MIRANDA: Okay.

MR. CARUSO: I'll get you a copy.

CHAIR BANERJEE: Okay.

MEMBER WALLIS: Now are we going to write a letter on this SRP, or what are we going to do?

MR. CARUSO: Yes, I think we are supposed to.

MEMBER WALLIS: Is this a follow up also –

MR. CARUSO: No, this isn't a form letter. I think this has to be a regular letter. That's the way it's been done with other of these sections that have been reviewed.

MEMBER WALLIS: Because with all of them, we said we didn't want to review those.

MR. CARUSO: Right. The ones that did get reviewed, I was told there was a regular letter that was written.

CHAIR BANERJEE: Okay.

MEMBER WALLIS: It's sort of like boiling water stability. We have an option of saying – this is a subcommittee, we don't think that the full committee needs to review it?

MR. CARUSO: I think that's another option if you decide to do that, yeah.

CHAIR BANERJEE: This I think the full committee needs to review it. And you have the issues brought up by the subcommittee. I mean there other issues that the full committee brings up.

But I think what you talked about was very informative for us. So we know which points need to be addressed. But we don't know exactly what the full committee will do. They have a different viewpoint perhaps.

Then what happens after the letter? We have to generate a letter.

MR. CARUSO: We generate a letter, and I don't know what NRR is going to do with it. I guess if it's a positive letter they will go forward with it; if it's a negative letter, I don't know.

MEMBER WALLIS: They may suggest some changes.

CHAIR BANERJEE: I think it's more likely to be a letter which might deal with some clarifications and suggestions.

MR. CARUSO: By dealing with those comments.

CHAIR BANERJEE: I don't think – I can't speak for the full committee – but it's likely to have a few suggestions.

MEMBER WALLIS: Well, it's certainly not a bad document. It's a very nice document. It's just that we want to discuss certain aspects of certain paths; that's all.

But in general, it's got to be a good document. It's matured over decades. How could it be bad?

MR. MIRANDA: It's a lot larger than the other documents.

MEMBER KRESS: You think things get better with age?

CHAIR BANERJEE: Only us.

Well, thanks very much. That was very

helpful.

I think now we will take a 15-minute break and then get on BWR Stability.

MEMBER KRESS: Be back at 10 till?

CHAIR BANERJEE: Ten till.

(Whereupon at 10:36 a.m. the proceeding in the above-entitled matter went off the record to return on the record at 10:59 a.m.)

CHAIR BANERJEE: So we are back in session.

So Dr. Huang, do you want to start off?

BWR STABILITY

INTRODUCTION AND REGULATORY PERSPECTIVE

MR. CRANSTON: This is Greg Cranston again.

The subject we are going to be talking about is boiling water reactor stability, which includes Standard Review Plan 15.9. And it's going to be presented by Dr. Huang, who is a reactor systems engineer, and also with assistance from Dr. Jose March-Leuba, who is an NRC consultant from Oak Ridge Laboratories.

DR. HUANG: Thank you.

This is Tai Huang, the ATWS system branch, the technical review on the stability issue, since the early `80s and at that time frame.

This presentation will cover two parts. The first part, for the BWR stability, where we will get the background on the whole story since the issue became important for the BWR operation.

And the second part will be after you get this background, the SRP 15.9 you are going to have more background, now why it is separated out from small part of standard review print 0.4.

Now the BWR stability, it have a potential violating subtle. And it effect the day-to-day BWR operations.

The details covered later, we try and show them in the presentation. And the regulatory requirement based on 10 CFR 50 appendix A, there are two. One is the generic design criteria, GDC 10 and GGDC 12.

GDC 10 would be the reactor design, and GGDC 12 would be power – reactor power oscillation. So these two criteria to meet.

And then we keep going for the spectrum you know like the history, and the BWR events. And you look at these ones, since the Vermont Yankee event, and then also they have a test over there. And we have Peach Bottom test, and keep going down to a generic letter, 8602. They say COC-80 from GE tell us that the operating limitation for detection and separation are acceptable to demonstrate compliance with GDC 10 and 12.

And they keep going for the La Salle event in 1988. And the staff has the enforcement notice, 8839, that would tell us, tell the industry what's going on there.

And down the row the NRC Bulletin 8807 and that require prints without automatic trip capability to manually scram if fuel the separation pump trip occurs.

And then keep going down the row to 1988. There is a generic letter, you know, like GE Part 21, talking about MCPR might be – might be violated if 10 percent APRM swing is used as a criteria for manual scram.

Since then, after that, the La Salle events, industry, very concentrated from this issues. And then there is an industry effort. So we, at that point, we have working on the NEDO 31960.

This is a BW Owners' Group who come out

with the resolution on how to deal with BWR and the Yucca instability issues.

And then in 1992 they say -- what they call WMT-2 events but now they call current event, the name change.

And then the 1994, the American labor, they call required all the reactors, BWR reactors. You have some kind of mechanism to control this instability if that occurs.

And then they say, INPO, in1994, there is INPO report, SER 07-00, they try to get something like a lessons learned from the instability events.

And then they keep going to the end to about 1990 – in or about, close to 1995 to 2000 time frame, they say, GE 21, time of issue.

Then after that generic letter in `94-02, all the industry BWR owners group, BW reactor owners, they had some kind of options, the detail we'll cover later.

And they already implement – some of them are now implemented. And some increment – some reactors, they implemented their system, and then they have one assumption like a generic issue. And then we, NRC as a result with this issue, and to come out with a resolution for the specific guidelines. You are not going to use the generic line slot to come out with set point.

Then in 2003 there's the Nine Mile Point-2 event. They're option three, but in the operation situations, they have an event occurs, and from there we have a lesson learned. They call Long-Term Solution-III, set insensitive, and the detail would be covered in later slides.

MEMBER WALLIS: Can I ask you on this historical trend here.

DR. HUANG: Yes.

MEMBER WALLIS: BWRs have been increasing their power level, our operators, and they have been changing fuel design. And they have been having fuel designs which are much more complicated, because now they can design and optimize their fuel loading pattern and all that to get more power out of them and various other things.

Have these changes led to the reactors being more stable or less stable or what?

DR. HUANG: Of course from these MELLLA+ operations, and single loop, all kind of operation situation.

If you don't have a control, of course it create more unstable situations.

MEMBER WALLIS: Does it become more difficult to control? And what's the trend?

DR. HUANG: The trend would be, they develop some kind of resolution from NRC and the industry to come up with a group from ICA into that –

MEMBER WALLIS: But do we need to have more stringent controls –

DR. HUANG: Yes.

MEMBER WALLIS: – or more sensitive diagnostics because these things are now getting more difficult to control? Or what is happening?

MR. MARCH-LEUBA: No, the reactors are getting more unstable because of the new fuels and the new extended operating procedures. The controlling the instabilities is just as simple as it used to be. So the solution is still working.

The frequency of events is increasing, its likely to increase.

MEMBER WALLIS: So it's like a car which is getting more unstable to drive?

MR. MARCH-LEUBA: You are driving faster, but your brakes still work. That's where we are.

CHAIR BANERJEE: Option three is an ABS system?

MR. MARCH-LEUBA: Option three is the real brakes. Whenever we start going too fast downhill, you hit the brakes.

MR. CRANSTON: This is Greg Cranston. I also want to add that in conjunction with this, we are in the process of going through the MELLLA+ and approving MELLLA+ for plants. We are tying this to stability, detect and suppress, with that in conjunction with making sure the plants have an operational system, prior to us approving their operation in the MELLLA+ domain.

So that's what we are considering too to make sure we've covering here the concerns that you expressed as far as are they pressing the limits) a little bit more, and do we need the fully automated scram system operable at the time we allow them to move into that expanded operating domain.

CHAIR BANERJEE: This Perry event, was that when they had option three?

MR. MARCH-LEUBA: Yes. Both Nine Mile Point and Perry are option three.

DR. HUANG: Yes, so this just give you the background on the regulatory history and BW events. And then the detail we slice.

So if you flip over the next slide, you

see like before La Salle events, what's going on there. And then after La Salle events, what's going on there.

And since then there are large industry effort result in BW owners group long term solutions. And this solution would be in the following --

And long-term solutions are now fully implemented in all BWRs right now. And there are many reactor years' experience. Also with complicated idea that Dr. Juarez mentioned comprehended by authority and second issue identifying the fuel stock 21. Also there is possibly a system noise level. And that the NRC staff will closely follow implementation of stability solution by three means.

One is through the technical specification review. And we do that, they plan audits on their system. And we confirmation or operator training on the crane simulators.

And staff conducted I would say a number of the decay measurements as the production of new fuel changes.

MEMBER WALLIS: There is no effort to design away the instability. It seems to be something you always have to live with. These reactors cannot improve the design so the region of instability shrinks?

MR. MARCH-LEUBA: You can. Unfortunately again, it was the economics of the plant.

MEMBER WALLIS: Oh it's economics that limit it.

MR. MARCH-LEUBA: Right. There are two big developments on fuel that have affected stability. Number one was going to faster-responding fuels, 9X 9 and 10X10 fuels. So there's longer to respond faster. They give you a much better CPR performance and recognition rate. So they are good for everything else except the stability.

So you're saving what you say for LOCA, and you make – the second big development that happened to fuel was the Parkland rods. And by eliminating 14 or 15 rods from the top of the core, they reduce the friction pressure drop significantly. And that's what saved us from instability.

If we did not have pull rods we could not live with the 10X10.

And the third development you'll see in

a few minutes, you will see why the --

So we can force the stability to be impossible in a reactor. It will make LOLA worse.

DR. HUANG: Okay, so now after that, the stability identify as a security concern. And then the resolution is, resolve by the EPG ATWS mediation actions.

