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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

February 28, 2007

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This transcript has not been reviewed, corrected and edited and it may contain inaccuracies.

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UNITED STATES OF AMERICA

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

1 NRC STAFF PRESENT:
2 GREG CRANSTON
3 SAMUEL MIRANDA
4 TAI HUANG
5 ZENA ABDULLAHI
6 KULIN DESAI
7
8 ALSO PRESENT:
9 JOSE MARCH-LEUBA
10 ALLAN CHUNG
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C-O-N-T-E-N-T-S

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

1
2 CHAIR BANERJEE: The meeting will now
3 come to order.

INTRODUCTION

4
5 CHAIR BANERJEE: This is a meeting of
6 the Advisory Committee on Reactor Safeguard,
7 Subcommittee on Thermal Hydraulic Phenomena.

8 I am Sanjoy Banerjee, chairman of the
9 subcommittee.

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

13 The purpose of this meeting today is to
14 discuss the post staff revisions to the standard
15 review plan, Section 15, introduction, and Section
16 15.9, BWR Stability.

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

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

25 Ralph Caruso is the designated federal

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1 official for this meeting.

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

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

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

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

16 Now that's optional.

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

19 Mr. Cranston.

20 OPENING REMARKS

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

24 And I just want to introduce Sam
25 Miranda, the senior reactor system engineer, and

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1 senior technical reviewer for the reactor system
2 branch.

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

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

9 Sam.

10 SRP SECTION 15.0 - INTRODUCTION

11 MR. MIRANDA: Thank you.

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

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

23 But in this revision, the 2007 revision,
24 which is the first one since 1996, we have an
25 opportunity here to make some accounting for the new

1 reactor designs, and to add some content to this
2 introduction.

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

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

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

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

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

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

20 This is a chronology of some related
21 events to this section in the SRPs. And we begin in
22 1968 with the promulgation of 10 CFR 50 Part 34,
23 which talks about the SRP.

24 And it also indicates in that section, a
25 couple of paragraphs that appear also in the SRPs,

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1 which basically say that the SRPs are not law; that
2 they are guidelines, and licensees are free to
3 propose alternatives. That's in the regulations,
4 and it's also in the SRPs.

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

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

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

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

24 Condition two events were anticipated
25 operational occurrences. They were events defined

1 by the ANS as events that can occur during a
2 calendar year in plant operation.

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

6 And condition four events are the
7 limiting faults.

8 Then in '73 -

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

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

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

23 MEMBER WALLIS: If they're significant,
24 yes.

25 MR. MIRANDA: But the sufficiently broad

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

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

6 MR. MIRANDA: Yes.

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

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

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

17 MR. MIRANDA: Yes.

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

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

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1 guidance to reviewers.

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

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

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

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

19 And I introduce ATWS in here because one
20 of the changes we are going to make in the SRP, in
21 Chapter 15 especially, is that we want to separate
22 ATWS. ATWS has sort of bled into the other events,
23 and ATWS was really in a class by itself. The
24 history of ATWS is sort of intertwined with all of
25 these others. But ATWS is not an AOO per se; it has

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1 to have a common failure in the reactor protection
2 system - a very unlikely event. So it's outside the
3 design basis of the plant, and including it in
4 Chapter 15 with the design basis events seems a
5 little bit out of place.

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

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

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

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

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

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

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

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

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

23 MR. MIRANDA: Well, the design basis are
24 the accidents that can occur due to failures of
25 components or systems. And some of these failures

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1 are more likely than others.

2 So these accidents are broken down into
3 two categories.

4 MEMBER WALLIS: Well, ATWS isn't a
5 failure of the system - the scram system,
6 presumably.

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

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

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

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

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

25 MEMBER WALLIS: When did LOCA become a

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1 design basis event?

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

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

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

12 What's the basis for deciding that?

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

18 Why is that not a design basis?

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

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

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1 MR. MIRANDA: And it does.

2 MEMBER KRESS: It seems like doublespeak
3 to me.

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

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

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

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

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

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

22 The GDCs -

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

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

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1 that.

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

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

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

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

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

19 So you would design protection equipment
20 for the limiting accidents.

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

23 MR. MIRANDA: That's right. Right.

24 MEMBER WALLIS: But unless you covered
25 everything -

1 MR. MIRANDA: That's right.

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

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

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

13 MEMBER WALLIS: Is that a good thing?

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

17 ATWS is not in the design basis, and the
18 agreement was that therefore the mitigation systems
19 for ATWS need not necessarily -

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

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

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

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

5 MR. MIRANDA: The -

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

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

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

15 MEMBER WALLIS: Anything.

16 MR. MIRANDA: Anything?

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

19 MEMBER KRESS: Should there even be a
20 design basis?

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

24 MEMBER KRESS: The new framework talks
25 about licensing basis again, which in my mind is the

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1 same thing as design basis. They just changed the
2 name.

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

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

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

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

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

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

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

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

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

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

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

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

24 Okay now we get into the standards. The
25 AMS standard which defined those three classes of

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1 events, conditions two, three and four, was issued
2 in '73.

3 CHAIR BANERJEE: What did the standards
4 say about ATWS?

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

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

12 And that refers to the regulation 50.34
13 which mentions the SRP. It's kind of a circular
14 reference. One reference - each references the
15 other.

16 1982 is a landmark year in which plants
17 that are docketed after that, May 17th, 1982, are
18 expected to follow the guidelines of the SRPs.

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

25 And if after 10 years they have revised

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1 it or replaced it, then they withdraw it. And the
2 standards that are mentioned that were replaced in
3 '83 were withdrawn in 1998. They were reaffirmed in
4 1988.

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

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

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

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

25 And the NRC staff reviewed those

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

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

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

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

25 MEMBER WALLIS: That are likely to occur.

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

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

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

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

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

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

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

22 MEMBER WALLIS: Well -

23 MR. MIRANDA: That's in the regulations.

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

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

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

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

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

11 MEMBER WALLIS: What was used previously?

12 MR. MIRANDA: It was "shall."

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

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

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

24 MEMBER WALLIS: But the present
25 Westinghouse method uses some sort of 95/95

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1 probability, that is not a shall; that's with a high
2 probability. And that's what the ECCS rule says.
3 It doesn't say, shall. It says with a high
4 probability. If you look at the actual 10 CFR,
5 50.46, it says with a high probability. It doesn't
6 say shall.

7 There is something different there.

8 MR. MIRANDA: Okay.

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

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

17 CHAIR BANERJEE: So if you use the CSA
18 methodology, and the best estimates -

19 MEMBER KRESS: Then you have to go to 95.

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

24 I don't want to interrupt your train of
25 thought. You are leading us through the history

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1 which would be good. Then perhaps we can look at
2 some of these details.

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

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

10 MR. MIRANDA: Yes.

11 MEMBER WALLIS: It prohibits.

12 MR. MIRANDA: Yes.

13 MEMBER WALLIS: That's a "shall."

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

16 That criterion first appeared in the ANS
17 standard of 1973 -

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

21 MR. MIRANDA: That's right. That was in
22 the ANS standard for PWRs in '73. It was repeated
23 in the ANS standard for BWRs in '78. And it appears
24 in licensing submittals that rely on the condition
25 two, three and four event classification, and it was

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1 approved by the NRC staff, although the standard
2 itself wasn't endorsed.

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

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

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

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

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

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

24 MR. MIRANDA: I can see that. But ATWS
25 is already -

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

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

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

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

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

18 MR. MIRANDA: That's right.

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

23 Okay.

24 CHAIR BANERJEE: Does that have to be
25 demonstrative by the applicant, that in some that -

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

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

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

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

25 MEMBER WALLIS: How about combinations of

1 events? I mean the problem at TMI wasn't that the
2 POVR stuck open; the problem was that there were two
3 problems, and someone had left the valves closed on
4 the aux feed. So that when they lost the feedwater,
5 and asked for aux feed, it didn't come on.

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

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

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

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

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

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1 wrong. Two systems failed.

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

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

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

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

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

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

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

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

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

9 MEMBER WALLIS: That is the problem.

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

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

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

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

24 MEMBER KRESS: The PRA space is reality
25 as we know it. The design basis space is a sort of

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1 manufactured - they are not real accidents.

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

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

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

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

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

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

23 MEMBER KRESS: Well, the designers like
24 to have something to base their design on. And to
25 base it primarily on the PRAs may be a little

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1 tricky. Because then you have to be very careful
2 how you deal with the uncertainties.

3 Design basis space, there are no
4 uncertainties.

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

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

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

12 MEMBER WALLIS: But that someone would
13 leave -

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

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

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

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

22 MEMBER KRESS: Sure. That is a
23 probabilistic event.

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

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

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

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

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

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

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

21 CHAIR BANERJEE: Yeah, strictly.

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

24 CHAIR BANERJEE: If that's a fairly high
25 probability event, then that should have informed

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1 the design basis space.

2 MEMBER KRESS: You would think so.

3 CHAIR BANERJEE: Do you have an answer
4 for that?

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

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

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

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

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

23 MEMBER ABDEL-KHALIK: Back to the
24 requirement of prohibiting one class of accidents
25 from escalating to a higher class. Now if the plant

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1 is designed to handle the higher class event, what
2 difference does it make how that event started,
3 whether it started as a lower class event, or from
4 time zero it was a higher class event?

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

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

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

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

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

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

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

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

8 MR. MIRANDA: Well -

9 MEMBER WALLIS: You have to make the risk
10 of the major accident less than the risk -

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

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

18 MEMBER WALLIS: Okay.

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

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

25 MEMBER WALLIS: Well, that's what you

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1 think.

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

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

10 MEMBER KRESS: Sure.

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

14 MR. MIRANDA: It's a design criteria.

15 MEMBER WALLIS: Someone has decided it.

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

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

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

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

25 MR. MIRANDA: Well, actually, that

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

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

5 MR. MIRANDA: I think so, yes.

6 MEMBER KRESS: I didn't know that.

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

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

14 MR. MIRANDA: No.

15 MEMBER WALLIS: So it's just sort of
16 stated without any -

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

20 And getting back to your question -

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

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1 is much more uncertainty about both the frequency
2 and the consequence.

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

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

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

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

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

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

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

24 MR. CARUSO: Remember also how this
25 policy gets determined. The staff is proposing

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1 guidance, and it's coming to the technical committee
2 for its comments. You are going to CRGR with us?

3 MR. MIRANDA: No.

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

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

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

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

16 (Laughter)

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

19 MEMBER ABDEL-KHALIK: I guess if I go
20 back to the question I asked earlier about the
21 escalation requirement, my concern there is that by
22 putting this requirement, you are actually excluding
23 - possibly excluding a whole group of initiating
24 events that you are excluding from eventually
25 becoming design basis events just simply by the fact

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1 that they are part of the lower classification of
2 events.

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

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

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

24 In that case you have a small-break LOCA
25 with the same probability of occurrence as the

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1 original opening of the POVR. And now you have an
2 accident with serious consequences postulated to
3 occur fairly frequently.

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

8 MEMBER WALLIS: Okay, thank you.

9 CHAIR BANERJEE: That's been very useful.

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

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

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

21 MR. MIRANDA: I'll get to that.

22 MEMBER WALLIS: Okay.

23 MR. MIRANDA: So we are defining the two
24 categories, and we're separating out - we are not
25 changing anything in ATWS, but we are making the

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1 distinction that ATWS is a separate category.

2 We want to retain this -

3 MEMBER WALLIS: What does prohibit mean?

4 Do you mean by design you make it impossible to
5 happen. Or is it you prohibit it in design basis
6 space? Is it a physical thing you are prohibiting
7 or a regulatory thing?

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

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

20 MR. MIRANDA: Yeah, that's right.

21 MEMBER WALLIS: Hard to do with design.

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

25 MEMBER WALLIS: Then they only relieve

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

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

6 MEMBER WALLIS: They always work?

7 MR. MIRANDA: - they always work, yeah.

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

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

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

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

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

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

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

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

11 MEMBER KRESS: It's not an AOO.

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

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

16 MR. MIRANDA: Well -

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

20 MR. MIRANDA: This is true.

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

24 Every 10 years roughly there is a new
25 problem that arises, Bill Shack says that, that we

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1 haven't thought of, and we get a leak.

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

8 MEMBER KRESS: They are covered in the
9 other category.

10 MR. MIRANDA: They are.

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

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

18 MEMBER KRESS: Well, the frequencies are
19 implied.

20 CHAIR BANERJEE: They are implied, yes.

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

24 CHAIR BANERJEE: Perhaps we should
25 reexamine those in the light of experience and see

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1 what should be reclassified as AOOs. I mean we have
2 a lot of experience now.

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

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

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

15 The question is, what changed?

16 MEMBER WALLIS: They happened more often.

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

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

22 MR. MIRANDA: From a practical standpoint
23 probably very little. Because class three events
24 has always been an ambiguous. The criteria for
25 class three has been some level of fuel damage which

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1 was defined by offsite dose limits.

2 It was - events have always been class
3 two or class four. Class three has been very hard
4 to define.

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

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

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

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

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

25 MEMBER KRESS: If you want to impose new

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

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

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

9 MEMBER WALLIS: What was it before?

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

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

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

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

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1 dose calculations.

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

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

12 That could be - that's any single act of
13 failure. That could be another AOO. That could be
14 something that is not related to the original
15 accident.

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

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

23 For example it's a loophole. I can take
24 an accident, an AOO, and postulate a single act of
25 failure with it that has nothing to do with the

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1 accident; that doesn't aggravate the accident. But
2 now I've just relaxed my acceptance criteria.