And then after that La Salle, and then keep going on to today –

MEMBER WALLIS: We're going to get into ATWS, I guess. But this ATWS has never happened, has it? So we are just sort of relying on computer simulations of ATWS stability?

MR. MARCH-LEUBA: Correct. Now on the La Salle event was analyzed up to the point of the scram. The ATWS scram system, the La Salle event was caused by the ATWS system causing a circulation pump trip. There was a low level transient that caused – the reactor thought it was in ATWS. So for the first two or three minutes to the point of a scram, it wasn't hours, as far as the reactor thought it was. What the computer was telling us is if you let it go. And you'll see at the end of the presentation a bad thing would have happened, an unacceptable thing.

DR. HUANG: So now the second bullet, up to this moment we have expanded operating domains something like MELLLA+ operations, the post-instability challenges. And there are true industry mechanisms for the systems to control this instability.

And there is one like a detect – like a DSS/CD detect in solution, confirmation density algorithm. GE Systems has been approved. And then another one is under staff review. It is called Enhanced Option III, EO3 from Ariba, is under staff review.

So these two systems are ready for that, expanding.

And our position and solution has evolved these two we just mentioned previous. One information becomes available for this BW operation in terms of stability issue, and also the design operating changes more aggressive core and fuel, and also a more expanded operating domain.

In the diagram later we show what a domain is.

CHAIR BANERJEE: Now is this meant to also deal with ESBWR, or is that a separate issue?

MR. MARCH-LEUBA: SRP 59 does deal with

ESBWR.

CHAIR BANERJEE: So at some point or the other, both Professor Wallis and I have been concerned about floraging (phonetic) type instabilities.

MR. MARCH-LEUBA: That's my first slide.

CHAIR BANERJEE: Hm?

MR. MARCH-LEUBA: My first slide.

BWR STABILITY

OVERVIEW OF STABILITY, REGULATORY ISSUES AND LONG TERM SOLUTIONS

MR. MARCH-LEUBA: There are – so now at last my turn.

MEMBER WALLIS: There is also the question of the computer simulation. I remember when we were doing the ESBWR, we're going to come back to this, the courant number is not properly –

MR. MARCH-LEUBA: That is correct.

MEMBER WALLIS: So there is an artificial damping of void waves. It really needs to be fixed.

MR. MARCH-LEUBA: And if you look at the record, a minute ago it was sitting right here, it tells you we will have that calculation, and we do have it. You will see it.

CHAIR BANERJEE: We asked for a fine

utilization calculation.

MR. MARCH-LEUBA: The chimney and it has been performed. So this chimney with notes about this smaller --

MEMBER WALLIS: You've been very responsive.

MR. MARCH-LEUBA: We believe our premises, because there is a record of them. And we expect you to ask us.

And it has been assured no issue. No what we call loop instabilities.

MEMBER WALLIS: No artificial damping.

MR. MARCH-LEUBA: With parameter one you don't have numerical damping on the chimney. You inevitably have damping somewhere else, but on the chimney certainly not. And it came out – the simulation show that this is not an issue.

So first let me tell you that this presentation was discussed with Ralph Caruso. We are supposed to present number 15.9, the SRP. And he said, well, why don't we have a summary of everything that has happened for the last 20 years. And let's just put it together, so we will make the review of the SRP a lot easier.

So what we are doing here is just a

summary for your benefit. And this afternoon on the second presentation we will talk about the SRP 15.9.

CHAIR BANERJEE: So today we could finish the stability overview by lunch. We can delay the lunch a little bit.

So the plan would be, let's say, if we could finish it by 12:15 or so, that gives you about an hour, to include the ATWS as well.

MR. MARCH-LEUBA: I'll talk faster.

CHAIR BANERJEE: Then after lunch we can discuss the SRP.

MEMBER KRESS: We'll talk faster than usual.

MR. MARCH-LEUBA: I suspect, I'm hoping, the SRP 15.9 is a lot more straightforward than the 15.0 this morning. And there won't be as many questions. So we don't really need three hours for the SRP.

CHAIR BANERJEE: So I mean however you guys want to arrange it is fine with me. But we do want to finish roughly at let's say 2:30 or so.

MR. MARCH-LEUBA: I promise by 1:45 we will move into SRP no matter where we are.

CHAIR BANERJEE: Okay.

MEMBER WALLIS: You can't promise

anything, because we might ask thousands of questions.

MR. MARCH-LEUBA: I promise I will try.

CHAIR BANERJEE: This is Said.

MR. MARCH-LEUBA: Said is well known.

MEMBER WALLIS: So I should be quiet and ask him to ask all the questions.

MR. MARCH-LEUBA: All right. There are many, many, many instability modes in two-phase floor systems. And you can't even enumerate them probably.

If you think about it, the transition from tubular to laminar or vice versa is an instability. There are two equilibrium points. It's a known instability. Two equilibrium points, one becomes unstable, the other one becomes stable, and it jumps from one to the other.

Boiling transition is an instability. There are two equilibrium points, one with steam, one with water. And if one of them becomes unstable it causes very significant consequences, boiling transition for example.

But that was handled by the CPR correlation. When we took over the stability, there are two modes that we see coming up. We see in BWRs with experience that have cause, potential to challenge the powers. And there are two. There are the control system instabilities, and there are the density wave instabilities.

Control system instabilities are handled by INC technicians. So what happens more often than not is, a sensor goes bad, or an actuator goes bad, and you start having oscillations.

And you send in the INC guy and he fixes it.

Density wave instabilities are the ones that cause like the La Salle event. They cause very large – they have the potential to cause very large power oscillations. Has the potential to violate SAFDLs. And they are handled by their long-term solutions.

And my presentation will talk about the long-term solutions, which is how we put the brakes on these instabilities.

MEMBER WALLIS: What do you do to suppress an instability?

MR. MARCH-LEUBA: Scram.

MEMBER WALLIS: You scram?

MR. MARCH-LEUBA: Yes.

MEMBER WALLIS: You shut down?

MR. MARCH-LEUBA: You shut down. That's the only – back on the pre-La Salle event, the seal 380 allowed you to reverse the actions that got you into that situation.

So if you pull rods, and you see an oscillation, you remove the rod that you pulled in, and you reinsert the rod, and you suppress the instability.

The new solution don't allow you to do that. If option three sees an instability it will scram. It doesn't ask questions.

And therefore it puts a big economic penalty on the plant on instability. Because any scram costs a lot of money.

MEMBER WALLIS: It means you have to suppress your noise level. Otherwise you would be getting all sorts of –

MR. MARCH-LEUBA: It has to go above the noise level.

MEMBER WALLIS: – false indicators.

MR. MARCH-LEUBA: And we did have one – I don't know if you are familiar with the Brunswick event in Christmas of 2006. We did have a false scram on most level.

All right, so we are going to

concentrate on this density wave. The controller system, the INC guys will fix, and the other instabilities, we have not seen them for the last 50 years of power.

So if we look at power versus flow, the operating domain, you have these blue lines. If you draw a red line that separates the unstable from the stable, it looks approximately like this. So it is a parabolic type of line, and it is always in this corner.

MEMBER WALLIS: Is that a natural circulation curve or something like that?

MR. MARCH-LEUBA: The blue line is the natural circulation curve.

MEMBER WALLIS: So it implies that the natural circulation phenomena are somehow related to the instability? It seems to, but apparently not.

MR. MARCH-LEUBA: No. Number one, this line is an artist's conception, depending on which reactor moves up to here, or up to there.

There are reactors in which this line is completely outside of –

MEMBER WALLIS: During the life of the fuel for instance or the cycle?

MR. MARCH-LEUBA: Oh, yes. It moves to

the event. It was – occurred about here. It scrammed. There was an instability. We have our inspection team, and we analyze all possible components of risk to the reactor.

We restart the reactor on the same power to flow ratio, the decay ratio was CO .2. Same position a week later. It was just a power distribution.

So by choosing different control flow patterns we chose a power distribution that was less peaked, and the characteristic went from 1 to 0.2.

So it changes daily. Now, I have this slide here also for another purpose. Last time I was here we were talking about MELLLA+ and EPU. This is 100 percent, 100 percent power, 100 percent flow, operating, which is called the OMTP. This is the 100 percent rod line, which means that if you keep your controllables fixed, and you change flow, the power follows this trajectory. And you see it's not 45 degrees. It's a little higher, because as you go down in flow, or in power, the fuel water heaters are not as effective, and you have difference of cooling, and you do get an increasing power.

MEMBER WALLIS: If you trip the pumps,

you follow down the –

MR. MARCH-LEUBA: If you trip the pumps, you will go like this.

MEMBER WALLIS: Go down there?

MR. MARCH-LEUBA: And then eventually go out. There is a transient. But if you do it slowly, so your fuel water temperature is in equilibrium, you will follow that line there.

And again this line depends on everything, on the reactor. In real life it will have a slightly different slope. And this is kind of an average base that comes from GE plant experience.

Now most reactors operate at what's called the MELLLA or ELLA line. Which is – it goes all the way to the 100 percent and 75 percent level. So you were allowed to operate along this line at 100 percent power; have flow control to compensate for all your burner.

What the reactor is for EPU was increase the flow line that was already allowed all the way to the higher power.

MEMBER WALLIS: Are those approximately lines of constant exit quality or something? Are they something like that?

MR. MARCH-LEUBA: No, because cooling has a lot to do with it. They are lines, of course void fraction, K infinity.

MEMBER WALLIS: So it's void fractions? Okay.

MR. MARCH-LEUBA: But the cooling is changing.

MEMBER WALLIS: Which feeds back to the reactivity.

MR. MARCH-LEUBA: Your K infinity must be one. But as you move down, your feedwater heater loses efficiency, because you have less steam. And I have never understood why completely, but as you move down this cooling changes, and you have colder temperature coming in the reactor.

You must have the same core average void. And therefore you have less or more power. The new proposed extended operating domain, what we call extended operating domain is this MELLLA+ which they actually want to regain this flexibility or having the same power SEPU, but be able to control burn up with flow. It gives them a lot more flexibility, operating flexibility, in the reactor.

What they have now, and the operator will tell you, we have now a DPU, is a flow crack.

They have only about roughly one percent flow that they can control the burner. So they are constantly moving control rods.

At one plant they were telling us, my neighbor is the guy that does all the operations on weekends. And every other weekend he has to be working, because they have to go down and change control rods and come back in. They have to do it every two weeks, where it used to be once every six months. And that's because of the lack of flow control.

So to gain the flow control, they are proposing to go to this MELLLA+, maximum extended low line limit analysis plus, which is 140 percent down to 80 percent. Which creates now this line.

And you can see what happens when you used to lose a pump, a separation pump from OTP, you ended up here. When you moved to MENA (phonetic) or MELLLA, right here, in the 100 percent and 75 percent, and you lose your pumps, you end up here.

When you are not in the MELLLA+ corner, you end up up here, way way inside the instability domain. And the simulations show that if you are in the MELLLA+, in a reactor today, operating below MELLLA, you have a 50-50 chance if you trip the pump that it will be unstable.

In a MELLLA+, you trip the pumps, you will be unstable, 95, 99 percent probability. So it does increase the probability.

CHAIR BANERJEE: What is that – how do you accomplish that straight line down? We have a presentation on MELLLA+ coming up.

MR. MARCH-LEUBA: Correct. Which line, this one?

CHAIR BANERJEE: Yes.

MR. MARCH-LEUBA: Oh this is arbitrary. That is a 55 percent flow. And the reason is to stay away from the red line, to stay away from the instability.

CHAIR BANERJEE: How do you do that?

MR. MARCH-LEUBA: You are not allowed to operate below there.

MEMBER WALLIS: You pull the rod – push in the rods.

MR. MARCH-LEUBA: You can, by tech specs, on the MELLLA+, an operator could stop like this and go and operate right here if he wanted to. There is probably no reason to do it, but he could.

He could not operate there on purpose. Now if he loses his pumps, and he moves there, he is now out of tech space, and he is supposed to insert rods and get out of there within 15 minutes.

So really for 15 minutes he is allowed to operate here, but not --

MEMBER WALLIS: Well, if the stability boundary is moving around, how does he know where it is?

MR. MARCH-LEUBA: He doesn't.

MEMBER WALLIS: He doesn't?

MR. MARCH-LEUBA: He doesn't. Nobody knows.

MEMBER WALLIS: So how does he know where he can be on this map then?

MR. MARCH-LEUBA: There is – what you do is, you define a stability boundary that is conservative enough so that it will cover most of the spectrum.

MEMBER WALLIS: What if he is looking at his various displays. Does he have a display like this that tells him where he is?

MR. MARCH-LEUBA: Let me go off here. He has a display like this.

MEMBER WALLIS: Well, okay, similar.

MR. MARCH-LEUBA: Similar. And this comes from –

MEMBER WALLIS: – know where the stability boundary is?

MR. MARCH-LEUBA: There is a stability boundary that has been –

MEMBER WALLIS: – moves around. Is that the very conservative one?

MR. MARCH-LEUBA: That's the conservative one. The conservative one is called the scram avoidance region.

MEMBER WALLIS: Okay. That's what he goes by.

MR. MARCH-LEUBA: This is what he goes by. And as Tai was saying, we do a lot of volumes. So Tai and I are well known in all the BWRs in the plan, they see us coming. And we always see this thing. This is from the core, the core operating limit report. There is always a copy of it, stuck with Scotch tape next to the operator's control. He has this map. Because he has to know where it is.

And the most prominent thing on this map – that's the reason I have this figure – is the stability region. There is a stability of awareness in the fleet which I cannot say there was 20 years ago.

I was involved in one of the stability

tests that we did when we were introducing the 9X9 fuel in a plant. And we were there for two days doing some stability measurements and tests. And after those tests, the guy, one of the operators, comes up and says, what are you talking about, there is a stability thing. What is that?

The operator didn't even know there was a stability problem. Now they do. Now they do, and we go to plant simulators. We interview operators. Everybody is well aware, because this is their control room, and that is the most prominent feature.

Plus every time they have to start, they get very close to it for startup. And it really bothers them. And by making the reactor more and more unstable, it's making a startup harder and harder.

CHAIR BANERJEE: Do they know where they are?

MR. MARCH-LEUBA: The power flow? Yes.

MEMBER WALLIS: There must be a cursor or something.

MR. MARCH-LEUBA: Depending on which display you are looking at. If you are looking at SPDS, safety parameter displace system, there will be a crosshair, a crosshair on where you are.

MEMBER WALLIS: And it probably has some history. It probably shows where they have been?

MR. MARCH-LEUBA: Some do, some don't. And operators like to rely on the core thermal power instead of APRM. The core therma power has a lag at the minimum of six seconds from the fuel, but typically it's a balance with steam and everything, it may have a lag.

So if you are having a transient, they will look at this PDS, because the coefficient of power has too much of a lag. They typically look at the hard wire controls on the wall.

CHAIR BANERJEE: Is the flow measure in the –

MR. MARCH-LEUBA: Jet pumps.

CHAIR BANERJEE: Yes. Well, in the jet pumps, or where is it measured?

MR. MARCH-LEUBA: In the jet pumps.

CHAIR BANERJEE: As well as the feed water flows.

MR. MARCH-LEUBA: The only flow that is measured is the drive flow, the circulation drive flow. And then you have jet pump delta Ps, and you want to control them, and you will see 20 jet pump delta Ps, and really it's the most prominent display in the control room.

And then somewhere somebody makes an estimation of what the core flow is. But there is no –

MEMBER WALLIS: – plotted here. Wasn't it plotted on the axis?

MR. MARCH-LEUBA: Oh, this is core flow. And that is a correlation based on the drive flow. So it is really – they measure the drive flow, and they know how –

MEMBER WALLIS: Drive function?

MR. MARCH-LEUBA: There is circulation drive flow in the jet pumps.

MEMBER WALLIS: What's actually drawn in by the pumps?

MR. MARCH-LEUBA: Yes, that's what you measure. And then they have a correlation that says, when I have 100 percent drive flow, I get 100 percent core flow. When I have sealed drive flow, I have about 30 percent drive flow. And that's what is used.

CHAIR BANERJEE: And the thermal power is estimated by the flow?

MR. MARCH-LEUBA: Thermal power is a

balance of energy.

CHAIR BANERJEE: Sure. So do you have to know the flow from the feedwater system?

MR. MARCH-LEUBA: Feedwater flow, steam flow.

CHAIR BANERJEE: Steam flow is not that secure.

MEMBER WALLIS: It's not done by neutronics.

MR. MARCH-LEUBA: That's the APRM power, and it's also displayed.

MEMBER WALLIS: But that's much quicker? That's much better, isn't it?

MS. ABDULLAHI: There is a core monitoring as well, system.

MR. MARCH-LEUBA: There is a whole other measurements, okay.

CHAIR BANERJEE: But what is actually displayed for that?

MR. MARCH-LEUBA: On an SPDS, typically, is the thermal power.

MEMBER WALLIS: The thermal power.

CHAIR BANERJEE: That's an energy –

MEMBER WALLIS: It has a lag of a few seconds.

MR. MARCH-LEUBA: It's probably more like 10, 10 or 20, for – but SPDS is not a safety display, right. All of their – depending on what you want to do. For ATWS they always look at SPRM power for example, for ATWS.

For – do you have several dimensions of power, and they use the one that applies for the particular – I'm not an expert in the field.

CHAIR BANERJEE: What about those two lines?

MR. MARCH-LEUBA: Oh, these are what's called the flow bias scram. This is called the APRM simulator thermal power scram. When you are at 100 percent power, it is 100 percent power, which is 77 megapounds per hour in this plant, your scram is 118 percent.

Now as you move down in flow, you have a flow balance scram. So if you hit 50 percent flow, you will scram if your power hits 85.

MEMBER WALLIS: So really an instability region.

MR. MARCH-LEUBA: It's way beyond that. The blue line is the rod block, which you can think of it as an alarm.

CHAIR BANERJEE: What is the blue line

again?

MR. MARCH-LEUBA: It's the APRM, it's called a rod block. It's an alarm. If you, for any reason you position yourself here, the system does not allow you to pull any control rods beyond there. That is a rod block. And it also has another alarm.

On this, if we ever get to the long-term solutions, there are two implementations of this flow bias scram. One of them uses the thermal power, or the simulated thermal power like this, in which they take the APRM signal and they filter it with a six-second time constant to simulate where the heat flux coming onto the fuel cladding is.

Or they can have what's called an unfilter (phonetic) flow bias scram, in which they take the APRM signal by itself.

And as you see – because the six-second constant on stability makes a big difference. If you are here, and you have an oscillation, and you are filtering with a six-second time constant, you dump it.

So then the flow scram doesn't help you for oscillations on the plants that have a simulated thermal power flow bias scram.

On the old plants that don't have the

STP, it helps you. You have to scram when the oscillation hits doubling. And that's how the plants call solution two are doing it, in option one D. They actually rely on this red line to scram, not on option three.

CHAIR BANERJEE: The red line is established for all time. Is that a matter of the state of core.

MR. MARCH-LEUBA: Sorry? The red line defines your analyzed domain. You – when you do your Chapter 15 analysis, you assume your scram when you get there.

CHAIR BANERJEE: How is that established? By analysis?

MR. MARCH-LEUBA: It's established – you can think of it as arbitrarily. The plant sets up a slope for this line. And then demonstrates that that slope is sufficient to satisfy all your Chapter 15 analysis.