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

5 MR. MIRANDA: Why have you done that?

6 CHAIR BANERJEE: That sounds like
7 gamesmanship.

8 MR. MIRANDA: Yes.

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

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

18 MEMBER KRESS: Would that be a single
19 failure?

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

22 MEMBER KRESS: Those are included in
23 single failures.

24 MR. MIRANDA: According to this language,
25 it says -

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

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

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

15 CHAIR BANERJEE: Has this actually ever
16 occurred?

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

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

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

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1 I have a more relaxed acceptance criteria.

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

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

7 MEMBER ABDEL-KHALIK: So your argument is
8 incorrect.

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

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

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

24 MEMBER KRESS: You have to design around
25 that.

1 MEMBER ABDEL-KHALIK: Correct.

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

4 MEMBER ABDEL-KHALIK: Absolutely.

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

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

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

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

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

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

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

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

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

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

25 And this is like -

1 MEMBER WALLIS: That's in PRA space
2 presumably.

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

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

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

20 I don't know what it means.

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

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

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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.

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

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

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

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

17 MEMBER WALLIS: There is no acceptance
18 criteria?

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

22 MEMBER WALLIS: Provided - that's the
23 only criteria.

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

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1 MEMBER WALLIS: Then presumably these
2 dose calculations have to meet the dose criteria.

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

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

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

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

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

21 MR. MIRANDA: Well, neither did I.

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

25 MEMBER KRESS: Risk space.

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

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

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

12 MR. MIRANDA: Well, at least since '96.
13 As a matter of fact -

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

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

21 I mean if you specified what the
22 radiological dose calculations of potential fuel
23 failures would be, you are attempting to limit that.
24 That could also provide some clarity, as Professor
25 Wallis said. You could just improve the language

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1 there so you would make it a little bit more
2 deterministic.

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

5 CHAIR BANERJEE: I don't know.

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

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

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

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

22 MEMBER WALLIS: And you clarify that too.

23 MR. MIRANDA: But then -

24 MEMBER ABDEL-KHALIK: Well, there is a
25 clear definition of - at least a part of the

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1 acceptance criteria. It is that the only failure as
2 far as fission product barriers would be just the
3 fuel cladding. The other two barriers would remain
4 intact. That's a clear acceptance criteria.

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

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

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

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

24 CHAIR BANERJEE: You are not maintaining
25 that last -

1 MR. CARUSO: Well, you're going from -
2 for ATWS you are going from two barriers to one
3 barrier. And if you look at pressure inside BWR
4 containments, I think they get pretty high in an
5 ATWS, don't they?

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

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

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

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

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

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

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1 Because you also said it's redundant, I think.

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

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

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

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

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

24 But generally they are limited to - you
25 know, they are set. They happen every year, and

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1 there are some that happen over a lifetime.

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

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

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

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

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

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

22 CHAIR BANERJEE: Right, but I mean the
23 combo.

24 MEMBER KRESS: The combo? Probably is
25 the same order as the LOCA. I don't know. You'd

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1 have to look at the PRA.

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

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

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

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

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

15 CHAIR BANERJEE: You want us to agree to
16 it?

17 MR. MIRANDA: Well -

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

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

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1 plug a hole.

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

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

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

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

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

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

23 MR. MIRANDA: That's why I said earlier
24 that I don't know what to do with this. When I see
25 analyses that come in with these combination events,

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1 I don't know what to do with them. I don't know how
2 to judge them. I don't have any acceptance
3 criteria.

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

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

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

11 CHAIR BANERJEE: That may be sufficient.

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

15 MR. MIRANDA: This comes from the current
16 1996 SRPs. I can get you a copy.

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

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

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

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

25 MR. MIRANDA: Of this language?

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1 CHAIR BANERJEE: No, of the SRP. I mean
2 we don't - it's going to - reading two SRPs and
3 comparing them is hard. So if you have a red line
4 version that would be a lot easier for us; edited
5 version.

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

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

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

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

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

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

23 MR. MIRANDA: 15.0?

24 MR. CARUSO: 15.0, yeah.

25 MEMBER WALLIS: Okay, well, if we've got

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1 to red line them, I'll provide it to the members.

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

5 MR. CARUSO: I have an old version of
6 15.0. I have the 1996 version, and I have the new
7 version that you are proposing. But I don't have a
8 comparison.

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

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

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

18 MR. MIRANDA: All right.

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

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

23 MEMBER WALLIS: Is that okay, Sanjoy?

24 CHAIR BANERJEE: Yes.

25 MEMBER WALLIS: There may be some more

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1 questions, too.

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

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

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

13 MR. CARUSO: Can I ask you a question?

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

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

24 The question itself has been considered
25 in the past in depth. There has always been this

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1 distinction between active and passive failures.
2 And I can't answer the question, because I don't
3 know whether the new reactor designs would change
4 that approach at all.

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

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

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

23 MEMBER WALLIS: Or is outside the tech
24 specs.

25 MR. MIRANDA: That's right. It's a

1 failure that will go undetected until you have gone
2 through your surveillance. And that way it would
3 not be any different from a diesel generator that's
4 in its 29th day on a 30-day surveillance schedule.

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

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

10 I didn't mean to stop. I think we
11 should -

12 MR. MIRANDA: I thought we were over
13 time.

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

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

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

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

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

25 Now this is a very philosophical policy

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1 issue. So perhaps, I don't know if we need to
2 debate this as part of this RP. It's a much larger
3 debate that you are talking about.

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

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

9 MEMBER WALLIS: I think we can flag it.

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

12 MEMBER WALLIS: We ought to discuss it.

13 CHAIR BANERJEE: All right.

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

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

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

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

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1 MR. MIRANDA: I haven't seen it written
2 anywhere except as I said in the passing reference
3 in a BWR standard -

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

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

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

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

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

16 MEMBER KRESS: It is implicit perhaps.

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

19 MEMBER WALLIS: Constant risk inference.

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

25 Those were derived from the current

1 regulations. They were trying to be consistent. So
2 it's implied in the regulations.

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

5 MEMBER KRESS: Yes.

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

13 CHAIR BANERJEE: And that is based on the
14 regulations.

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

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

19 MR. MIRANDA: Yes.

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

23 MEMBER WALLIS: I think it's something
24 that should be presented like this to the full
25 committee, and the full committee wants to say this

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1 is something we'll take up with new reactors or
2 something, then we can do that.

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

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

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

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

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

13 MEMBER WALLIS: We will take it from the
14 formal hydraulic -

15 CHAIR BANERJEE: I hope so.

16 All right.

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

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

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

23 MR. MIRANDA: Yes, that is their
24 language. The only thing it says, that we have on
25 this slide, is for new plants and any operating

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1 plants that choose to do so, we would use the two
2 categories of the GDC's appendix A, and for
3 operating plants that have submitted their analyses
4 according to the condition two, three and four event
5 scheme, you just continue to apply that system.

6 So there would be no back-fitting here.

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

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

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

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

22 MR. MIRANDA: No, there wasn't.

23 CHAIR BANERJEE: It was arbitrary?

24 MR. MIRANDA: I don't know if it was
25 arbitrary. I can tell you that there were other

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1 versions of standards from the ANS that appeared
2 after that that further talked about accident
3 categorization.

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

13 But that was never adopted.

14 CHAIR BANERJEE: Was there any reg guide
15 or anything?

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

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

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1 The reason is, if you had divided AOOs
2 into different frequency ranges, like a year or two
3 years or five years, 20 years, whatever, then you
4 could have different acceptance criteria for those,
5 to follow the principle of costs and risks.

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

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

16 CHAIR BANERJEE: I don't either.

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

20 MEMBER KRESS: If you retain --

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

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

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1 MR. MIRANDA: That's right, and that's
2 exactly what we wanted to do. What we are doing is,
3 we are folding the condition three events into
4 condition two, and condition two is an AOO. And
5 condition two does not allow for field failures.

6 MEMBER KRESS: So it adds some
7 conservatism.

8 MEMBER WALLIS: Correct.

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

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

15 Let's move on.

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

23 But the regulations, the GDCs, had only
24 the AOOs and the postulated accidents. And this
25 slide will show you that the infrequent events, the

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1 condition three, are going to have to meet the same
2 criteria as the AOOs.

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

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

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

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

17 MEMBER KRESS: And he has to use approved
18 calculations in their design, and they have to show
19 that their system will not lead to any fuel failure
20 -

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

25 An AOO could have a probability of 10 to

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1 the minus one per year, but the probabilities have
2 been developing into a postulated accident could be
3 another 10 to the minus five or something.

4 MR. MIRANDA: That's true.

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

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

13 MEMBER WALLIS: It's not as if -

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

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

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

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1 The same thing with fuel rods. If they
2 into DNB, they fail. The probability is one.

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

5 CHAIR BANERJEE: Yes. Let's move on.

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

11 MEMBER WALLIS: And you talked about that
12 one.

13 MR. MIRANDA: That is an open item.

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

18 MR. MIRANDA: Okay.

19 MEMBER WALLIS: Or can I ask questions?

20 MR. MIRANDA: Go ahead.

21 MEMBER WALLIS: All right.

22 At the top of the page, it says, lists
23 of basic criteria to meet the requirements of GDC
24 postulated accidents. And it lists them. It says,
25 pressure in the RCS should be maintained below -

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1 fuel clarity will be maintained. These are sort of
2 slightly different things, should be, will be and
3 shall be.

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

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

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

20 MEMBER WALLIS: This is for postulated
21 accidents.

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

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

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

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

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

11 MEMBER KRESS: Well, you know if you are
12 a reviewer, this is a review plan -

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

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

21 MEMBER KRESS: In terms of postulated
22 accidents -

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

25 MEMBER KRESS: If the analyst makes an

1 analysis of a postulated accident and it shows that
2 there is significant fuel damage, but it still meets
3 all the criteria, the reviewer must say, well, is
4 this acceptable or not? And I think what he's
5 saying is, even if there is fuel damage it could be
6 acceptable.

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

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

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

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

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

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

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1 okay for this accident.

2 MEMBER KRESS: That's what it says.

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

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

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

14 MR. CARUSO: Maybe it can be revised.

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

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

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

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

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1 CHAIR BANERJEE: I guess that is the
2 regulation.

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

5 CHAIR BANERJEE: Oh.

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

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

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

14 CHAIR BANERJEE: Clarify that.

15 MEMBER WALLIS: 10 CFR 50.46 says, with a
16 high probability -

17 CHAIR BANERJEE: I think you should
18 clarify that.

19 MEMBER WALLIS: It says with a high
20 probability.

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

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

25 MEMBER WALLIS: That needs to be fixed.

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1 And then - you're going to sort that
2 out? And then this statement, calculated changes in
3 core geometry shall be such that the core remains
4 amenable to cooling, really means nothing. TMI was
5 cooled. Anything can be cooled eventually.

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

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

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

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

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

17 MEMBER KRESS: It means you don't exceed
18 a certain energy, you don't exceed a certain
19 hydrogen generated, and you don't -

20 MEMBER WALLIS: That's different, because
21 -

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

24 MEMBER WALLIS: Because the core can
25 balloon and still not exceed 2,200. It could be at

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1 2,000 for a very long time, so other things
2 happening to it.

3 (Simultaneous voices)

4 MEMBER WALLIS: How do you interpret a
5 coolable geometry?

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

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

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

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

19 (Simultaneous voices)

20 MEMBER WALLIS: Doesn't it?

21 MEMBER KRESS: No.

22 MEMBER WALLIS: Amenable to cooling.

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

25 MEMBER WALLIS: Well, then you have to

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1 explain that in some way.

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

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

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

9 MEMBER WALLIS: Is it?

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

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

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

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

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

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

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

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1 captured.

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

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

9 MEMBER WALLIS: But the tubes, they all
10 buckle and -

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

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

17 MR. CARUSO: That could be considered,
18 yes.

19 MEMBER ABDEL-KHALIK: Boron
20 precipitation?

21 MR. CARUSO: Yes, it could be.

22 MEMBER WALLIS: Boron precipitation, yes.

23 MEMBER KRESS: That is exactly the sort
24 of thing that -

25 MEMBER WALLIS: What is your criterion to

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1 determine that it is coolable?

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

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

9 MEMBER ABDEL-KHALIK: No.

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

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

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

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

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

21 MR. MIRANDA: Yes, there is.

22 MS. ABDULLAHI: That would define more -

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

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1 MS. ABDULLAHI: No, but I think each
2 licensee, like Ralph pointed out, each fuel vendor
3 has to show how they meet those criteria, and they
4 define exactly how they meet coolable geometry, and
5 when that process, like Dr. Kress said, is approved,
6 then you have that criteria approved. And
7 subsequently every plant would have to meet that.

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

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

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

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

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

21 CHAIR BANERJEE: Is there anything else
22 we should know?

23 MR. MIRANDA: No, I believe that the
24 subcommittee had questions on what is sufficiently
25 broad spectrum of events, and the definition of a

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1 design basis, and questions regarding the LOCA
2 acceptance criteria, whether all those shelves
3 really belong there. And whether or not - I don't
4 know what to discuss about the constant risk
5 principle, but I will bring it up again so you can
6 debate that.

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

10 MR. MIRANDA: Thank you.

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

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

18 CHAIR BANERJEE: That was probably the
19 most significant issue.

20 Let me just look through my notes.

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

24 CHAIR BANERJEE: For example, that is
25 another issue that you might want to clarify what

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1 you mean by that.