If it wasn't sufficient, they will go a little lower, or they will change particulars, or do something. So it typically mirrors the roll line, and you can see that the smoke is a little flatter, to accommodate variations on the real core line. And it's just an arbitrary – has a coefficient.

And this shape that you see here is because the scram is done on dry flow, again. And you see here, the dry flow and you going into another circulation.

So the scram line is really linear on dry flow domain.

CHAIR BANERJEE: Why is the blue line more sloped than that? Or is it parallel?

MR. MARCH-LEUBA: I think it's a percentage. It's probably a percentage. That's why they are getting closer here.

CHAIR BANERJEE: So that could explain it.

MR. MARCH-LEUBA: Yeah, it's a percentage.

So moving on, you do understand now why we are concerned with MELLLA+ for stability. And you understand now why we are not that concerned with EPU for stability. Because the stability happens here. So to get there, you have to lose your circulation powers.

So by moving from this point to that point, that's what EPU plants have done, you are still on the same line, and you end up going on the same position. If you remember I gave you the analogy with the onion, that you can model an onion as a homogeneous sphere. As a homogeneous sphere, EPU doesn't affect the stability at all. You start peeling the onion and seeing all the details, you do see that indeed it has some effects. Because to make your plant go up there, you have to change all your power distributions and your loading. And even your fuel.

And therefore, it does have second order effects, which in stability can be very important.

So again the presentation. And there are three recognized instability models within density wave. One of them is the channel mode, and there are two core instabilities, the core one and the regional.

And the channel instability is purely thermodhyraulic. And this happens with only one channel, it becomes thermohydraulically unstable, and the power remains constant.

And this is the stability that most thermodyraulic people are used to. This is just a flow oscillation. And this happened twice. It happened once in an Italian reactor in the `60s that had a turbine flow meter on the outlet of the channel, and the turbine blocked, creating a big pressure drop at the outlet of the channel that caused this flow instability.

It happened the second time in Sweden recently, 10 years ago, when a channel was not properly seated. And there was a tremendous amount of bypass flow. So the flow of that channel was significantly reduced as opposed to the rest of the core. And that channel stopped oscillating, and they saw it on the LPRMs close by, and they saw the oscillation, and they couldn't figure out where it was coming from. And eventually they found out that there was a channel with static flow.

CHAIR BANERJEE: Was this Fosmark (phonetic)?

MR. MARCH-LEUBA: It was a Swedish plant. I'm not sure which of them. I don't know the true details.

And the core instabilities – so this is purely thermohydraulic. The power is 100 percent constant. And the core instabilities, now you have a thermodydraulic oscillation, so your void fraction oscillating being referred also by the reactivity feedback.

So you have now not only your thermohydraulic but your power oscillating in phase.

And there are two models for that one. There is the core-wide instability where you excite the fundamental mode in neutronics, and all of the channels are going up and down at the same time. And this is regional, or I call it out-of-phase instability mode in which you excited the second model of the neutronics, and half of the core goes up and half of the core goes down. So it's just going side to side.

And sometimes this one may even precede, because there are two installation models, one in this direction, and one in this direction. And it may sometimes, it jumps from this to 90 degrees periodically. And it might even going forth some people have seen helicoidal behavior.

Again, those two types of instabilities have been observed. Typically 75 percent of the instabilities are core-wide; 25 percent are out of phase in history.

We have not had any out-of-phase instability in the United States. I'm talking about mostly European – okay, I'll move fast.

For those three modes of instability, there are two ways in which you can approach the stability boundary. You can have a flow reduction, or you can have a power increase. And they are completely different.

Because when are having a power increase going out this way, you put in control rods, and you do that in a very controlled manner. So typically when you have a step up instability like this, you are putting control rods, you get a slightly inside oscillation, and you have time to recover and insert the control rod and get out. Because by long time solutions you will not be allowed to do that, because the protection system will take over.

But this type of instabilities are not of great significance from a regulatory point of view, because they are going to be small.

These type of instabilities, the flow reduction stabilities, are significant, because when you lose your pumps, you don't know where you are going to end. And you end up way inside the crucial region, and you end up with a very large oscillation.

So those are the ones that you should worry more, and we worry more, about.

There is a third type which is the time in which you do the pump action. But the BWRs operate with pumps that have two speeds, slow speed and fast speed. And in between they use a flow control valve. And they are – there is some mechanism that for NPSH considerations you always start on the slow speed until you have power, and then you have to go back and that was the cause of WP-II. The speed of time, will move fast. D

Here is a list of all the instability events. There was – the very early ones in the states was in the Vermont Yankee. Which was followed then by some tests in which they actually pulled rods in a controlled manner, and they actually made the reactor unstable again.

In between there was the Peach Bottom test, where they were not unstable. It was a very, very stable configuration.

The thing that started everything was La Salle, which as I said before, it was really an ATWS for the first three minutes until the reactor scram. And it was a very large unpredictable oscillation. It reached the high amplitude, 118 percent power. So the oscillations – they were operating on roughly 50 - 60 percent power, and the oscillations reached 120. So fairly large amplitude oscillations.

CHAIR BANERJEE: What happened there?

MR. MARCH-LEUBA: There was a fuel water

controller failure above that site. And that reduced the water level in the vessel.

So it tripped the circulation pumps. When it tripped the circulation pumps it got this into the region, and everything started going.

CHAIR BANERJEE: Now if we go back, this is an old plant, right?

MR. MARCH-LEUBA: 3 or 5.

CHAIR BANERJEE: So when it went down, if you go back to that old figure, was it on the blue – oh it was on that line?

MR. MARCH-LEUBA: Yes. It was on this. I mean remember La Salle could have had the stability.

CHAIR BANERJEE: So it wasn't on the lowest line there. Okay.

MR. MARCH-LEUBA: Now you can plot the lines of constant decay ratio by using some assumptions, and they are all like this. So this is decay ratio one, and then there will be decay ratio point eight, point six, point four.

And on the other side you can plot the lines of limit cycle amplitude. And so this will be a limit cycle of zero, and this will be a limit cycle of 10 percent, 20 percent, 100 percent. So you can think of it as, the more you get in there the larger your limit cycle.

CHAIR BANERJEE: La Salle went into –

MR. MARCH-LEUBA: Way –

MEMBER WALLIS: Because it's not exponential growth; there's a limit cycle.

MR. MARCH-LEUBA: Correct. There is a limit cycle that protects the growth.

Now unfortunately it's not limited in size. That's what we're seeing on the ATWS stability. It gets to very large, 1000 percent oscillation. Very large.

Okay. Instabilities, we did have the WNP2 event. And since then at that point we were already working on the long term solutions. After the La Salle event, the staff said, operator action – before La Salle, and as a consequence of Vermont Yankee, we have the famous Seal 380 that Dr. Huang talked about which said, basically, operators are supposed to look at their PRM ratings. If they see any upscale or downscale alarms, that's an indication there is instability. If there is instability, you do the reverse action that you got you there. And if you cannot do that, you scram. That was Seal 380.

After La Salle we had what is called an interim correction actions, which really reduced the operator flexibility after an instability, and mandated some immediate scrams for some conditions, and started working on the long-term solutions.

So we have these two nomenclatures which now are 20 years old, interim corrective action versus long term solution. So the interims were supposed to work while we were working on the long-term solution.

So while we are working on the long term solutions, there will be WP-2 instability was during the startup, and we talked about that before. And then we had a spell of 10 years with the LTS, long-term solutions, implemented, and nothing happened. Everything was really good. And we started having 9X9 fuel, 10X10 fuel, and then EPU, and all the things that Dr. Wallis has mentioned.

And now we see a trend. I mean 2003 we had Nine Mile Point, we had an instability. 2004 we have very instability. Recently we had an event in Brunswick which was not an instability, but we do see a trend that all these crucial regions, or these red lines, are moving to the right.

CHAIR BANERJEE: So the EPUs, you are on

the EPU line for all of these? So what line are you on then?

MR. MARCH-LEUBA: The ELLA+. So it's the EPU line, but you are in the same EPU line. So they are operating back in the –

mR. BANERJEE: I see.

MR. MARCH-LEUBA: And I don't remember where the –

CHAIR BANERJEE: So they are in an extended operating range, right?

MR. MARCH-LEUBA: We have an expert to help us.

CHAIR BANERJEE: It's okay.

MR. MARCH-LEUBA: But as we said, the EPU has really not a major effect on the stability.

CHAIR BANERJEE: I realize that. You are on that line.

MR. MARCH-LEUBA: In the meantime there have been many, many events in foreign reactors. In Spain there have been two, in Sweden there have been a large number. In Germany they actually run stability tests every cycle, and they actually mark the red line for every cycle before a startup. So they actually go unstable every time.

We see this – the purpose of this slide

when I was writing it is to tell you that when you look in the COLA (phonetic), when you look in the control room, stability hits you in the eye. Every single time we went to a power plant and we asked them, every single operator knows about it. They are aware of it.

CHAIR BANERJEE: What's the green regions?

MR. MARCH-LEUBA: This is the – this is a solution three plant. And the OPRM scram, the solution three scram, is armed inside the green region, and is not armed, so even if there is noise in this area, it will not scram.

This is set conservatively at 60 percent flow, arbitrary. Thorough analysis shows that we have never seen stabilities at 60 percent flow.

What controls the stability, and we are talking about an ATWS circulation, is really the frequency of the oscillation is the most important part of it. And the frequency of the oscillation is controlled by the bubbles core. And as you move down in flow, that's where you get lower frequencies.

And the most important parameter you have to worry about instability, and that's why you don't have instabilities at 100 percent power, at 100 percent flow, is the frequency.

If you were to match higher frequencies, the fuel filters in an oscillation doesn't let it go into thermohydraulics. The void fraction doesn't see your power oscillations.

Next. So we said, following La Salle, there was a large industry wide effort. We are talking meetings, there were groups where there were 50 people from industry involved in every meeting. And lots of back and forth between the industry and the staff.

And the main concern was a concern with the regional or out-of-phase instability mode, the one that goes from left to right. Because the protection system in most reactors averages APRMs from the whole core. So the right side goes up, but the left side goes down. And when you sum them all, in theory you don't get anything.

So that's when GE says that if we do an analysis and we wait for APRM to have a 10 percent oscillation, the local channel is 200 percent, and we are violating CPR. And there is a real tremendous magnification on that.

So that was APRM and said, we need to do something about that.

And what we did in the meantime, we issued interim corrective actions, and we worked on the long-term solutions.

CHAIR BANERJEE: But operator who was looking at the core thermal power to find where they area would not see a big deviation from core thermal power when this happened, right?

MR. MARCH-LEUBA: Oh, no, the thermal power doesn't even oscillate.

CHAIR BANERJEE: You would see no oscillation?

MR. MARCH-LEUBA: At this point the operator would have two instrumentations. One of them is a strip chart, which is paper copy with a pen, that has the APRM time trace. And instead of being a line, you will have a wiggle in a paper.

You will also have the LPRM upscale and downscale alarms. Around every one of the control rods you have the upscale and downscale alarms. So if the APRM was oscillating it will have a red light.

Unfortunately, if you have actually had an APRM failure some time a week ago, that red light was already on, and it's locked. And until they fix it, then that instrument was unavailable.

And the moment there is one red light in the whole panel that was on, there would not have been an audible alarm. So the other lights would be coming on and off, but there wouldn't be any ding-ding-ding to make you look at it. So it wasn't even reliable, which is to say that it was unreliable.

When we decide to do long-term solutions, we looked at the regulations. And we will see that on the SRP. The main rule that we have is the general number 12, which says in short that oscillations are either not possible or can be reliably detected and suppressed.

So on this point there was a split in the BWR group. Some plants have already digital protection systems, which they can implement as solution three. Oil plants did not have a digital protection system, and it would be very expensive to implement a scram of this magnitude.

So there was a break. And there were actually a lot of actions. Everybody chose their own, and some actions were cheap, and they didn't have to pay anything to develop it.

In general there are two types. There is the prevention as CDC allows you. You say, oscillations are not possible in my reactor. And then the solution that detectors suppress. You allow oscillations to occur, but if they happen they will not violate anything.

And the preventive oscillations are option – enhanced 1A and option 1D which basically define a red area in the map where you are not allowed to operate. And in the case of option 1A it's enforced automatically by scram system. If you get in there, you scram; that's it, you don't have any option.

Option 1D has this famous flow bias scram, which was not filtered, and therefore it has some protection for core-wide oscillations. And they were to demonstrate that they could not have out-of-phase oscillations because of the characteristics of the core.

And frankly, to do –

CHAIR BANERJEE: That's option two?

MR. MARCH-LEUBA: Option 1D.

CHAIR BANERJEE: Oh, 1D.

MR. MARCH-LEUBA: There are slides later on that describe each one.

To do justice to this, this would have to be a semester class, and each of these slides would be a lecture. So I'm going to give you a headache by going this fast. But I'm giving you a flavor of –

CHAIR BANERJEE: 1D in some way analyzes out-of-phase oscillations.

MR. MARCH-LEUBA: 1D plants, they must demonstrate by analysis that oscillations are unlikely in the regional norm. And that happens because you have a lot of separation between the fundamental and the first harmonic, and you have a tight inlet orifice which makes flow oscillators more unlikely. And those two things tend to favor the core-wide versus the regional model.

In addition you do have unfiltered flow bias scram, so you do have protection against the core-wide model solution. So those, I believe there are three plans that satisfy this requirements, and they refine a region of the map where they were not allowed to operate, but they were allowed to do it administratively. They didn't have to scram immediately, because even inside their plant, inside the region, they have protection. So they were off really cheap and didn't have to do anything.

So we will go into all of them if we talk real fast. The good thing about this –

CHAIR BANERJEE: Just give us a flavor.

MR. MARCH-LEUBA: Yes. Let me tell you, the good thing about all these solutions is that they are publicly available. They are owned by the owners group, and anybody – anybody that wants to use them, has to negotiate with the owners group. If they didn't pay the fees to start with, they will have to pay for the fees. But all these solutions are available, and they can be implemented for SBWR, for whatever.

Let me give a flavor. Option E1A is a crucial region which has an immediate scram component and it's automatic.

1D demonstrates that you would only have core-wide instabilities; demonstrate that you have protection against core-wide instabilities with a flow bias scram; and that you will not – that's it.

Option II only applies to the BWR II type, which is the very old plants. And those plants, the APRM averaging was actually done in quarters. Instead of being the whole core, the APRM-A is only one quarter of the core. APRM-B is the other quarter. C is the other quarter, and this is a quarter.

And therefore it does not prevent from

the instability, and they can demonstrate that they have protection from both, core-wide and out-of-phase.

And what they do is, they do similar to option D. They have an area of the map where they are not allowed to operate, but it's administrative. And even if they get there, their scram protects them.

Option three is the one that most plants chose because it gives them the most operating flexibility. You go anywhere you want. And we have a detection system. If there is an instability we will see it. And it will scram on it.

And that is what has – often it's called the oscillation power range monitor, OPRM, which created a new – you have the local power range monitor, the average power range monitor, and then the OPRM monitor, oscillation, that is now a range around OPRM plus is to be able to detect these out-of-phase instabilities.

Now recently we have been coming in to the extended operating domains, and MELLLA+ in particular, and through analysis we found out that it is very difficult to make this old options to operate when your instabilities are so likely to happen if it goes through pumps.

And indeed, what we saw with MELLLA+ is that the oscillation happened even during the flow run-back. Therefore the frequency oscillation is changing, and the algorithm really doesn't have time to catch up.

CHAIR BANERJEE: By analysis?

MR. MARCH-LEUBA: By analysis. By analysis General Electric demonstrated that an option three maybe would work, but it would require very, very small cell points, and there would be too susceptible to noise problems.

Therefore, they proposed the solution, confirmation density oscillation.

The problem with this one is known as the GE proprietary. The owners group didn't have anything to do with it. It's owned by GE, and if you want it you have to buy it from them.

It has been approved, and if we want to see the details of this one, we will have to have a closed session, because it is owned by GE.

Basic flavor which is not proprietary is, like a solution three, but instead of requiring two channels to oscillate, you know, to get a scram in a reactor you have to have train A and train B to coincide, and both agree that it's a scram.

With confirmation density you require now at leave five, maybe more, depending on how many LPRMs are operating. There is a density of OPRMs that agree there is an instability. And if all five of them agree, you get a scram.

By doing that they are able to reduce the scram cell points to essentially nothing, and be able to deal with MELLLA+.

And there is a whole bunch of other details which are proprietary.

Areva doesn't want to be behind, and they have proposed an enhance of two three, which is also proprietary. And that one is under staff review.

And this one, they have some understanding of what the issues are with this process, and they are trying to solve it with a combination of a crucial region and a scram. So they will have a crucial region for a particular model instability and a scram for the other.

And as I say, this is under review, and we have issued a number of REIs, because we have concerns about implementation.

These are a list of other plans and

which options they chose.

CHAIR BANERJEE: Let me ask a naive question. What are we supposed to review in this MELLLA+ meeting that is being arranged?

MR. MARCH-LEUBA: For stability?

MR. CARUSO: No, remember, we're here today to talk about –

CHAIR BANERJEE: SRP, right.

MR. CARUSO: – SRP. In the future you are going to look at a topic report that relates to MELLLA+. And another optical report that is related to that, which involves GE analytical methods.

MR. MARCH-LEUBA: And at the same time we will give you a full presentation on the DSS/CD.

MR. CARUSO: Oh, okay, that's when we're going to hear – because there was some talk at some point about coming to talk about DSS/CD.

MR. MARCH-LEUBA: It makes sense to do it at that point.

CHAIR BANERJEE: And just to understand the situation, that's going to happen in April, sometime?

MR. CARUSO: What's the date I have currently for that? I thought it was March 27-28.

MS. ABDULLAHI: No, March 28th you would

get the methods, I guess. You should get it by today from Projects.

The MELLLA+ itself will come a little bit later.

MR. CARUSO: No, no, when were we going to meet to talk about it?

MS. ABDULLAHI: Oh, the meeting of the MELLLA+ method?

MR. CARUSO: Yes.

MS. ABDULLAHI: April 2nd to the 5th.

MR. CARUSO: That's it, okay, I'm sorry.

CHAIR BANERJEE: Three days?

MS. ABDULLAHI: Well, I think it's more than three days –

MR. CARUSO: It's the week of the full committee meeting. I believe it's the Monday and Tuesday of the full committee meeting. And I didn't recall that was in March or if that was in April.

MS. ABDULLAHI: I think it's in April, April 2nd and 3rd.

MR. CARUSO: You said you will be coming back from Washington, so you'll stop there for a week.

CHAIR BANERJEE: Fine, go ahead.

MR. MARCH-LEUBA: Next, please.

Okay, I gave you the real flavor. Are you interested in the details of the solutions? Or just go through the –

CHAIR BANERJEE: I don't think we have time. We are interested in the details. Right, so tell us what you think we need to know.

MR. MARCH-LEUBA: E1A has a cycle-specific Exclusion Region defined, where stabilities are very likely – very unlikely to occur outside of which – it uses very conservative generic assumptions which are very well defined on an LTR that has been reviewed by the staff. So anybody that wants to do E1A they just have to read the LTR and do the calculations that are prescribed there in extreme detail that define a crucial region, modify the protection systems so that if they get in there they scram. And basically what they do is modify the – remember that red line and blue line? They modify that red line to cover this exclusion region. So they have that scram with E1A.