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

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

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

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

14 MR. MIRANDA: Okay.

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

16 CHAIR BANERJEE: Okay.

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

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

21 MEMBER WALLIS: Is this a follow up also

22 -

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

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1 sections that have been reviewed.

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

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

7 CHAIR BANERJEE: Okay.

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

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

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

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

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

25 MR. CARUSO: We generate a letter, and I

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1 don't know what NRR is going to do with it. I guess
2 if it's a positive letter they will go forward with
3 it; if it's a negative letter, I don't know.

4 MEMBER WALLIS: They may suggest some
5 changes.

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

9 MR. CARUSO: By dealing with those
10 comments.

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

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

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

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

23 MEMBER KRESS: You think things get
24 better with age?

25 CHAIR BANERJEE: Only us.

1 Well, thanks very much. That was very
2 helpful.

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

5 MEMBER KRESS: Be back at 10 till?

6 CHAIR BANERJEE: Ten till.

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

12 CHAIR BANERJEE: So we are back in
13 session.

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

15 BWR STABILITY

16 INTRODUCTION AND REGULATORY PERSPECTIVE

17 MR. CRANSTON: This is Greg Cranston
18 again.

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

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1 DR. HUANG: Thank you.

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

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

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

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

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

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

24 And then we keep going for the spectrum
25 you know like the history, and the BWR events. And

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

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

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

16 And then keep going down the row to
17 1988. There is a generic letter, you know, like GE
18 Part 21, talking about MCPR might be - might be
19 violated if 10 percent APRM swing is used as a
20 criteria for manual scram.

21 Since then, after that, the La Salle
22 events, industry, very concentrated from this
23 issues. And then there is an industry effort. So
24 we, at that point, we have working on the NEDO
25 31960.

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1 This is a BW Owners' Group who come out
2 with the resolution on how to deal with BWR and the
3 Yucca instability issues.

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

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

11 And then they say, INPO, in 1994, there
12 is INPO report, SER 07-00, they try to get something
13 like a lessons learned from the instability events.

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

17 Then after that generic letter in '94-
18 02, all the industry BWR owners group, BW reactor
19 owners, they had some kind of options, the detail
20 we'll cover later.

21 And they already implement - some of
22 them are now implemented. And some increment - some
23 reactors, they implemented their system, and then
24 they have one assumption like a generic issue. And
25 then we, NRC as a result with this issue, and to

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1 come out with a resolution for the specific
2 guidelines. You are not going to use the generic
3 line slot to come out with set point.

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

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

12 DR. HUANG: Yes.

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

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

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

25 If you don't have a control, of course

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1 it create more unstable situations.

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

4 DR. HUANG: The trend would be, they
5 develop some kind of resolution from NRC and the
6 industry to come up with a group from ICA into that
7 -

8 MEMBER WALLIS: But do we need to have
9 more stringent controls -

10 DR. HUANG: Yes.

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

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

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

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

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

25 CHAIR BANERJEE: Option three is an ABS

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1 system?

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

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

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

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

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

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

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1 So if you flip over the next slide, you
2 see like before La Salle events, what's going on
3 there. And then after La Salle events, what's going
4 on there.

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

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

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

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

25 MEMBER WALLIS: There is no effort to

1 design away the instability. It seems to be
2 something you always have to live with. These
3 reactors cannot improve the design so the region of
4 instability shrinks?

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

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

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

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

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

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1 And the third development you'll see in
2 a few minutes, you will see why the --

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

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

9 And then after that La Salle, and then
10 keep going on to today -

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

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

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1 unacceptable thing.

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

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

14 So these two systems are ready for that,
15 expanding.

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

22 In the diagram later we show what a
23 domain is.

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

1 MR. MARCH-LEUBA: SRP 59 does deal with
2 ESBWR.

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

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

8 CHAIR BANERJEE: Hm?

9 MR. MARCH-LEUBA: My first slide.

10 BWR STABILITY
11 OVERVIEW OF STABILITY, REGULATORY ISSUES AND
12 LONG TERM SOLUTIONS

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

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

19 MR. MARCH-LEUBA: That is correct.

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

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

1 CHAIR BANERJEE: We asked for a fine
2 utilization calculation.

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

6 MEMBER WALLIS: You've been very
7 responsive.

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

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

13 MEMBER WALLIS: No artificial damping.

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

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

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1 So what we are doing here is just a
2 summary for your benefit. And this afternoon on the
3 second presentation we will talk about the SRP 15.9.

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

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

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

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

13 MEMBER KRESS: We'll talk faster than
14 usual.

15 MR. MARCH-LEUBA: I suspect, I'm hoping,
16 the SRP 15.9 is a lot more straightforward than the
17 15.0 this morning. And there won't be as many
18 questions. So we don't really need three hours for
19 the SRP.

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

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

25 CHAIR BANERJEE: Okay.

1 MEMBER WALLIS: You can't promise
2 anything, because we might ask thousands of
3 questions.

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

5 CHAIR BANERJEE: This is Said.

6 MR. MARCH-LEUBA: Said is well known.

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

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

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

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

24 But that was handled by the CPR
25 correlation. When we took over the stability, there

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1 are two modes that we see coming up. We see in BWRs
2 with experience that have cause, potential to
3 challenge the powers. And there are two. There are
4 the control system instabilities, and there are the
5 density wave instabilities.

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

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

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

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

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

23 MR. MARCH-LEUBA: Scram.

24 MEMBER WALLIS: You scram?

25 MR. MARCH-LEUBA: Yes.

1 MEMBER WALLIS: You shut down?

2 MR. MARCH-LEUBA: You shut down. That's
3 the only - back on the pre-La Salle event, the seal
4 380 allowed you to reverse the actions that got you
5 into that situation.

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

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

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

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

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

21 MEMBER WALLIS: - false indicators.

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

1 All right, so we are going to
2 concentrate on this density wave. The controller
3 system, the INC guys will fix, and the other
4 instabilities, we have not seen them for the last 50
5 years of power.

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

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

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

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

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

22 There are reactors in which this line is
23 completely outside of -

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

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1 MR. MARCH-LEUBA: Oh, yes. It moves to
2 the event. It was - occurred about here. It
3 scrambled. There was an instability. We have our
4 inspection team, and we analyze all possible
5 components of risk to the reactor.

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

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

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

1 MEMBER WALLIS: If you trip the pumps,
2 you follow down the -

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

5 MEMBER WALLIS: Go down there?

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

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

15 Now most reactors operate at what's
16 called the MELLLA or ELLA line. Which is - it goes
17 all the way to the 100 percent and 75 percent level.
18 So you were allowed to operate along this line at
19 100 percent power; have flow control to compensate
20 for all your burner.

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

24 MEMBER WALLIS: Are those approximately
25 lines of constant exit quality or something? Are

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1 they something like that?

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

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

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

9 MEMBER WALLIS: Which feeds back to the
10 reactivity.

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

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

25 What they have now, and the operator

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1 will tell you, we have now a DPU, is a flow crack.
2 They have only about roughly one percent flow that
3 they can control the burner. So they are constantly
4 moving control rods.

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

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

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

22 When you are not in the MELLLA+ corner,
23 you end up up here, way way inside the instability
24 domain. And the simulations show that if you are in
25 the MELLLA+, in a reactor today, operating below

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1 MELLLA, you have a 50-50 chance if you trip the pump
2 that it will be unstable.

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

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

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

11 CHAIR BANERJEE: Yes.

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

16 CHAIR BANERJEE: How do you do that?

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

19 MEMBER WALLIS: You pull the rod - push
20 in the rods.

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

25 He could not operate there on purpose.

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1 Now if he loses his pumps, and he moves there, he is
2 now out of tech space, and he is supposed to insert
3 rods and get out of there within 15 minutes.

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

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

9 MR. MARCH-LEUBA: He doesn't.

10 MEMBER WALLIS: He doesn't?

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

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

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

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

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

24 MEMBER WALLIS: Well, okay, similar.

25 MR. MARCH-LEUBA: Similar. And this

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1 comes from -

2 MEMBER WALLIS: - know where the
3 stability boundary is?

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

6 MEMBER WALLIS: - moves around. Is that
7 the very conservative one?

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

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

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

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

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

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

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

19 CHAIR BANERJEE: Do they know where they
20 are?

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

22 MEMBER WALLIS: There must be a cursor or
23 something.

24 MR. MARCH-LEUBA: Depending on which
25 display you are looking at. If you are looking at

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1 SPDS, safety parameter displace system, there will
2 be a crosshair, a crosshair on where you are.

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

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

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

15 CHAIR BANERJEE: Is the flow measure in
16 the -

17 MR. MARCH-LEUBA: Jet pumps.

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

20 MR. MARCH-LEUBA: In the jet pumps.

21 CHAIR BANERJEE: As well as the feed
22 water flows.

23 MR. MARCH-LEUBA: The only flow that is
24 measured is the drive flow, the circulation drive
25 flow. And then you have jet pump delta Ps, and you

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1 want to control them, and you will see 20 jet pump
2 delta Ps, and really it's the most prominent display
3 in the control room.

4 And then somewhere somebody makes an
5 estimation of what the core flow is. But there is
6 no -

7 MEMBER WALLIS: - plotted here. Wasn't
8 it plotted on the axis?

9 MR. MARCH-LEUBA: Oh, this is core flow.
10 And that is a correlation based on the drive flow.
11 So it is really - they measure the drive flow, and
12 they know how -

13 MEMBER WALLIS: Drive function?

14 MR. MARCH-LEUBA: There is circulation
15 drive flow in the jet pumps.

16 MEMBER WALLIS: What's actually drawn in
17 by the pumps?

18 MR. MARCH-LEUBA: Yes, that's what you
19 measure. And then they have a correlation that
20 says, when I have 100 percent drive flow, I get 100
21 percent core flow. When I have sealed drive flow, I
22 have about 30 percent drive flow. And that's what
23 is used.

24 CHAIR BANERJEE: And the thermal power is
25 estimated by the flow?

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1 MR. MARCH-LEUBA: Thermal power is a
2 balance of energy.

3 CHAIR BANERJEE: Sure. So do you have to
4 know the flow from the feedwater system?

5 MR. MARCH-LEUBA: Feedwater flow, steam
6 flow.

7 CHAIR BANERJEE: Steam flow is not that
8 secure.

9 MEMBER WALLIS: It's not done by
10 neutronics.

11 MR. MARCH-LEUBA: That's the APRM power,
12 and it's also displayed.

13 MEMBER WALLIS: But that's much quicker?
14 That's much better, isn't it?

15 MS. ABDULLAHI: There is a core
16 monitoring as well, system.

17 MR. MARCH-LEUBA: There is a whole other
18 measurements, okay.

19 CHAIR BANERJEE: But what is actually
20 displayed for that?

21 MR. MARCH-LEUBA: On an SPDS, typically,
22 is the thermal power.

23 MEMBER WALLIS: The thermal power.

24 CHAIR BANERJEE: That's an energy -

25 MEMBER WALLIS: It has a lag of a few

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1 seconds.

2 MR. MARCH-LEUBA: It's probably more like
3 10, 10 or 20, for - but SPDS is not a safety
4 display, right. All of their - depending on what
5 you want to do. For ATWS they always look at SPRM
6 power for example, for ATWS.

7 For - do you have several dimensions of
8 power, and they use the one that applies for the
9 particular - I'm not an expert in the field.

10 CHAIR BANERJEE: What about those two
11 lines?

12 MR. MARCH-LEUBA: Oh, these are what's
13 called the flow bias scram. This is called the APRM
14 simulator thermal power scram. When you are at 100
15 percent power, it is 100 percent power, which is 77
16 megapounds per hour in this plant, your scram is 118
17 percent.

18 Now as you move down in flow, you have a
19 flow balance scram. So if you hit 50 percent flow,
20 you will scram if your power hits 85.

21 MEMBER WALLIS: So really an instability
22 region.

23 MR. MARCH-LEUBA: It's way beyond that.
24 The blue line is the rod block, which you can think
25 of it as an alarm.

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1 CHAIR BANERJEE: What is the blue line
2 again?

3 MR. MARCH-LEUBA: It's the APRM, it's
4 called a rod block. It's an alarm. If you, for any
5 reason you position yourself here, the system does
6 not allow you to pull any control rods beyond there.
7 That is a rod block. And it also has another alarm.

8 On this, if we ever get to the long-term
9 solutions, there are two implementations of this
10 flow bias scram. One of them uses the thermal
11 power, or the simulated thermal power like this, in
12 which they take the APRM signal and they filter it
13 with a six-second time constant to simulate where
14 the heat flux coming onto the fuel cladding is.

15 Or they can have what's called an
16 unfilter (phonetic) flow bias scram, in which they
17 take the APRM signal by itself.

18 And as you see - because the six-second
19 constant on stability makes a big difference. If
20 you are here, and you have an oscillation, and you
21 are filtering with a six-second time constant, you
22 dump it.

23 So then the flow scram doesn't help you
24 for oscillations on the plants that have a simulated
25 thermal power flow bias scram.

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1 On the old plants that don't have the
2 STP, it helps you. You have to scram when the
3 oscillation hits doubling. And that's how the
4 plants call solution two are doing it, in option one
5 D. They actually rely on this red line to scram,
6 not on option three.

7 CHAIR BANERJEE: The red line is
8 established for all time. Is that a matter of the
9 state of core.

10 MR. MARCH-LEUBA: Sorry? The red line
11 defines your analyzed domain. You - when you do
12 your Chapter 15 analysis, you assume your scram when
13 you get there.