It does have some different in there, where there are some buffer regions, it's what's called a detection algorithm, which is the next slide. It will be the next other slide.

At the time we didn't even know why the

regional model of instability occurred, much less how to calculate it. There had been some rumors that somebody had seen one in Europe, but that was it. But that was back in the La Salle event. After that many have occurred, and we have a much deeper understanding of what happened.

But other time we didn't have a calculation and tool that will tell us what the decay ratio of the outer face mold is.

So that's what the so-called dog-bite correlation, which is also called the core versus external correlation, or the bypass correlation came into play.

And what the owners group is – we will know how to calculate core decay ratio. And they plotted on this domain all of the events that had occurred at the time with out of phase. And they all happen to be in this area.

And the idea is that now that we know what the regional stability is, regional instabilities are mostly thermohydraulic, and so are enforced by the neutronics, which means that channel degradation tells you how thermohydraulically unstable you are, so when you have a high channel decay ratio, and also some activity feedback with the core, that's when you tend to get regional instabilities.

And I would love to give you a two-hour presentation on this, because I was the one that discovered it.

But basically what we did is, we threw a line that covered experimentally all of the events that were known at the time. And this has become – officially it's called the bypass acceptance criteria. But really everybody calls it a dog bite, because this is like somebody – a dog came here and took a bite out of your map.

And what you do to calculate the crucial region is you change the power and flow, and start plotting core versus external decay ratio, one comes here, comes here, comes here, comes there. And when it crosses this line, that's the point where the red exclusion region is drawn.

And if it goes through here, if that sequence of points goes through here, you think it's going to be an out-of-phase instability. If it goes through here you think it's going to be a core-wide instability.

Since then we have all of the cores now can do the regional instability, and indeed, for years BWR, we did not allow them to use this correlation. But this is – it would be a back-fit now to require everybody to do it the right way in a sense. Because this is good enough.

CHAIR BANERJEE: Is it a correlation, or is it a linear stability analysis?

MR. MARCH-LEUBA: This is a correlation, this is an empirical correlation; 100 percent empirical.

CHAIR BANERJEE: But it can't be analyzed?

MR. MARCH-LEUBA: The decay ratio for original model, yes, indeed it is analyzed now regularly. All of the frequency domain calls, and all of the good time domain calls calculate regional model instability.

CHAIR BANERJEE: These are all linear analyses?

MR. MARCH-LEUBA: The time domain calls are nonlinear, but this is a linear instability.

Okay? So just so you know, in the SRP it will say use of the bypass correlation is acceptable. That's what we mean. It is a historical thing. If we were not allowed to do it, it would be a back fit.

For new reactors like BWR, we don't allow them to do it. We want them to it right.

But for other reactors, it's already approved.

The other defense in that is that the period based algorithm. And maybe we will spend all of the time of your lunch doing this. But this is how – solution three detects instabilities.

This is your power time trace, like that. And it's looking for periodicity. And what it's looking for is what what are called confirmations, is the time it takes to go from a minimum to a minimum, and from a maximum to a maximum, is within the program.

So this is your first base period. And then the second one is a first confirmation, because the distance between peaks is the same as before plus minus epsilon.

Then you have a second confirmation, and a third confirmation, and a fourth confirmation. If you get 10 confirmations, it's a variable depending on which plant you are, then it says, your single is periodic, you have an instability.

So that's why when you look at option three, people are talking about so many confirmation counts. That's what it means; you have so many confirmation counts.

To prevent problems there are some safety features, like the T-min and t-max. You do have – or we have a range of frequencies, of which this oscillation is considered to be a density wave.

So we have an oscillation that is 10 Hertz. We know it is not a density wave.

So to have a confirmation the base period has to be greater than T-min and less than T-max, so that there are some parameters that you have.

There is an Epsilon that allows you to say there is a confirmation or not. And then there is the number of confirmations.

And these are the parameters we talked about before on Nine Mile Point 2. The plants have an option based on their experience of how many false positives they were getting to make this more sensitive. And all the plants, guess what, they have taken into the minimum sensitivity parameter allowed by the OTR, and it was not sufficiently sensitive. There was a Part 21, and some parameters were tight enough.

CHAIR BANERJEE: What's the time scale,

and the amplitude in rough terms?

MR. MARCH-LEUBA: The oscillations are roughly two seconds from peak to peak, a half a Hertz. And the amplitude at the time of the scram would be a volume of 10 percent. There is a minimum amplitude for solution three to scram. It's done at this, the set point. When somebody tells you the option three set point, it's how large the amplitude needs to be. And on the order of 10 percent.

Typical noise which you have day-in and day-out is about three percent. So three times above noise.

CHAIR BANERJEE: These are then based on, in option three, some averaging done?

MR. MARCH-LEUBA: The OPM averaging is done by collecting a list eight LPRMs that are close together, or in a corner of the core and then there is another LPRM here and another LPRM here.

And any one from the A side of the protected system has to say, yes, there is an instability. And then you go to the B side, the B chain, you know, fire protection and separation of powers and all that.

CHAIR BANERJEE: It's a virtual OPRM. It depends on LPRMs.

MR. MARCH-LEUBA: Oh, it's an LPRM. It's a sum of LPRMs. But they are averaged together to represent the power in a core breach.

So issue one has something similar to Option III, but it's only an alarm. So Enhanced 1A we also have an alarm if it detects instability. The operator then will have to make a decision.

We talk about Solution 1D, it has an unstable region where you are not allowed to operate unless you satisfy some conditions, and you demonstrate that you have protection by analysis, because you will not have an out-of-phase instability. If you have an in-phase instability your flow bias scram will defend it.

Option II plants, we talk about the Option II plants, only applies to the quadrant-based APRM scrams, which is the BWR-IIs. These actually again don't have to do anything. They don't have to modify anything. They actually have protection, and they just have demonstrate that they do have protection, and every cycle they do that.

We look also at Solution III is based on –

CHAIR BANERJEE: – by analysis, I presume, codes which have been approved.

MR. MARCH-LEUBA: Correct. Correct.

CHAIR BANERJEE: Are these like best estimate codes? Or what sort of codes are they?

I mean when you say by analysis.

MR. MARCH-LEUBA: It's like every other scram system. You have to demonstrate that your reactor set point value, you protect against CPR violations or sample. But in particular CPR.

And that's when we go into what's called a DIVOM correlation. And that will require our displaying why. But basically what the industry does with TRAC-G for General Electric for example, approved code for DIVOM, or Framaton used their approved – one of their remote alerts.

What they do is, they postulate different oscillation amplitudes. And they calculate a delta CPR versus an initial CPR.

CHAIR BANERJEE: This is steady state?

MR. MARCH-LEUBA: This is now – you superimpose a sine wave on the –

mR. BANERJEE: But on a steady state correlation?

MR. MARCH-LEUBA: On a steady state correlation, correct.

CHAIR BANERJEE: But the oscillation

period, it says about one second.

MR. MARCH-LEUBA: Two seconds.

CHAIR BANERJEE: Two seconds.

MR. MARCH-LEUBA: There are – in the TRAC-G qualification report there are several examples where it has been qualified for this type of instability. Periodic dry-out and rewetting. And it does a pretty good job. You would think it wouldn't, but it does.

So basically they set up different oscillation amplitudes, using the correlation for GE. They calculated the CPR over ICPR, and plot the cases. Here they are, and here are some No. 9 fuel rolls, and 10X10 fuel rolls and different conditions.

And they created what was called delta – well, the DIVOM core. I don't know exactly what – delta initial versus oscillation magnitude, I think.

And create this slope. Now with this slope, then knowing what your scram set point is, you know how large your amplitude is. Then you go back and calculate how much CPR you lose for that oscillation. And then that's how you demonstrate that you have protection against that oscillation.

I frankly have problems with this, and I would love to explain why.

CHAIR BANERJEE: Well, let me ask you something. The delta CPR, has it been actually validated ever in terms of oscillating flows?

MR. MARCH-LEUBA: Well, the correlations – and I'm not an expert on CPR correlations – but what I've seen is that they go into a facility. And the oscillate power in a sine wave. And you do get periodic dry out and re-wets. And they go with TRAC-G. And they simulated that, and they go into dry out and re-wet at the same time or about the same time. And about the same time – same power level, and it does simulate the dry out and re-wet.

CHAIR BANERJEE: I'm saying, these were experimentally validated.

MR. MARCH-LEUBA: That has been experimentally validated. It's part of the correlation or the Framaton correlation validation. Both vendors have that.

DR. HUANG: I think we can move on for the stability, how about that?

MR. MARCH-LEUBA: Sure. There were some, particularly ones which you can read about, some issues with implementation of Solution III.

The implementation of Solution III –

I'll just move real fast out of there – took a long time. I mean really, really long time; we're talking about 10 years. Because everybody was having problems, and as they were really collecting information, they were finding more problems.

Now I can say, everybody is implemented. We are all fine.

But there is argumentation why it took so long. It is a very complex professional system. It is very difficult. It is making noise analysis, and then to scram on that. And it took that long because it was that complex.

Now we are going into the operating domains. We talked about that. The issue with the operating domains when you are moving now from MELLLA or from EPU to MELLLA+, if you lose your pumps, you move farther inside into the stability region. It makes it more unstable.

And indeed you become unstable on the middle. There are issues with frequencies changing. So there are new challenges. And because of that the industry has responded with DSS/CD, and solution III.

CHAIR BANERJEE: Don't run away from DSS/CD. What is it?

MR. MARCH-LEUBA: DSS/CD is an Option III in which the amplitude set point is removed. But it is really – on the original –

CHAIR BANERJEE: It's a hair trigger then.

MR. MARCH-LEUBA: It's a hair trigger. But it requires a lot of OPRMs to agree. So if you have one OPRM signal doing like that, it doesn't do it.