14 CHAIR BANERJEE: How is that established?
15 By analysis?

16 MR. MARCH-LEUBA: It's established - you
17 can think of it as arbitrarily. The plant sets up a
18 slope for this line. And then demonstrates that
19 that slope is sufficient to satisfy all your Chapter
20 15 analysis.

21 If it wasn't sufficient, they will go a
22 little lower, or they will change particulars, or do
23 something. So it typically mirrors the roll line,
24 and you can see that the smoke is a little flatter,
25 to accommodate variations on the real core line.

1 And it's just an arbitrary - has a coefficient.

2 And this shape that you see here is
3 because the scram is done on dry flow, again. And
4 you see here, the dry flow and you going into
5 another circulation.

6 So the scram line is really linear on
7 dry flow domain.

8 CHAIR BANERJEE: Why is the blue line
9 more sloped than that? Or is it parallel?

10 MR. MARCH-LEUBA: I think it's a
11 percentage. It's probably a percentage. That's why
12 they are getting closer here.

13 CHAIR BANERJEE: So that could explain
14 it.

15 MR. MARCH-LEUBA: Yeah, it's a
16 percentage.

17 So moving on, you do understand now why
18 we are concerned with MELLLA+ for stability. And
19 you understand now why we are not that concerned
20 with EPU for stability. Because the stability
21 happens here. So to get there, you have to lose
22 your circulation powers.

23 So by moving from this point to that
24 point, that's what EPU plants have done, you are
25 still on the same line, and you end up going on the

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1 same position. If you remember I gave you the
2 analogy with the onion, that you can model an onion
3 as a homogeneous sphere. As a homogeneous sphere,
4 EPU doesn't affect the stability at all. You start
5 peeling the onion and seeing all the details, you do
6 see that indeed it has some effects. Because to
7 make your plant go up there, you have to change all
8 your power distributions and your loading. And even
9 your fuel.

10 And therefore, it does have second order
11 effects, which in stability can be very important.

12 So again the presentation. And there
13 are three recognized instability models within
14 density wave. One of them is the channel mode, and
15 there are two core instabilities, the core one and
16 the regional.

17 And the channel instability is purely
18 thermodynamic. And this happens with only one
19 channel, it becomes thermodynamically unstable,
20 and the power remains constant.

21 And this is the stability that most
22 thermodynamic people are used to. This is just a
23 flow oscillation. And this happened twice. It
24 happened once in an Italian reactor in the '60s that
25 had a turbine flow meter on the outlet of the

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1 channel, and the turbine blocked, creating a big
2 pressure drop at the outlet of the channel that
3 caused this flow instability.

4 It happened the second time in Sweden
5 recently, 10 years ago, when a channel was not
6 properly seated. And there was a tremendous amount
7 of bypass flow. So the flow of that channel was
8 significantly reduced as opposed to the rest of the
9 core. And that channel stopped oscillating, and
10 they saw it on the LPRMs close by, and they saw the
11 oscillation, and they couldn't figure out where it
12 was coming from. And eventually they found out that
13 there was a channel with static flow.

14 CHAIR BANERJEE: Was this Fosmark
15 (phonetic)?

16 MR. MARCH-LEUBA: It was a Swedish plant.
17 I'm not sure which of them. I don't know the true
18 details.

19 And the core instabilities - so this is
20 purely thermohydraulic. The power is 100 percent
21 constant. And the core instabilities, now you have
22 a thermodynamic oscillation, so your void fraction
23 oscillating being referred also by the reactivity
24 feedback.

25 So you have now not only your

1 thermohydraulic but your power oscillating in phase.
2 And there are two models for that one. There is the
3 core-wide instability where you excite the
4 fundamental mode in neutronics, and all of the
5 channels are going up and down at the same time.
6 And this is regional, or I call it out-of-phase
7 instability mode in which you excited the second
8 model of the neutronics, and half of the core goes
9 up and half of the core goes down. So it's just
10 going side to side.

11 And sometimes this one may even precede,
12 because there are two installation models, one in
13 this direction, and one in this direction. And it
14 may sometimes, it jumps from this to 90 degrees
15 periodically. And it might even going forth some
16 people have seen helicoidal behavior.

17 Again, those two types of instabilities
18 have been observed. Typically 75 percent of the
19 instabilities are core-wide; 25 percent are out of
20 phase in history.

21 We have not had any out-of-phase
22 instability in the United States. I'm talking about
23 mostly European - okay, I'll move fast.

24 For those three modes of instability,
25 there are two ways in which you can approach the

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1 stability boundary. You can have a flow reduction,
2 or you can have a power increase. And they are
3 completely different.

4 Because when are having a power increase
5 going out this way, you put in control rods, and you
6 do that in a very controlled manner. So typically
7 when you have a step up instability like this, you
8 are putting control rods, you get a slightly inside
9 oscillation, and you have time to recover and insert
10 the control rod and get out. Because by long time
11 solutions you will not be allowed to do that,
12 because the protection system will take over.

13 But this type of instabilities are not
14 of great significance from a regulatory point of
15 view, because they are going to be small.

16 These type of instabilities, the flow
17 reduction stabilities, are significant, because when
18 you lose your pumps, you don't know where you are
19 going to end. And you end up way inside the crucial
20 region, and you end up with a very large
21 oscillation.

22 So those are the ones that you should
23 worry more, and we worry more, about.

24 There is a third type which is the time
25 in which you do the pump action. But the BWRs

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1 operate with pumps that have two speeds, slow speed
2 and fast speed. And in between they use a flow
3 control valve. And they are - there is some
4 mechanism that for NPSH considerations you always
5 start on the slow speed until you have power, and
6 then you have to go back and that was the cause of
7 WP-II. The speed of time, will move fast. D

8 Here is a list of all the instability
9 events. There was - the very early ones in the
10 states was in the Vermont Yankee. Which was
11 followed then by some tests in which they actually
12 pulled rods in a controlled manner, and they
13 actually made the reactor unstable again.

14 In between there was the Peach Bottom
15 test, where they were not unstable. It was a very,
16 very stable configuration.

17 The thing that started everything was La
18 Salle, which as I said before, it was really an ATWS
19 for the first three minutes until the reactor scram.
20 And it was a very large unpredictable oscillation.
21 It reached the high amplitude, 118 percent power.
22 So the oscillations - they were operating on roughly
23 50 - 60 percent power, and the oscillations reached
24 120. So fairly large amplitude oscillations.

25 CHAIR BANERJEE: What happened there?

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1 MR. MARCH-LEUBA: There was a fuel water
2 controller failure above that site. And that
3 reduced the water level in the vessel.

4 So it tripped the circulation pumps.
5 When it tripped the circulation pumps it got this
6 into the region, and everything started going.

7 CHAIR BANERJEE: Now if we go back, this
8 is an old plant, right?

9 MR. MARCH-LEUBA: 3 or 5.

10 CHAIR BANERJEE: So when it went down, if
11 you go back to that old figure, was it on the blue -
12 oh it was on that line?

13 MR. MARCH-LEUBA: Yes. It was on this.
14 I mean remember La Salle could have had the
15 stability.

16 CHAIR BANERJEE: So it wasn't on the
17 lowest line there. Okay.

18 MR. MARCH-LEUBA: Now you can plot the
19 lines of constant decay ratio by using some
20 assumptions, and they are all like this. So this is
21 decay ratio one, and then there will be decay ratio
22 point eight, point six, point four.

23 And on the other side you can plot the
24 lines of limit cycle amplitude. And so this will be
25 a limit cycle of zero, and this will be a limit

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1 cycle of 10 percent, 20 percent, 100 percent. So
2 you can think of it as, the more you get in there
3 the larger your limit cycle.

4 CHAIR BANERJEE: La Salle went into -

5 MR. MARCH-LEUBA: Way -

6 MEMBER WALLIS: Because it's not
7 exponential growth; there's a limit cycle.

8 MR. MARCH-LEUBA: Correct. There is a
9 limit cycle that protects the growth.

10 Now unfortunately it's not limited in
11 size. That's what we're seeing on the ATWS
12 stability. It gets to very large, 1000 percent
13 oscillation. Very large.

14 Okay. Instabilities, we did have the
15 WNP2 event. And since then at that point we were
16 already working on the long term solutions. After
17 the La Salle event, the staff said, operator action
18 - before La Salle, and as a consequence of Vermont
19 Yankee, we have the famous Seal 380 that Dr. Huang
20 talked about which said, basically, operators are
21 supposed to look at their PRM ratings. If they see
22 any upscale or downscale alarms, that's an
23 indication there is instability. If there is
24 instability, you do the reverse action that you got
25 you there. And if you cannot do that, you scram.

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1 That was Seal 380.

2 After La Salle we had what is called an
3 interim correction actions, which really reduced the
4 operator flexibility after an instability, and
5 mandated some immediate scrams for some conditions,
6 and started working on the long-term solutions.

7 So we have these two nomenclatures which
8 now are 20 years old, interim corrective action
9 versus long term solution. So the interims were
10 supposed to work while we were working on the long-
11 term solution.

12 So while we are working on the long term
13 solutions, there will be WP-2 instability was during
14 the startup, and we talked about that before. And
15 then we had a spell of 10 years with the LTS, long-
16 term solutions, implemented, and nothing happened.
17 Everything was really good. And we started having
18 9X9 fuel, 10X10 fuel, and then EPU, and all the
19 things that Dr. Wallis has mentioned.

20 And now we see a trend. I mean 2003 we
21 had Nine Mile Point, we had an instability. 2004 we
22 have very instability. Recently we had an event in
23 Brunswick which was not an instability, but we do
24 see a trend that all these crucial regions, or these
25 red lines, are moving to the right.

1 CHAIR BANERJEE: So the EPUs, you are on
2 the EPU line for all of these? So what line are you
3 on then?

4 MR. MARCH-LEUBA: The ELLA+. So it's the
5 EPU line, but you are in the same EPU line. So they
6 are operating back in the -

7 MR. BANERJEE: I see.

8 MR. MARCH-LEUBA: And I don't remember
9 where the -

10 CHAIR BANERJEE: So they are in an
11 extended operating range, right?

12 MR. MARCH-LEUBA: We have an expert to
13 help us.

14 CHAIR BANERJEE: It's okay.

15 MR. MARCH-LEUBA: But as we said, the EPU
16 has really not a major effect on the stability.

17 CHAIR BANERJEE: I realize that. You are
18 on that line.

19 MR. MARCH-LEUBA: In the meantime there
20 have been many, many events in foreign reactors. In
21 Spain there have been two, in Sweden there have been
22 a large number. In Germany they actually run
23 stability tests every cycle, and they actually mark
24 the red line for every cycle before a startup. So
25 they actually go unstable every time.

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1 We see this - the purpose of this slide
2 when I was writing it is to tell you that when you
3 look in the COLA (phonetic), when you look in the
4 control room, stability hits you in the eye. Every
5 single time we went to a power plant and we asked
6 them, every single operator knows about it. They
7 are aware of it.

8 CHAIR BANERJEE: What's the green
9 regions?

10 MR. MARCH-LEUBA: This is the - this is a
11 solution three plant. And the OPRM scram, the
12 solution three scram, is armed inside the green
13 region, and is not armed, so even if there is noise
14 in this area, it will not scram.

15 This is set conservatively at 60 percent
16 flow, arbitrary. Thorough analysis shows that we
17 have never seen stabilities at 60 percent flow.

18 What controls the stability, and we are
19 talking about an ATWS circulation, is really the
20 frequency of the oscillation is the most important
21 part of it. And the frequency of the oscillation is
22 controlled by the bubbles core. And as you move
23 down in flow, that's where you get lower
24 frequencies.

25 And the most important parameter you

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1 have to worry about instability, and that's why you
2 don't have instabilities at 100 percent power, at
3 100 percent flow, is the frequency.

4 If you were to match higher frequencies,
5 the fuel filters in an oscillation doesn't let it go
6 into thermohydraulics. The void fraction doesn't
7 see your power oscillations.

8 Next. So we said, following La Salle,
9 there was a large industry wide effort. We are
10 talking meetings, there were groups where there were
11 50 people from industry involved in every meeting.
12 And lots of back and forth between the industry and
13 the staff.

14 And the main concern was a concern with
15 the regional or out-of-phase instability mode, the
16 one that goes from left to right. Because the
17 protection system in most reactors averages APRMs
18 from the whole core. So the right side goes up, but
19 the left side goes down. And when you sum them all,
20 in theory you don't get anything.

21 So that's when GE says that if we do an
22 analysis and we wait for APRM to have a 10 percent
23 oscillation, the local channel is 200 percent, and
24 we are violating CPR. And there is a real
25 tremendous magnification on that.

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1 So that was APRM and said, we need to do
2 something about that.

3 And what we did in the meantime, we
4 issued interim corrective actions, and we worked on
5 the long-term solutions.

6 CHAIR BANERJEE: But operator who was
7 looking at the core thermal power to find where they
8 area would not see a big deviation from core thermal
9 power when this happened, right?

10 MR. MARCH-LEUBA: Oh, no, the thermal
11 power doesn't even oscillate.

12 CHAIR BANERJEE: You would see no
13 oscillation?

14 MR. MARCH-LEUBA: At this point the
15 operator would have two instrumentations. One of
16 them is a strip chart, which is paper copy with a
17 pen, that has the APRM time trace. And instead of
18 being a line, you will have a wiggle in a paper.

19 You will also have the LPRM upscale and
20 downscale alarms. Around every one of the control
21 rods you have the upscale and downscale alarms. So
22 if the APRM was oscillating it will have a red
23 light.

24 Unfortunately, if you have actually had
25 an APRM failure some time a week ago, that red light

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1 was already on, and it's locked. And until they fix
2 it, then that instrument was unavailable.

3 And the moment there is one red light in
4 the whole panel that was on, there would not have
5 been an audible alarm. So the other lights would be
6 coming on and off, but there wouldn't be any ding-
7 ding-ding to make you look at it. So it wasn't even
8 reliable, which is to say that it was unreliable.

9 When we decide to do long-term
10 solutions, we looked at the regulations. And we
11 will see that on the SRP. The main rule that we
12 have is the general number 12, which says in short
13 that oscillations are either not possible or can be
14 reliably detected and suppressed.

15 So on this point there was a split in
16 the BWR group. Some plants have already digital
17 protection systems, which they can implement as
18 solution three. Oil plants did not have a digital
19 protection system, and it would be very expensive to
20 implement a scram of this magnitude.

21 So there was a break. And there were
22 actually a lot of actions. Everybody chose their
23 own, and some actions were cheap, and they didn't
24 have to pay anything to develop it.

25 In general there are two types. There

1 is the prevention as CDC allows you. You say,
2 oscillations are not possible in my reactor. And
3 then the solution that detectors suppress. You
4 allow oscillations to occur, but if they happen they
5 will not violate anything.

6 And the preventive oscillations are
7 option - enhanced 1A and option 1D which basically
8 define a red area in the map where you are not
9 allowed to operate. And in the case of option 1A
10 it's enforced automatically by scram system. If you
11 get in there, you scram; that's it, you don't have
12 any option.

13 Option 1D has this famous flow bias
14 scram, which was not filtered, and therefore it has
15 some protection for core-wide oscillations. And
16 they were to demonstrate that they could not have
17 out-of-phase oscillations because of the
18 characteristics of the core.

19 And frankly, to do -

20 CHAIR BANERJEE: That's option two?

21 MR. MARCH-LEUBA: Option 1D.

22 CHAIR BANERJEE: Oh, 1D.

23 MR. MARCH-LEUBA: There are slides later
24 on that describe each one.

25 To do justice to this, this would have

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1 to be a semester class, and each of these slides
2 would be a lecture. So I'm going to give you a
3 headache by going this fast. But I'm giving you a
4 flavor of -

5 CHAIR BANERJEE: 1D in some way analyzes
6 out-of-phase oscillations.

7 MR. MARCH-LEUBA: 1D plants, they must
8 demonstrate by analysis that oscillations are
9 unlikely in the regional norm. And that happens
10 because you have a lot of separation between the
11 fundamental and the first harmonic, and you have a
12 tight inlet orifice which makes flow oscillators
13 more unlikely. And those two things tend to favor
14 the core-wide versus the regional model.

15 In addition you do have unfiltered flow
16 bias scram, so you do have protection against the
17 core-wide model solution. So those, I believe there
18 are three plants that satisfy this requirements, and
19 they refine a region of the map where they were not
20 allowed to operate, but they were allowed to do it
21 administratively. They didn't have to scram
22 immediately, because even inside their plant, inside
23 the region, they have protection. So they were off
24 really cheap and didn't have to do anything.

25 So we will go into all of them if we

1 talk real fast. The good thing about this -

2 CHAIR BANERJEE: Just give us a flavor.

3 MR. MARCH-LEUBA: Yes. Let me tell you,
4 the good thing about all these solutions is that
5 they are publicly available. They are owned by the
6 owners group, and anybody - anybody that wants to
7 use them, has to negotiate with the owners group.
8 If they didn't pay the fees to start with, they will
9 have to pay for the fees. But all these solutions
10 are available, and they can be implemented for SBWR,
11 for whatever.

12 Let me give a flavor. Option E1A is a
13 crucial region which has an immediate scram
14 component and it's automatic.

15 1D demonstrates that you would only have
16 core-wide instabilities; demonstrate that you have
17 protection against core-wide instabilities with a
18 flow bias scram; and that you will not - that's it.

19 Option II only applies to the BWR II
20 type, which is the very old plants. And those
21 plants, the APRM averaging was actually done in
22 quarters. Instead of being the whole core, the
23 APRM-A is only one quarter of the core. APRM-B is
24 the other quarter. C is the other quarter, and this
25 is a quarter.

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1 And therefore it does not prevent from
2 the instability, and they can demonstrate that they
3 have protection from both, core-wide and out-of-
4 phase.

5 And what they do is, they do similar to
6 option D. They have an area of the map where they
7 are not allowed to operate, but it's administrative.
8 And even if they get there, their scram protects
9 them.

10 Option three is the one that most plants
11 chose because it gives them the most operating
12 flexibility. You go anywhere you want. And we have
13 a detection system. If there is an instability we
14 will see it. And it will scram on it.

15 And that is what has - often it's called
16 the oscillation power range monitor, OPRM, which
17 created a new - you have the local power range
18 monitor, the average power range monitor, and then
19 the OPRM monitor, oscillation, that is now a range
20 around OPRM plus is to be able to detect these out-
21 of-phase instabilities.

22 Now recently we have been coming in to
23 the extended operating domains, and MELLLA+ in
24 particular, and through analysis we found out that
25 it is very difficult to make this old options to

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1 operate when your instabilities are so likely to
2 happen if it goes through pumps.

3 And indeed, what we saw with MELLLA+ is
4 that the oscillation happened even during the flow
5 run-back. Therefore the frequency oscillation is
6 changing, and the algorithm really doesn't have time
7 to catch up.

8 CHAIR BANERJEE: By analysis?

9 MR. MARCH-LEUBA: By analysis. By
10 analysis General Electric demonstrated that an
11 option three maybe would work, but it would require
12 very, very small cell points, and there would be too
13 susceptible to noise problems.

14 Therefore, they proposed the solution,
15 confirmation density oscillation.

16 The problem with this one is known as
17 the GE proprietary. The owners group didn't have
18 anything to do with it. It's owned by GE, and if
19 you want it you have to buy it from them.

20 It has been approved, and if we want to
21 see the details of this one, we will have to have a
22 closed session, because it is owned by GE.

23 Basic flavor which is not proprietary
24 is, like a solution three, but instead of requiring
25 two channels to oscillate, you know, to get a scram

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1 in a reactor you have to have train A and train B to
2 coincide, and both agree that it's a scram.

3 With confirmation density you require
4 now at leave five, maybe more, depending on how many
5 LPRMs are operating. There is a density of OPRMs
6 that agree there is an instability. And if all five
7 of them agree, you get a scram.

8 By doing that they are able to reduce
9 the scram cell points to essentially nothing, and be
10 able to deal with MELLLA+.

11 And there is a whole bunch of other
12 details which are proprietary.

13 Areva doesn't want to be behind, and
14 they have proposed an enhance of two three, which is
15 also proprietary. And that one is under staff
16 review.

17 And this one, they have some
18 understanding of what the issues are with this
19 process, and they are trying to solve it with a
20 combination of a crucial region and a scram. So
21 they will have a crucial region for a particular
22 model instability and a scram for the other.

23 And as I say, this is under review, and
24 we have issued a number of REIs, because we have
25 concerns about implementation.

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1 These are a list of other plans and
2 which options they chose.

3 CHAIR BANERJEE: Let me ask a naive
4 question. What are we supposed to review in this
5 MELLLA+ meeting that is being arranged?

6 MR. MARCH-LEUBA: For stability?

7 MR. CARUSO: No, remember, we're here
8 today to talk about -

9 CHAIR BANERJEE: SRP, right.

10 MR. CARUSO: - SRP. In the future you
11 are going to look at a topic report that relates to
12 MELLLA+. And another optical report that is related
13 to that, which involves GE analytical methods.

14 MR. MARCH-LEUBA: And at the same time we
15 will give you a full presentation on the DSS/CD.

16 MR. CARUSO: Oh, okay, that's when we're
17 going to hear - because there was some talk at some
18 point about coming to talk about DSS/CD.

19 MR. MARCH-LEUBA: It makes sense to do it
20 at that point.

21 CHAIR BANERJEE: And just to understand
22 the situation, that's going to happen in April,
23 sometime?

24 MR. CARUSO: What's the date I have
25 currently for that? I thought it was March 27-28.

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1 MS. ABDULLAHI: No, March 28th you would
2 get the methods, I guess. You should get it by
3 today from Projects.

4 The MELLLA+ itself will come a little
5 bit later.

6 MR. CARUSO: No, no, when were we going
7 to meet to talk about it?

8 MS. ABDULLAHI: Oh, the meeting of the
9 MELLLA+ method?

10 MR. CARUSO: Yes.

11 MS. ABDULLAHI: April 2nd to the 5th.

12 MR. CARUSO: That's it, okay, I'm sorry.

13 CHAIR BANERJEE: Three days?

14 MS. ABDULLAHI: Well, I think it's more
15 than three days -

16 MR. CARUSO: It's the week of the full
17 committee meeting. I believe it's the Monday and
18 Tuesday of the full committee meeting. And I didn't
19 recall that was in March or if that was in April.

20 MS. ABDULLAHI: I think it's in April,
21 April 2nd and 3rd.

22 MR. CARUSO: You said you will be coming
23 back from Washington, so you'll stop there for a
24 week.

25 CHAIR BANERJEE: Fine, go ahead.

1 MR. MARCH-LEUBA: Next, please.

2 Okay, I gave you the real flavor. Are
3 you interested in the details of the solutions? Or
4 just go through the -

5 CHAIR BANERJEE: I don't think we have
6 time. We are interested in the details. Right, so
7 tell us what you think we need to know.

8 MR. MARCH-LEUBA: E1A has a cycle-
9 specific Exclusion Region defined, where stabilities
10 are very likely - very unlikely to occur outside of
11 which - it uses very conservative generic
12 assumptions which are very well defined on an LTR
13 that has been reviewed by the staff. So anybody
14 that wants to do E1A they just have to read the LTR
15 and do the calculations that are prescribed there in
16 extreme detail that define a crucial region, modify
17 the protection systems so that if they get in there
18 they scram. And basically what they do is modify
19 the - remember that red line and blue line? They
20 modify that red line to cover this exclusion region.
21 So they have that scram with E1A.

22 It does have some different in there,
23 where there are some buffer regions, it's what's
24 called a detection algorithm, which is the next
25 slide. It will be the next other slide.

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1 At the time we didn't even know why the
2 regional model of instability occurred, much less
3 how to calculate it. There had been some rumors
4 that somebody had seen one in Europe, but that was
5 it. But that was back in the La Salle event. After
6 that many have occurred, and we have a much deeper
7 understanding of what happened.

8 But other time we didn't have a
9 calculation and tool that will tell us what the
10 decay ratio of the outer face mold is.

11 So that's what the so-called dog-bite
12 correlation, which is also called the core versus
13 external correlation, or the bypass correlation came
14 into play.

15 And what the owners group is - we will
16 know how to calculate core decay ratio. And they
17 plotted on this domain all of the events that had
18 occurred at the time with out of phase. And they
19 all happen to be in this area.

20 And the idea is that now that we know
21 what the regional stability is, regional
22 instabilities are mostly thermohydraulic, and so are
23 enforced by the neutronics, which means that channel
24 degradation tells you how thermohydraulically
25 unstable you are, so when you have a high channel

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1 decay ratio, and also some activity feedback with
2 the core, that's when you tend to get regional
3 instabilities.

4 And I would love to give you a two-hour
5 presentation on this, because I was the one that
6 discovered it.

7 But basically what we did is, we threw a
8 line that covered experimentally all of the events
9 that were known at the time. And this has become -
10 officially it's called the bypass acceptance
11 criteria. But really everybody calls it a dog bite,
12 because this is like somebody - a dog came here and
13 took a bite out of your map.

14 And what you do to calculate the crucial
15 region is you change the power and flow, and start
16 plotting core versus external decay ratio, one comes
17 here, comes here, comes here, comes there. And when
18 it crosses this line, that's the point where the red
19 exclusion region is drawn.

20 And if it goes through here, if that
21 sequence of points goes through here, you think it's
22 going to be an out-of-phase instability. If it goes
23 through here you think it's going to be a core-wide
24 instability.

25 Since then we have all of the cores now

1 can do the regional instability, and indeed, for
2 years BWR, we did not allow them to use this
3 correlation. But this is - it would be a back-fit
4 now to require everybody to do it the right way in a
5 sense. Because this is good enough.

6 CHAIR BANERJEE: Is it a correlation, or
7 is it a linear stability analysis?

8 MR. MARCH-LEUBA: This is a correlation,
9 this is an empirical correlation; 100 percent
10 empirical.

11 CHAIR BANERJEE: But it can't be
12 analyzed?

13 MR. MARCH-LEUBA: The decay ratio for
14 original model, yes, indeed it is analyzed now
15 regularly. All of the frequency domain calls, and
16 all of the good time domain calls calculate regional
17 model instability.

18 CHAIR BANERJEE: These are all linear
19 analyses?

20 MR. MARCH-LEUBA: The time domain calls
21 are nonlinear, but this is a linear instability.

22 Okay? So just so you know, in the SRP
23 it will say use of the bypass correlation is
24 acceptable. That's what we mean. It is a
25 historical thing. If we were not allowed to do it,

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1 it would be a back fit.

2 For new reactors like BWR, we don't
3 allow them to do it. We want them to it right.

4 But for other reactors, it's already
5 approved.

6 The other defense in that is that the
7 period based algorithm. And maybe we will spend all
8 of the time of your lunch doing this. But this is
9 how - solution three detects instabilities.