During testing we found out that we still need a small amplitude to protect against noise fluctuations. And there was revision two of the DDS/CD that allowed for a very small amplitude set point.

CHAIR BANERJEE: Do they look for a correlation coefficient? Or how do they actually look and see that these are all saying the same thing?

MR. MARCH-LEUBA: Oh, well, you have the PVDR which I show you the figure of there. You have ten confirmations of periodicity. But the OPRM on this corner of the core has to live with the OPRM on this corner of the core, and has to live with that corner –

CHAIR BANERJEE: But is it a correlation

coefficient –

MR. MARCH-LEUBA: No, all of them have to have a permissive. So OPRM I is scram. OPRM II is scram. OPRM III is scram. And if enough of them scram, it's a minimum of five, and depending on how many –

MEMBER WALLIS: – where some of them don't show a selection?

MR. MARCH-LEUBA: Well, the expectation was that you would have this spurious noise problems. We only happening one of them, but it was happening in 10 of them.

MEMBER WALLIS: No, that's right. But aren't there some modes of oscillation where some of them don't show anything?

MR. MARCH-LEUBA: Correct.

MEMBER WALLIS: So how does the –

MR. MARCH-LEUBA: You still have enough of the others.

MEMBER WALLIS: Have to have enough of the others.

MR. MARCH-LEUBA: Right. You don't really five when there are when there are 35 OPRMs.

MEMBER WALLIS: Okay. So I guess that's all right.

MR. MARCH-LEUBA: Yes.

MEMBER WALLIS: The whole question – I'm listening to all your explanation here. We are talking here about an SRP. Is the reviewer of all this stuff knowledgeable enough to understand whether or not this is good enough.

MR. MARCH-LEUBA: The reviewer is knowledgeable enough to know, and the SRP tells you, are they using a long term solution that has been reviewed and approved by the staff.

MEMBER WALLIS: Okay. So there is a check off, this has all been reviewed and –

MR. MARCH-LEUBA: Absolutely. Now for new reactors, for new MELLEA+s, then new NTTSR requirements, then you need to have a reviewer that is knowledgeable.

And Dr. Huang has been working on this for 30 years. I've been working on it for 25.

DR. HUANG: This is detail on the desk references in a lot of the stuff in there. So the reviewer can go back to here and get that information, get that paper, so they can reviewed based on it.

CHAIR BANERJEE: Now how much of this review is – say I can see that non-ATWS stuff, TRAC-

G, has been approved, right. But for ATWS we've never looked at even TRAC-G up to now.

MR. MARCH-LEUBA: No, actually TRAC-G has been approved for ATWS stability.

CHAIR BANERJEE: It has been approved for ATWS stability.

MR. MARCH-LEUBA: ATWS stability, correct.

CHAIR BANERJEE: I didn't know that.

MR. MARCH-LEUBA: Yeah, it was the only tool we have available to do it.

CHAIR BANERJEE: Because presumably it came through ACRS at some point.

MR. MARCH-LEUBA: Oh, yes.

CHAIR BANERJEE: TRAC-G.

MR. MARCH-LEUBA: TRAC-G and all the ATWS stability, we had lots of interaction with – we had – it was not like this where we do the work and then we tell you. We involved ACRS over many meetings during development over a couple of years.

We had some meetings in San Francisco, because most of the ACRS members work on the West Coast.

CHAIR BANERJEE: This is going back how long?

MR. MARCH-LEUBA: Back to `92.

CHAIR BANERJEE: TRAC-G?

MR. MARCH-LEUBA: TRAC-G, yes.

MS. ABDULLAHI: This is Zena, I'd make a little bit of a correction regulatorywise. At that time it was acceptance of TRAC-G for use, but licensing wise, approval of TRAC-G for instability is the reason, quite recent.

CHAIR BANERJEE: But I didn't know that it had been approved for ATWS.

MS. ABDULLAHI: That's a different story. For instability per se, the 1980 – after the La Salle period, I think we looked at it. And that's when the ACRS and everybody in the industry was involved. And at that point it was accepted for use for instability only.

CHAIR BANERJEE: ATWS instability.

MS. ABDULLAHI: ATWS instability. But right now it's not approved specifically for ATWS instability. But GE has committed to come in I think December, `07, and convert all their ATWS analysis to TRAC-G.

CHAIR BANERJEE: They are still using ODIN for ATWS.

MS. ABDULLAHI: That's a long story.

Yes, you will hear all of that when you do the MELLLA+.

CHAIR BANERJEE: Well, the reason I'm asking this is that I was at a meeting about two years ago in San Jose, GE, and you were there too, Professor Wallis. And the results we saw with TRAC-G for ATWS were not comforting that the code was doing anything useful at that time.

MEMBER WALLIS: It was probably more than two years ago.

CHAIR BANERJEE: About three years ago.

MEMBER WALLIS: A long time ago.

MS. ABDULLAHI: Yes, I know what it was.

CHAIR BANERJEE: No, we have never seen TRAC-G after that showing ATWS calculations.

MS. ABDULLAHI: Well, the MELLLA+ presentation would entail basically mostly instability and ATWS instability, because these are the predominant response that affects MELLLA+.

So in April that's what we will be focusing on. But beyond acceptance of ATWS instability at the time of the 1988 - `90 –

DR. HUANG: `92, 1992-94 time frame, that staff has reviewed and approved at number 32007, along with the needle 32164. One is for the outer loop issues, BWR co-thermal hydraulic stability.

The other one is BWR mitigation of BWR co-thermal hydraulic instability in ATWS.

So they are `90,'92 and `94.

CHAIR BANERJEE: So then why does GE come in to have it approved in December, TRAC-G?

MR. MARCH-LEUBA: Oh, they are waiting for ATWS, not the one –

CHAIR BANERJEE: Yes, that's what I mean.

MR. MARCH-LEUBA: It's different. It was approved – let's move into ATWS stability, and you will know why it was approved.

CHAIR BANERJEE: Keep on going for 10 minutes more, 15 minutes.

MR. MARCH-LEUBA: There are many, many, many different types of ATWS events, just like a LOCA. Like ATWS instability. And when you put those two names together, it gets a visceral reaction from many people – ATWS stability – because it's a really bad event.

It's a particular class of ATWS events where the following has happened: the condensate is available. So you can get very cold water from the condenser. So then all that cold water is fed into the vessel.

And then because of that very cold water is fed into the vessel, you could raise the power of the core so much that extreme amplitude oscillations are developed, and you don't have a scram.

And this oscillation we are talking about, more than 1,000 percent. And they are large enough that you do have all this periodic dry-out and re-wetting. Whenever you see these oscillations, you dry out and you don't re-wet. So you just continue to heat them up, and cladding failure occurs. You heat 2,200. So it's a really bad event.

And the worst thing is –

MEMBER WALLIS: What sort of frequency are these?

MR. MARCH-LEUBA: About every four seconds, four or five seconds. It's supposed to be every two seconds, but as they become linear, they space out.

Once – what happens is, you have a peak that is so large, that you get heat of such temperature that it doesn't record. Even if you re-wet it with cold water it doesn't re-wet.

The serious problem, the serious instabilities, is that it is not a full transient evolution. So if the operator takes hands off in some plants, that's exactly what will happen for ATWS events.

So something needed to be done. And this is one simulation from the Brookhaven analyzer at the time of the La Salle event. La Salle happened up to here. Here is where the scram happened. And they predicted what would happen if the scram had failed. And at the time nobody was really aware of this notion that the most important thing during ATWS instability certainly is what happens with the balance of plant. Because what you have is, you have your power train, and then this is the relative power, increases a little bit. But then as you start getting all the cold condenser water, you start increasing the power of the core, and you end up having an analyzed power of 80 percent, 90 percent. And these oscillations are allowed to grow.

MEMBER WALLIS: It goes 1,000 percent.

MR. MARCH-LEUBA: That's the ATWS power. The oscillations are measured on this side; they are a factor of 12.

MEMBER WALLIS: Oh, that's relative. That's 10 times –

MR. MARCH-LEUBA: That's 12 – 1,000 to 1,200 percent, very large oscillations. And one of the peaks becomes so large that it just blows up the fuel. I mean it mixes so hot that it cannot re-wet.

So the balance of plant modeling was crucial for this event. And we have to credit the Brookhaven guys, because at the time we were not aware of it. It was a St. Louis engineer and a plant engineer analyzer that we found out about this.

The issue, and why this happens, is that the fuel water heaters work with extraction steam from the turbines. So when the turbine trips, you don't have steam to heat up the fuel water. And the fuel water keeps pumping water, but it's not heated.

So if you lose your turbine, you are putting cold water in the core. So if you have a no occilation ATWS the – and the bypass, the turbine bypass valve is fully open, you are sending all of that steam to the condenser. You are not – have no pressure. Nothing happening other than your average power is going up and up and up, and your oscillations are developing.

And that's when a very large sample to limit cycle occurs.

And if it is a default hands-off sequence for some plants, and most plants don't do this. La Salle does this. And that was the one we were focusing on.

You require – so this is the sequence of events. You have turbine trip. The bypass opens. And somehow you send a scram signal to become an ATWS.

So the scram fails, and you are in ATWS. Because you are in ATWS, maybe an oscillation of the water level like happened in La Salle, you have a recirculation pump trip. You go into the red area.

The control system now stabilizes the water level, and everything to the operator looks normal. I have my containment open. All my heat is going to the condenser. And they are still cooling the core. Everything is fine.

But the power continues to rise because of the cold water, and you start developing these very large oscillations.

We can ignore this one. We talked about MELLLA+ enough.

MEMBER WALLIS: What do you do about it?

MR. MARCH-LEUBA: First, let me tell you why some plants you don't have to worry about it.

Some plants like La Salle have 100 percent bypass capacity for determining it.

MEMBER WALLIS: There's instability on the computer.