10 This is your power time trace, like
11 that. And it's looking for periodicity. And what
12 it's looking for is what what are called
13 confirmations, is the time it takes to go from a
14 minimum to a minimum, and from a maximum to a
15 maximum, is within the program.

16 So this is your first base period. And
17 then the second one is a first confirmation, because
18 the distance between peaks is the same as before
19 plus minus epsilon.

20 Then you have a second confirmation, and
21 a third confirmation, and a fourth confirmation. If
22 you get 10 confirmations, it's a variable depending
23 on which plant you are, then it says, your single is
24 periodic, you have an instability.

25 So that's why when you look at option

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1 three, people are talking about so many confirmation
2 counts. That's what it means; you have so many
3 confirmation counts.

4 To prevent problems there are some
5 safety features, like the T-min and t-max. You do
6 have - or we have a range of frequencies, of which
7 this oscillation is considered to be a density wave.

8 So we have an oscillation that is 10
9 Hertz. We know it is not a density wave.

10 So to have a confirmation the base
11 period has to be greater than T-min and less than T-
12 max, so that there are some parameters that you
13 have.

14 There is an Epsilon that allows you to
15 say there is a confirmation or not. And then there
16 is the number of confirmations.

17 And these are the parameters we talked
18 about before on Nine Mile Point 2. The plants have
19 an option based on their experience of how many
20 false positives they were getting to make this more
21 sensitive. And all the plants, guess what, they
22 have taken into the minimum sensitivity parameter
23 allowed by the OTR, and it was not sufficiently
24 sensitive. There was a Part 21, and some parameters
25 were tight enough.

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1 CHAIR BANERJEE: What's the time scale,
2 and the amplitude in rough terms?

3 MR. MARCH-LEUBA: The oscillations are
4 roughly two seconds from peak to peak, a half a
5 Hertz. And the amplitude at the time of the scram
6 would be a volume of 10 percent. There is a minimum
7 amplitude for solution three to scram. It's done at
8 this, the set point. When somebody tells you the
9 option three set point, it's how large the amplitude
10 needs to be. And on the order of 10 percent.

11 Typical noise which you have day-in and
12 day-out is about three percent. So three times
13 above noise.

14 CHAIR BANERJEE: These are then based on,
15 in option three, some averaging done?

16 MR. MARCH-LEUBA: The OPM averaging is
17 done by collecting a list eight LPRMs that are close
18 together, or in a corner of the core and then there
19 is another LPRM here and another LPRM here.

20 And any one from the A side of the
21 protected system has to say, yes, there is an
22 instability. And then you go to the B side, the B
23 chain, you know, fire protection and separation of
24 powers and all that.

25 CHAIR BANERJEE: It's a virtual OPRM. It

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1 depends on LPRMs.

2 MR. MARCH-LEUBA: Oh, it's an LPRM. It's
3 a sum of LPRMs. But they are averaged together to
4 represent the power in a core breach.

5 So issue one has something similar to
6 Option III, but it's only an alarm. So Enhanced 1A
7 we also have an alarm if it detects instability.
8 The operator then will have to make a decision.

9 We talk about Solution 1D, it has an
10 unstable region where you are not allowed to operate
11 unless you satisfy some conditions, and you
12 demonstrate that you have protection by analysis,
13 because you will not have an out-of-phase
14 instability. If you have an in-phase instability
15 your flow bias scram will defend it.

16 Option II plants, we talk about the
17 Option II plants, only applies to the quadrant-based
18 APRM scrams, which is the BWR-IIIs. These actually
19 again don't have to do anything. They don't have to
20 modify anything. They actually have protection, and
21 they just have demonstrate that they do have
22 protection, and every cycle they do that.

23 We look also at Solution III is based on

24 -

25 CHAIR BANERJEE: - by analysis, I

1 presume, codes which have been approved.

2 MR. MARCH-LEUBA: Correct. Correct.

3 CHAIR BANERJEE: Are these like best
4 estimate codes? Or what sort of codes are they?

5 I mean when you say by analysis.

6 MR. MARCH-LEUBA: It's like every other
7 scram system. You have to demonstrate that your
8 reactor set point value, you protect against CPR
9 violations or sample. But in particular CPR.

10 And that's when we go into what's called
11 a DIVOM correlation. And that will require our
12 displaying why. But basically what the industry
13 does with TRAC-G for General Electric for example,
14 approved code for DIVOM, or Framaton used their
15 approved - one of their remote alerts.

16 What they do is, they postulate
17 different oscillation amplitudes. And they
18 calculate a delta CPR versus an initial CPR.

19 CHAIR BANERJEE: This is steady state?

20 MR. MARCH-LEUBA: This is now - you
21 superimpose a sine wave on the -

22 mR. BANERJEE: But on a steady state
23 correlation?

24 MR. MARCH-LEUBA: On a steady state
25 correlation, correct.

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1 CHAIR BANERJEE: But the oscillation
2 period, it says about one second.

3 MR. MARCH-LEUBA: Two seconds.

4 CHAIR BANERJEE: Two seconds.

5 MR. MARCH-LEUBA: There are - in the
6 TRAC-G qualification report there are several
7 examples where it has been qualified for this type
8 of instability. Periodic dry-out and rewetting.
9 And it does a pretty good job. You would think it
10 wouldn't, but it does.

11 So basically they set up different
12 oscillation amplitudes, using the correlation for
13 GE. They calculated the CPR over ICPR, and plot the
14 cases. Here they are, and here are some No. 9 fuel
15 rolls, and 10X10 fuel rolls and different
16 conditions.

17 And they created what was called delta -
18 well, the DIVOM core. I don't know exactly what -
19 delta initial versus oscillation magnitude, I think.

20 And create this slope. Now with this
21 slope, then knowing what your scram set point is,
22 you know how large your amplitude is. Then you go
23 back and calculate how much CPR you lose for that
24 oscillation. And then that's how you demonstrate
25 that you have protection against that oscillation.

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1 I frankly have problems with this, and I
2 would love to explain why.

3 CHAIR BANERJEE: Well, let me ask you
4 something. The delta CPR, has it been actually
5 validated ever in terms of oscillating flows?

6 MR. MARCH-LEUBA: Well, the correlations
7 - and I'm not an expert on CPR correlations - but
8 what I've seen is that they go into a facility. And
9 the oscillate power in a sine wave. And you do get
10 periodic dry out and re-wets. And they go with
11 TRAC-G. And they simulated that, and they go into
12 dry out and re-wet at the same time or about the
13 same time. And about the same time - same power
14 level, and it does simulate the dry out and re-wet.

15 CHAIR BANERJEE: I'm saying, these were
16 experimentally validated.

17 MR. MARCH-LEUBA: That has been
18 experimentally validated. It's part of the
19 correlation or the Framaton correlation validation.
20 Both vendors have that.

21 DR. HUANG: I think we can move on for
22 the stability, how about that?

23 MR. MARCH-LEUBA: Sure. There were some,
24 particularly ones which you can read about, some
25 issues with implementation of Solution III.

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1 The implementation of Solution III -
2 I'll just move real fast out of there - took a long
3 time. I mean really, really long time; we're
4 talking about 10 years. Because everybody was
5 having problems, and as they were really collecting
6 information, they were finding more problems.

7 Now I can say, everybody is implemented.
8 We are all fine.

9 But there is argumentation why it took
10 so long. It is a very complex professional system.
11 It is very difficult. It is making noise analysis,
12 and then to scram on that. And it took that long
13 because it was that complex.

14 Now we are going into the operating
15 domains. We talked about that. The issue with the
16 operating domains when you are moving now from
17 MELLLA or from EPU to MELLLA+, if you lose your
18 pumps, you move farther inside into the stability
19 region. It makes it more unstable.

20 And indeed you become unstable on the
21 middle. There are issues with frequencies changing.
22 So there are new challenges. And because of that
23 the industry has responded with DSS/CD, and solution
24 III.

25 CHAIR BANERJEE: Don't run away from

1 DSS/CD. What is it?

2 MR. MARCH-LEUBA: DSS/CD is an Option III
3 in which the amplitude set point is removed. But it
4 is really - on the original -

5 CHAIR BANERJEE: It's a hair trigger
6 then.

7 MR. MARCH-LEUBA: It's a hair trigger.
8 But it requires a lot of OPRMs to agree. So if you
9 have one OPRM signal doing like that, it doesn't do
10 it.

11 During testing we found out that we
12 still need a small amplitude to protect against
13 noise fluctuations. And there was revision two of
14 the DDS/CD that allowed for a very small amplitude
15 set point.

16 CHAIR BANERJEE: Do they look for a
17 correlation coefficient? Or how do they actually
18 look and see that these are all saying the same
19 thing?

20 MR. MARCH-LEUBA: Oh, well, you have the
21 PVDR which I show you the figure of there. You have
22 ten confirmations of periodicity. But the OPRM on
23 this corner of the core has to live with the OPRM on
24 this corner of the core, and has to live with that
25 corner -

1 CHAIR BANERJEE: But is it a correlation
2 coefficient -

3 MR. MARCH-LEUBA: No, all of them have to
4 have a permissive. So OPRM I is scram. OPRM II is
5 scram. OPRM III is scram. And if enough of them
6 scram, it's a minimum of five, and depending on how
7 many -

8 MEMBER WALLIS: - where some of them
9 don't show a selection?

10 MR. MARCH-LEUBA: Well, the expectation
11 was that you would have this spurious noise
12 problems. We only happening one of them, but it was
13 happening in 10 of them.

14 MEMBER WALLIS: No, that's right. But
15 aren't there some modes of oscillation where some of
16 them don't show anything?

17 MR. MARCH-LEUBA: Correct.

18 MEMBER WALLIS: So how does the -

19 MR. MARCH-LEUBA: You still have enough
20 of the others.

21 MEMBER WALLIS: Have to have enough of
22 the others.

23 MR. MARCH-LEUBA: Right. You don't
24 really five when there are when there are 35 OPRMs.

25 MEMBER WALLIS: Okay. So I guess that's

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1 all right.

2 MR. MARCH-LEUBA: Yes.

3 MEMBER WALLIS: The whole question - I'm
4 listening to all your explanation here. We are
5 talking here about an SRP. Is the reviewer of all
6 this stuff knowledgeable enough to understand
7 whether or not this is good enough.

8 MR. MARCH-LEUBA: The reviewer is
9 knowledgeable enough to know, and the SRP tells you,
10 are they using a long term solution that has been
11 reviewed and approved by the staff.

12 MEMBER WALLIS: Okay. So there is a
13 check off, this has all been reviewed and -

14 MR. MARCH-LEUBA: Absolutely. Now for
15 new reactors, for new MELLEAs, then new NTTSR
16 requirements, then you need to have a reviewer that
17 is knowledgeable.

18 And Dr. Huang has been working on this
19 for 30 years. I've been working on it for 25.

20 DR. HUANG: This is detail on the desk
21 references in a lot of the stuff in there. So the
22 reviewer can go back to here and get that
23 information, get that paper, so they can reviewed
24 based on it.

25 CHAIR BANERJEE: Now how much of this

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1 review is - say I can see that non-ATWS stuff, TRAC-
2 G, has been approved, right. But for ATWS we've
3 never looked at even TRAC-G up to now.

4 MR. MARCH-LEUBA: No, actually TRAC-G has
5 been approved for ATWS stability.

6 CHAIR BANERJEE: It has been approved for
7 ATWS stability.

8 MR. MARCH-LEUBA: ATWS stability,
9 correct.

10 CHAIR BANERJEE: I didn't know that.

11 MR. MARCH-LEUBA: Yeah, it was the only
12 tool we have available to do it.

13 CHAIR BANERJEE: Because presumably it
14 came through ACRS at some point.

15 MR. MARCH-LEUBA: Oh, yes.

16 CHAIR BANERJEE: TRAC-G.

17 MR. MARCH-LEUBA: TRAC-G and all the ATWS
18 stability, we had lots of interaction with - we had
19 - it was not like this where we do the work and then
20 we tell you. We involved ACRS over many meetings
21 during development over a couple of years.

22 We had some meetings in San Francisco,
23 because most of the ACRS members work on the West
24 Coast.

25 CHAIR BANERJEE: This is going back how

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1 long?

2 MR. MARCH-LEUBA: Back to '92.

3 CHAIR BANERJEE: TRAC-G?

4 MR. MARCH-LEUBA: TRAC-G, yes.

5 MS. ABDULLAHI: This is Zena, I'd make a
6 little bit of a correction regulatorywise. At that
7 time it was acceptance of TRAC-G for use, but
8 licensing wise, approval of TRAC-G for instability
9 is the reason, quite recent.

10 CHAIR BANERJEE: But I didn't know that
11 it had been approved for ATWS.

12 MS. ABDULLAHI: That's a different story.
13 For instability per se, the 1980 - after the La
14 Salle period, I think we looked at it. And that's
15 when the ACRS and everybody in the industry was
16 involved. And at that point it was accepted for use
17 for instability only.

18 CHAIR BANERJEE: ATWS instability.

19 MS. ABDULLAHI: ATWS instability. But
20 right now it's not approved specifically for ATWS
21 instability. But GE has committed to come in I
22 think December, '07, and convert all their ATWS
23 analysis to TRAC-G.

24 CHAIR BANERJEE: They are still using
25 ODIN for ATWS.

1 MS. ABDULLAHI: That's a long story.
2 Yes, you will hear all of that when you do the
3 MELLLA+.

4 CHAIR BANERJEE: Well, the reason I'm
5 asking this is that I was at a meeting about two
6 years ago in San Jose, GE, and you were there too,
7 Professor Wallis. And the results we saw with TRAC-
8 G for ATWS were not comforting that the code was
9 doing anything useful at that time.

10 MEMBER WALLIS: It was probably more than
11 two years ago.

12 CHAIR BANERJEE: About three years ago.

13 MEMBER WALLIS: A long time ago.

14 MS. ABDULLAHI: Yes, I know what it was.

15 CHAIR BANERJEE: No, we have never seen
16 TRAC-G after that showing ATWS calculations.

17 MS. ABDULLAHI: Well, the MELLLA+
18 presentation would entail basically mostly
19 instability and ATWS instability, because these are
20 the predominant response that affects MELLLA+.

21 So in April that's what we will be
22 focusing on. But beyond acceptance of ATWS
23 instability at the time of the 1988 - '90 -

24 DR. HUANG: '92, 1992-94 time frame, that
25 staff has reviewed and approved at number 32007,

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1 along with the needle 32164. One is for the outer
2 loop issues, BWR co-thermal hydraulic stability.

3 The other one is BWR mitigation of BWR
4 co-thermal hydraulic instability in ATWS.

5 So they are '90, '92 and '94.

6 CHAIR BANERJEE: So then why does GE come
7 in to have it approved in December, TRAC-G?

8 MR. MARCH-LEUBA: Oh, they are waiting
9 for ATWS, not the one -

10 CHAIR BANERJEE: Yes, that's what I mean.

11 MR. MARCH-LEUBA: It's different. It
12 was approved - let's move into ATWS stability, and
13 you will know why it was approved.

14 CHAIR BANERJEE: Keep on going for 10
15 minutes more, 15 minutes.

16 MR. MARCH-LEUBA: There are many, many,
17 many different types of ATWS events, just like a
18 LOCA. Like ATWS instability. And when you put
19 those two names together, it gets a visceral
20 reaction from many people - ATWS stability - because
21 it's a really bad event.

22 It's a particular class of ATWS events
23 where the following has happened: the condensate is
24 available. So you can get very cold water from the
25 condenser. So then all that cold water is fed into

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1 the vessel.

2 And then because of that very cold water
3 is fed into the vessel, you could raise the power of
4 the core so much that extreme amplitude oscillations
5 are developed, and you don't have a scram.

6 And this oscillation we are talking
7 about, more than 1,000 percent. And they are large
8 enough that you do have all this periodic dry-out
9 and re-wetting. Whenever you see these
10 oscillations, you dry out and you don't re-wet. So
11 you just continue to heat them up, and cladding
12 failure occurs. You heat 2,200. So it's a really
13 bad event.

14 And the worst thing is -

15 MEMBER WALLIS: What sort of frequency
16 are these?

17 MR. MARCH-LEUBA: About every four
18 seconds, four or five seconds. It's supposed to be
19 every two seconds, but as they become linear, they
20 space out.

21 Once - what happens is, you have a peak
22 that is so large, that you get heat of such
23 temperature that it doesn't record. Even if you re-
24 wet it with cold water it doesn't re-wet.

25 The serious problem, the serious

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1 instabilities, is that it is not a full transient
2 evolution. So if the operator takes hands off in
3 some plants, that's exactly what will happen for
4 ATWS events.

5 So something needed to be done. And
6 this is one simulation from the Brookhaven analyzer
7 at the time of the La Salle event. La Salle
8 happened up to here. Here is where the scram
9 happened. And they predicted what would happen if
10 the scram had failed. And at the time nobody was
11 really aware of this notion that the most important
12 thing during ATWS instability certainly is what
13 happens with the balance of plant. Because what you
14 have is, you have your power train, and then this is
15 the relative power, increases a little bit. But
16 then as you start getting all the cold condenser
17 water, you start increasing the power of the core,
18 and you end up having an analyzed power of 80
19 percent, 90 percent. And these oscillations are
20 allowed to grow.

21 MEMBER WALLIS: It goes 1,000 percent.

22 MR. MARCH-LEUBA: That's the ATWS power.
23 The oscillations are measured on this side; they are
24 a factor of 12.

25 MEMBER WALLIS: Oh, that's relative.

1 That's 10 times -

2 MR. MARCH-LEUBA: That's 12 - 1,000 to
3 1,200 percent, very large oscillations. And one of
4 the peaks becomes so large that it just blows up the
5 fuel. I mean it mixes so hot that it cannot re-wet.

6 So the balance of plant modeling was
7 crucial for this event. And we have to credit the
8 Brookhaven guys, because at the time we were not
9 aware of it. It was a St. Louis engineer and a
10 plant engineer analyzer that we found out about
11 this.

12 The issue, and why this happens, is that
13 the fuel water heaters work with extraction steam
14 from the turbines. So when the turbine trips, you
15 don't have steam to heat up the fuel water. And the
16 fuel water keeps pumping water, but it's not heated.

17 So if you lose your turbine, you are
18 putting cold water in the core. So if you have a no
19 oscillation ATWS the - and the bypass, the turbine
20 bypass valve is fully open, you are sending all of
21 that steam to the condenser. You are not - have no
22 pressure. Nothing happening other than your average
23 power is going up and up and up, and your
24 oscillations are developing.

25 And that's when a very large sample to

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1 limit cycle occurs.

2 And if it is a default hands-off
3 sequence for some plants, and most plants don't do
4 this. La Salle does this. And that was the one we
5 were focusing on.

6 You require - so this is the sequence of
7 events. You have turbine trip. The bypass opens.
8 And somehow you send a scram signal to become an
9 ATWS.

10 So the scram fails, and you are in ATWS.
11 Because you are in ATWS, maybe an oscillation of the
12 water level like happened in La Salle, you have a
13 recirculation pump trip. You go into the red area.

14 The control system now stabilizes the
15 water level, and everything to the operator looks
16 normal. I have my containment open. All my heat is
17 going to the condenser. And they are still cooling
18 the core. Everything is fine.

19 But the power continues to rise because
20 of the cold water, and you start developing these
21 very large oscillations.

22 We can ignore this one. We talked about
23 MELLLA+ enough.

24 MEMBER WALLIS: What do you do about it?

25 MR. MARCH-LEUBA: First, let me tell you

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1 why some plants you don't have to worry about it.
2 Some plants like La Salle have 100 percent bypass
3 capacity for determining it.

4 MEMBER WALLIS: There's instability on
5 the computer.

6 MR. CARUSO: Well, we've lost our signal.
7 We've lost our screen here.

8 CHAIR BANERJEE: If this is the case, why
9 don't we stop it now. If we can't recover this,
10 we'll come back after lunch and briefly - oh, it's
11 back. Let's finish it.

12 MR. MARCH-LEUBA: So in some plants which
13 don't have as much bypass capacity this cannot
14 happen. And some plants, really most plants, the
15 fuel water pumps are driven by the same steam that
16 heats the fuel water. So that cannot happen either.
17 Because at the same time you lose the fuel water
18 heating capacity, you lose your fuel water pumping
19 capacity.

20 So it's not a problem for everybody.
21 But definitely was deemed unacceptable, and it was -
22 we decided to deal with it generically.

23 It was dealt with through the emergency
24 procedure guidelines. It was an extensive study by
25 the industry, ACRS, the staff, everybody was

1 involved. And it resulted in the ATWS study
2 mitigation actions.

3 And those mitigation actions are
4 included in the emergency procedure guidelines,
5 which then get reflected into the emergency
6 operating procedures in the plant. And every time
7 we go to our control room on a plant simulator, I
8 ask them to pull the emergency operating procedures.
9 They pull those, and I see exactly where these
10 mitigation efforts are.

11 The mitigation actions are several, but
12 the most important ones is, there is an early boron
13 injection, so that if oscillations develop, the
14 boron goes in immediately. You don't wait until you
15 start - before you had to wait until you were
16 hitting the suppression pool before you could inject
17 boron. And in this scenario you are not hitting the
18 suppression pool.

19 So you start injecting the boron. But
20 boron is too slow. It takes 20 to 30 minutes to
21 actually work. The really thing that works is the
22 immediate water level reduction. And you reduce the
23 water level in the vessel to below the fuel water.
24 And the fuel water with this cold water is injecting
25 into the steam area of the vessel, and is

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1 splattering all over, and is doing two things.
2 First it is condensing the steam that is now going
3 to the suppression pool maybe; and it is preheating
4 the water that goes into the core.

5 MEMBER WALLIS: Is this something that
6 can be very accurately predicted, this condensation,
7 indirect contact?

8 MR. MARCH-LEUBA: There was review by
9 better experts than me, and they claim that two feet
10 was sufficient to preheat the fuel water.

11 And the argument was that the fuel water
12 nozzle sprays against the core and splatters all
13 over. So you have very fine bubbles. It's not -

14 CHAIR BANERJEE: Shroud.

15 MR. MARCH-LEUBA: Yeah, it's not a faucet
16 coming down. It would never hit.

17 CHAIR BANERJEE: - that's spraying.

18 MR. MARCH-LEUBA: It was revealed by
19 better people than me, and concluded that two feet
20 was sufficient to preheat. I would want to see four
21 or five, ten feet of steam.

22 So the EPGs now tell you you lower the
23 water level at least two feet below the sparger and
24 it typically ends up lowering more than that. All
25 plans have a range of five or ten feet that they can

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1 control the water level. So you prevent the problem
2 from occurring.

3 CHAIR BANERJEE: And how do they do that?

4 MR. MARCH-LEUBA: They lower the level.
5 Because once you are in ATWS, you are now, the
6 operator just controls manually at the control
7 system. And he sets a control level.

8 If you are doing it will feed water,
9 it's relatively easy. Because feed water has nice
10 fine control. If you are doing it with SPCI it's
11 almost more like a bang bang. If you go see an ATWS
12 in the plant simulator, there's a full guy, full-
13 time guy, doing the water level control. That's all
14 he does.

15 MEMBER WALLIS: Does he wait until he
16 gets oscillations? Or -

17 MR. MARCH-LEUBA: No, no, that's
18 immediate. The moment there is an ATWS red light,
19 they pull the charts, and the SRO tells him, lower
20 the water level to a hundred and so.

21 CHAIR BANERJEE: Now why doesn't that
22 conduct be automated? Is there a reason for that?

23 MR. MARCH-LEUBA: Because at this point
24 you are not sure what systems are working in that.
25 And you may have to realign valves to get water into

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1 the vessel. You are having a bad day and you
2 cannot really rely on the control system to do it.

3 CHAIR BANERJEE: Can you rely on the
4 operator to do it?

5 MR. MARCH-LEUBA: Better than the control
6 system. Because you are, in this case, you don't
7 know what happened. You have to realize what's
8 happened. Also they will have to realign valves to
9 get water from the suppression pool or from the
10 condenser or from whatever it is available. What
11 systems you have, you have SPCI, SPS? Is it
12 sufficient with fuel water? Maybe I have only 20
13 percent fuel water, and we have to supplement it.

14 MEMBER WALLIS: Figuring out how to
15 realign valves doesn't happen instantly, does it?

16 MR. MARCH-LEUBA: No, it doesn't.

17 CHAIR BANERJEE: So long before the
18 operator -

19 MR. MARCH-LEUBA: The assumptions on the
20 analysis were, it takes two minutes for them to do
21 it. And you can here the oscillations grow, and
22 then when the cooling start going down because the
23 water was reduced, the oscillations are eliminated.

24 MEMBER WALLIS: So those are the
25 oscillations on the top?

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1 MR. MARCH-LEUBA: These are the
2 oscillations on the top for the first two minutes.
3 This is two minutes.

4 MEMBER WALLIS: It's a log scale. Those
5 are oscillations -

6 MR. MARCH-LEUBA: Oh, yeah, this is more
7 than 1,000 percent.

8 MEMBER WALLIS: We still get 10 times.

9 MR. MARCH-LEUBA: Oh, yeah. Oh, yeah.

10 MEMBER WALLIS: But not for very long.

11 MR. MARCH-LEUBA: Right.

12 MEMBER WALLIS: It's an oscillation.

13 MR. MARCH-LEUBA: So we need to get them
14 as fast as we can.

15 MEMBER WALLIS: Is that good enough to
16 save the fuel?

17 MR. MARCH-LEUBA: No.

18 MEMBER WALLIS: No?

19 MR. MARCH-LEUBA: It may or may not. You
20 cannot guarantee it. You cannot guarantee it.

21 In this particular case the temperature
22 never reached 2,200. What has happened in the
23 simulations, occasionally it's a peak like this one
24 here, it is larger than the others.

25 MEMBER WALLIS: And a full strike is very

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1 capable of predicting these oscillations accurately?

2 MR. MARCH-LEUBA: No.

3 CHAIR BANERJEE: Not the evidence we saw.

4 So this must be very recent then.

5 MR. MARCH-LEUBA: No, this is 1994. 1992.

6 CHAIR BANERJEE: Certainly TRAC-G doesn't
7 do this today. I mean it has a lot of difficulty.

8 MR. MARCH-LEUBA: This is using what is
9 called the stability normalization and stability
10 numerics, explicit methods from the core, and
11 finalization at the bottom of the core.

12 All cores do that. TRACE does this.
13 Even TRACE does it.

14 MEMBER WALLIS: Even TRACE does it?

15 MR. MARCH-LEUBA: Yeah. Not very
16 reliable, but it has done it. I mean we did run
17 from MELLLA+. We did run some confirmatory
18 calculations using TRACE.