MR. CARUSO: Well, we've lost our signal. We've lost our screen here.

CHAIR BANERJEE: If this is the case, why don't we stop it now. If we can't recover this, we'll come back after lunch and briefly – oh, it's back. Let's finish it.

MR. MARCH-LEUBA: So in some plants which don't have as much bypass capacity this cannot happen. And some plants, really most plants, the fuel water pumps are driven by the same steam that heats the fuel water. So that cannot happen either. Because at the same time you lose the fuel water heating capacity, you lose your fuel water pumping capacity.

So it's not a problem for everybody. But definitely was deemed unacceptable, and it was – we decided to deal with it generically.

It was dealt with through the emergency procedure guidelines. It was an extensive study by the industry, ACRS, the staff, everybody was involved. And it resulted in the ATWS study mitigation actions.

And those mitigation actions are included in the emergency procedure guidelines, which then get reflected into the emergency operating procedures in the plant. And every time we go to our control room on a plant simulator, I ask them to pull the emergency operating procedures. They pull those, and I see exactly where these mitigation efforts are.

The mitigation actions are several, but the most important ones is, there is an early boron injection, so that if oscillations develop, the boron goes in immediately. You don't wait until you start – before you had to wait until you were hitting the suppression pool before you could inject boron. And in this scenario you are not hitting the suppression pool.

So you start injecting the boron. But boron is too slow. It takes 20 to 30 minutes to actually work. The really thing that works is the immediate water level reduction. And you reduce the water level in the vessel to below the fuel water. And the fuel water with this cold water is injecting into the steam area of the vessel, and is splattering all over, and is doing two things.

First it is condensing the steam that is now going to the suppression pool maybe; and it is preheating the water that goes into the core.

MEMBER WALLIS: Is this something that can be very accurately predicted, this condensation, indirect contact?

MR. MARCH-LEUBA: There was review by better experts than me, and they claim that two feet was sufficient to preheat the fuel water.

And the argument was that the fuel water nozzle sprays against the core and splatters all over. So you have very fine bubbles. It's not –

CHAIR BANERJEE: Shroud.

MR. MARCH-LEUBA: Yeah, it's not a faucet coming down. It would never hit.

CHAIR BANERJEE: – that's spraying.

MR. MARCH-LEUBA: It was revealed by better people than me, and concluded that two feet was sufficient to preheat. I would want to see four or five, ten feet of steam.

So the EPGs now tell you you lower the water level at least two feet below the sparger and it typically ends up lowering more than that. All plans have a range of five or ten feet that they can control the water level. So you prevent the problem from occurring.

CHAIR BANERJEE: And how do they do that?

MR. MARCH-LEUBA: They lower the level. Because once you are in ATWS, you are now, the operator just controls manually at the control system. And he sets a control level.

If you are doing it will feed water, it's relatively easy. Because feed water has nice fine control. If you are doing it with SPCI it's almost more like a bang bang. If you go see an ATWS in the plant simulator, there's a full guy, full-time guy, doing the water level control. That's all he does.

MEMBER WALLIS: Does he wait until he gets oscillations? Or –

MR. MARCH-LEUBA: No, no, that's immediate. The moment there is an ATWS red light, they pull the charts, and the SRO tells him, lower the water level to a hundred and so.

CHAIR BANERJEE: Now why doesn't that conduct be automated? Is there a reason for that?

MR. MARCH-LEUBA: Because at this point you are not sure what systems are working in that. And you may have to realign valves to get water into the vessel. You are having a bad day and you cannot really rely on the control system to do it.

CHAIR BANERJEE: Can you rely on the operator to do it?

MR. MARCH-LEUBA: Better than the control system. Because you are, in this case, you don't know what happened. You have to realize what's happened. Also they will have to realign valves to get water from the suppression pool or from the condenser or from whatever it is available. What systems you have, you have SPCI, SPS? Is it sufficient with fuel water? Maybe I have only 20 percent fuel water, and we have to supplement it.

MEMBER WALLIS: Figuring out how to realign valves doesn't happen instantly, does it?

MR. MARCH-LEUBA: No, it doesn't.

CHAIR BANERJEE: So long before the operator –

MR. MARCH-LEUBA: The assumptions on the analysis were, it takes two minutes for them to do it. And you can here the oscillations grow, and then when the cooling start going down because the water was reduced, the oscillations are eliminated.

MEMBER WALLIS: So those are the oscillations on the top?

MR. MARCH-LEUBA: These are the

oscillations on the top for the first two minutes. This is two minutes.

MEMBER WALLIS: It's a log scale. Those are oscillations –

MR. MARCH-LEUBA: Oh, yeah, this is more than 1,000 percent.

MEMBER WALLIS: We still get 10 times.

MR. MARCH-LEUBA: Oh, yeah. Oh, yeah.

MEMBER WALLIS: But not for very long.

MR. MARCH-LEUBA: Right.

MEMBER WALLIS: It's an oscillation.

MR. MARCH-LEUBA: So we need to get them as fast as we can.

MEMBER WALLIS: Is that good enough to save the fuel?

MR. MARCH-LEUBA: No.

MEMBER WALLIS: No?

MR. MARCH-LEUBA: It may or may not. You cannot guarantee it. You cannot guarantee it.

In this particular case the temperature never reached 2,200. What has happened in the simulations, occasionally it's a peak like this one here, it is larger than the others.

MEMBER WALLIS: And a full strike is very capable of predicting these oscillations accurately?

MR. MARCH-LEUBA: No.

CHAIR BANERJEE: Not the evidence we saw. So this must be very recent then.

MR. MARCH-LEUBA: No, this is 1994. 1992.

CHAIR BANERJEE: Certainly TRAC-G doesn't do this today. I mean it has a lot of difficulty.

MR. MARCH-LEUBA: This is using what is called the stability normalization and stability numerics, explicit methods from the core, and finalization at the bottom of the core.

All cores do that. TRACE does this. Even TRACE does it.

MEMBER WALLIS: Even TRACE does it?

MR. MARCH-LEUBA: Yeah. Not very reliable, but it has done it. I mean we did run from MELLLA+. We did run some confirmatory calculations using TRACE.

MEMBER WALLIS: Since it's only an analysis that you are relying upon, it should be done independently by different codes.

MR. MARCH-LEUBA: This has been done independently by several codes, right.

MEMBER WALLIS: It would be interesting to see that.

MR. MARCH-LEUBA: Next slide. Okay, this

next slide shows that boron is effective, but it takes a long time. Now here, remember, with the water level reduction, at 150 we were already down. This continues, and it continues down here.

And finally at 300 to 500 seconds, boron started to bypass occilations. So boron is what eventually cancels everything. But it takes a long time. It takes 20 - 30 minutes to shut down the reactor.

The implication for extended fractal remains, we will see them next month. We do start transit with a high power to flow ratio. So everything is going to be even worse.

But the issue was – the question we had is, the mitigation actions, lowering the water level and boron injection, were good enough before. Has anything changed qualitatively to change the conclusions that mitigation actions are effective?

So we asked General Electric to re-run the same calculations. And when they lowered the water level with TRAC-G and injected boron early, they show that the oscillations are indeed reduced as effectively as before.

We have performed some efforts on the timing of operator actions. We have gone to the simulators, and seen what operators do during this ATWS stability events. And frankly, they are not stressed at all. It's a very calm – there is plenty of time to do what they are required to do.

CHAIR BANERJEE: Two minutes.

MR. MARCH-LEUBA: Two minutes is what we give them credit for on the TRAC-G analysis. In reality it happens in 20 seconds. Because they are ready for the transient; it's coming. But the transient in the real plant, you almost miss it if you are not looking for it.

MEMBER ABDEL-KHALIK: And they do that primarily by reducing feedwater flow?

MR. MARCH-LEUBA: Yeah, and in most plants feedwater cuts itself automatically, because you don't have a steam obstruction.

But what you see, whenever an ATWS is declared, is the SRO says, ATWS, he goes pulls his big charts, where he has all the flow assessments. It says, entering RC1. Lower the water level to level 120 inches. And he goes there and starts working on it.

In the meantime, he sends the other guy to ARI, say, start inserting alternate rod injection. And the other guy is working with alternate rod injection.

And he may have to call INC to bypass some things like MSID closure valve and things like that.

But it's fairly – I mean it really – I would recommend it to anybody that – if you ever get invited to one of these simulators, to walk through and see, it's not as bad as you will make it look like on PRA analysis. It really is fairly relaxed, very professional – very professional – and well trained people.

MEMBER WALLIS: So this ATWS stuff has nothing to do with this SRP that we are going to look at?

MR. MARCH-LEUBA: This is something I want to tell you, because ATWS stability was consulted. And one question we have for you is, we decided to put the stability with 15.8 ATWS instead of 15.9 stability.

So you will not see anything on 15.9, SRP 15.9 stability of ATWS stability. Because stability is always a long term solution. ATWS stability is solved with the emergency procedure guidelines, which belongs under ATWS. It's more logical to review under there. And that will be one of the questions we pose for you this afternoon.

MR. CARUSO: Staff does not plan to send us the ATWS SRP section for review. If you think we should do that, then I need to know that soon so that we can decide to review it.

Has that been issued yet, do you know? ATWS 3.8?

MR. DESAI: I think staff decided that ATWS, the ATWS acceptance criteria is like a current practice, and that's why it's not planned to send it to ICRS. But if you are interested, and go with all the changes, we would like to do that. It is completed. It is available.

CHAIR BANERJEE: Why don't we take up this issue after we have the 15.9 discussion. And then if we have time for discussion.

Right now, I think we have come to a logical sort of point to stop, then we will go and have lunch and then continue this after lunch. Is that good?

All right, so we will go out of session, and then come back at 20 to 2:00.

(Whereupon at 12:41 p.m. the proceeding in the above-entitled matter went off the record.)