19 MEMBER WALLIS: Since it's only an
20 analysis that you are relying upon, it should be
21 done independently by different codes.

22 MR. MARCH-LEUBA: This has been done
23 independently by several codes, right.

24 MEMBER WALLIS: It would be interesting
25 to see that.

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1 MR. MARCH-LEUBA: Next slide. Okay, this
2 next slide shows that boron is effective, but it
3 takes a long time. Now here, remember, with the
4 water level reduction, at 150 we were already down.
5 This continues, and it continues down here.

6 And finally at 300 to 500 seconds, boron
7 started to bypass oscillations. So boron is what
8 eventually cancels everything. But it takes a long
9 time. It takes 20 - 30 minutes to shut down the
10 reactor.

11 The implication for extended fractal
12 remains, we will see them next month. We do start
13 transit with a high power to flow ratio. So
14 everything is going to be even worse.

15 But the issue was - the question we had
16 is, the mitigation actions, lowering the water level
17 and boron injection, were good enough before. Has
18 anything changed qualitatively to change the
19 conclusions that mitigation actions are effective?

20 So we asked General Electric to re-run
21 the same calculations. And when they lowered the
22 water level with TRAC-G and injected boron early,
23 they show that the oscillations are indeed reduced
24 as effectively as before.

25 We have performed some efforts on the

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1 timing of operator actions. We have gone to the
2 simulators, and seen what operators do during this
3 ATWS stability events. And frankly, they are not
4 stressed at all. It's a very calm - there is plenty
5 of time to do what they are required to do.

6 CHAIR BANERJEE: Two minutes.

7 MR. MARCH-LEUBA: Two minutes is what we
8 give them credit for on the TRAC-G analysis. In
9 reality it happens in 20 seconds. Because they are
10 ready for the transient; it's coming. But the
11 transient in the real plant, you almost miss it if
12 you are not looking for it.

13 MEMBER ABDEL-KHALIK: And they do that
14 primarily by reducing feedwater flow?

15 MR. MARCH-LEUBA: Yeah, and in most
16 plants feedwater cuts itself automatically, because
17 you don't have a steam obstruction.

18 But what you see, whenever an ATWS is
19 declared, is the SRO says, ATWS, he goes pulls his
20 big charts, where he has all the flow assessments.
21 It says, entering RC1. Lower the water level to
22 level 120 inches. And he goes there and starts
23 working on it.

24 In the meantime, he sends the other guy
25 to ARI, say, start inserting alternate rod

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1 injection. And the other guy is working with
2 alternate rod injection.

3 And he may have to call INC to bypass
4 some things like MSID closure valve and things like
5 that.

6 But it's fairly - I mean it really - I
7 would recommend it to anybody that - if you ever get
8 invited to one of these simulators, to walk through
9 and see, it's not as bad as you will make it look
10 like on PRA analysis. It really is fairly relaxed,
11 very professional - very professional - and well
12 trained people.

13 MEMBER WALLIS: So this ATWS stuff has
14 nothing to do with this SRP that we are going to
15 look at?

16 MR. MARCH-LEUBA: This is something I
17 want to tell you, because ATWS stability was
18 consulted. And one question we have for you is, we
19 decided to put the stability with 15.8 ATWS instead
20 of 15.9 stability.

21 So you will not see anything on 15.9,
22 SRP 15.9 stability of ATWS stability. Because
23 stability is always a long term solution. ATWS
24 stability is solved with the emergency procedure
25 guidelines, which belongs under ATWS. It's more

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1 logical to review under there. And that will be one
2 of the questions we pose for you this afternoon.

3 MR. CARUSO: Staff does not plan to send
4 us the ATWS SRP section for review. If you think we
5 should do that, then I need to know that soon so
6 that we can decide to review it.

7 Has that been issued yet, do you know?
8 ATWS 3.8?

9 MR. DESAI: I think staff decided that
10 ATWS, the ATWS acceptance criteria is like a current
11 practice, and that's why it's not planned to send it
12 to ICRS. But if you are interested, and go with all
13 the changes, we would like to do that. It is
14 completed. It is available.

15 CHAIR BANERJEE: Why don't we take up
16 this issue after we have the 15.9 discussion. And
17 then if we have time for discussion.

18 Right now, I think we have come to a
19 logical sort of point to stop, then we will go and
20 have lunch and then continue this after lunch. Is
21 that good?

22 All right, so we will go out of session,
23 and then come back at 20 to 2:00.

24 (Whereupon at 12:41 p.m. the proceeding
25 in the above-entitled matter went off the record.)

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CERTIFICATE

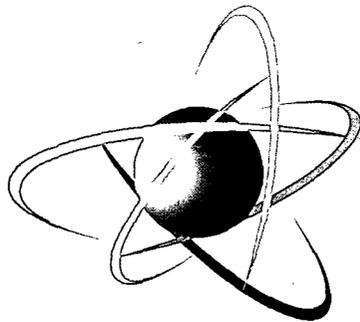
This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on
Reactor Safeguards
Thermal-Hydraulic Phenomena
Docket Number: n/a
Location: Rockville, MD

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



Charles Morrison
Official Reporter
Neal R. Gross & Co., Inc.



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Protecting People and the Environment

Standard Review Plan (SRP) 15.9 - Stability

Dr. Tai L. Huang (NRR/DSS/SRXB)

Dr. Jose March-Leuba (ORNL)

ACRS Subcommittee Meeting

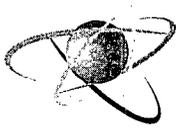
February 28, 2007



U.S.NRC Outline

UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

- Introduction and regulatory perspective
- High level Issues
 - SRP 15.9 is a new section that used to be covered under SRP 4.4 “TH Design”
 - ATWS/Stability is covered under 15.8 “ATWS”
 - Applicability of SRP 15.9 to new designs
- Detailed review of SRP



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Introduction and Regulatory Perspective

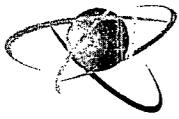
- SRP 15.9, Stability
 - New section of NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants”
 - Previously in SRP 4.4, “Thermal-Hydraulic Design”
 - Applicable to:
 - Operating plants
 - New plants
 - Extended operating domains



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Introduction and Regulatory Perspective (cont'd)

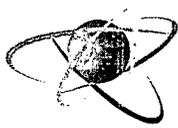
- Developed specific SRP 15.9 on Stability
 - Detect and suppress system has dedicated protection system function
 - Stability can have significant impact on operation (e.g., exclusion regions)
 - Specialized calculations required
 - Specific guidance provided for issues identified and resolved in operating reactors (e.g., Long Term Solutions)
 - Generic criteria that are applicable to all situations is provided



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Introduction and Regulatory Perspective (cont'd)

- ATWS/Stability
 - Covered under SRP 15.8, “ATWS”
 - Addressed by manual operator actions described in the emergency operating procedures (EOPs) which are reviewed under SRP 15.8



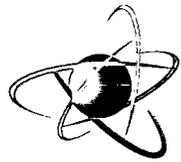
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SRP 15.9 Follows the Standard SRP Outline

- I. Areas of Review
- II. Acceptance Criteria
 - Requirements
 - Specific Criteria
 - Technical Rationale
- III. Review Procedures
- IV. Evaluation Findings
- V. Implementation
- VI. References



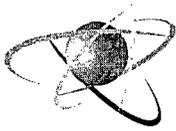
- Density-Wave instability mode
 - Core-Wide
 - Regional
 - Channel
- Other instability modes
 - Control system instabilities
 - Design-dependent modes (e.g. startup instabilities in passive BWR chimneys)



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SRP 15.9 Acceptance Criteria

- GDC 12 requires that oscillations be either
 - not possible, or
 - reliably and readily detected and suppressed
- “The reactor core and associated coolant, control, and protection systems shall be designed to assure that power oscillations which can result in conditions exceeding specified acceptable fuel design limits are not possible or can be reliably and readily detected and suppressed.”



SRP 15.9 Acceptance Criteria

(cont'd)

- GDC 10 requires that SAFDLs are not exceeded even if oscillations develop
- Other applicable GDCs
 - GDC 13 “I&C”
 - GDC 20 “Protection System Functions”
 - GDC 29, “Protection against AOOs”
- Generic Letter 94-02, “Long-Term Solutions and Upgrade of Interim Operating Recommendations for Thermal-Hydraulic Instabilities in BWRs,” requires all reactors to implement a stability Long Term Solution (LTS)



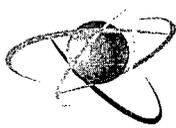
SRP 15.9 Implementation Options

- Currently approved Long-Term Solutions are:
 - Enhanced I-A
 - Option I-D
 - Option II
 - Option III (ABB + GE hardware implementation)
 - Detect and Suppress Solutions/Confirmation Density Algorithm (DSS/CD) - approved for Maximum Extended Load Line Limit Analysis Plus (MELLLA+)
- Under staff review: Enhanced Option III



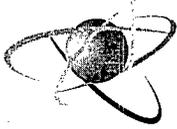
SRP 15.9 Specific Acceptance Criteria

1. Oscillations are not possible
2. Or can be Detected and Suppressed
3. A number of LTS are available
4. Stability is defined as
 - A. Calculated decay ratio $< (1 - \sigma)$
[σ = methodology uncertainty]
 - B. Use an approved correlation (e.g. core-channel decay ratio acceptance criteria)
5. New LTS may be based on Exclusion Region
6. New LTS may be based on Detect & Suppress



SRP 15.9 Specific Acceptance Criteria (cont'd)

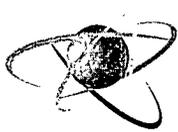
7. For D&S Solutions, DIVOM is acceptable
8. New LTS must have a backup (<120 days)
9. States criteria for new LTS
 - A. Protect SFADL
 - B. Demonstrated by analysis
 - C. Provide a backup
 - D. Provide generic tech specs
10. LTS instrumentation must satisfy GDC 13
11. Other instability modes that don't violate SAFDLs are acceptable



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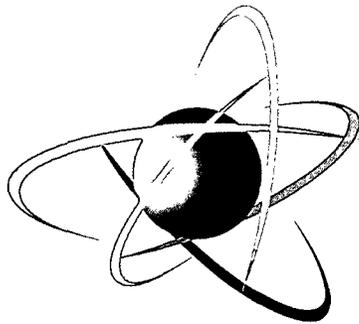
SRP 15.9 Review Procedures

- Reviewer verifies that
 - Long-Term Solution is installed
 - Design is free from non-density-wave instabilities that may compromise SAFDLs
 - All methodologies used are approved
 - Tech Specs satisfy criteria
- Reviewer evaluates the need for confirmatory calculations



SRP 15.9 Summary

- The staff concludes that
 - SRP 15.9 provides adequate guidance and criteria on long term solutions for
 - Operating reactors
 - New reactors
 - Future design changes
 - Operating domain changes
 - ATWS/Stability is properly covered under 15.8



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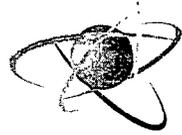
BWR Stability

Dr. Tai L. Huang (NRR/DSS/SRXB)

Dr. Jose March-Leuba (ORNL)

ACRS Subcommittee Meeting

February 28, 2007

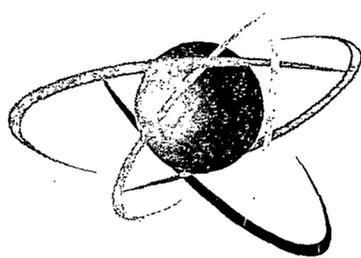


U.S. NRC Presentation Outline

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Protecting People and the Environment

- Introduction and Regulatory Perspective
- Stability Overview, Events, and Regulatory Implementation
- ATWS/Stability

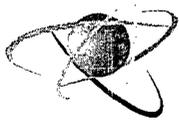


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Protecting People and the Environment

Introduction and Regulatory Perspective



U.S. NRC Introduction

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- BWR Stability
 - Has potential of violating Specified Acceptable Fuel Design Limits (SAFDLs)
 - Affects day to day operation of BWRs
- Regulatory requirements based on 10CFR50, Appendix A, General Design Criteria
 - GDC 10: Reactor designed such that fuel design limits are not exceeded during normal, abnormal, and Anticipated Operational Occurrences (AOOs)
 - GDC 12: Power oscillations either not possible OR reliably and readily detected and suppressed



Regulatory History & BWR Events

• VY Event/Test + PB tests

• GL 86-02 (GESIL 380 operating limitations for detection & suppression are acceptable to demonstrate compliance w/ GDC 10 & 12)

• LaSalle Event: IN 88-39

• NRC Bulletin 88-07 (Required plants w/o auto trip capability to manually scram if dual recirc pump trip occurs)

• GE Part 21 1988 (MCPR might be violated if 10% APRM swing is used as criteria for manual scram)

• NEDO 31960 (1991-93)

• WNP-2 Event: IN 92-74 (Columbia)

• GL 94-02 (Req'd Long term sol'n)

• INPO SER 07-00

• GE Part 21 - DIVOM

• Plant-Specific DIVOM Guidelines

• NMP-2 Event 2003

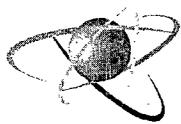
• LTS-III Parameter Settings Insensitive

• Perry Event 2004



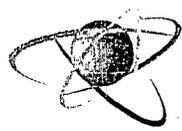
The Industry and Regulatory Position Has Evolved

- Before LaSalle event
 - SIL-380 required operators to identify instabilities and mitigate them manually
- After LaSalle event
 - GE issued Part 21 indicating that small Average Power Range Monitor (APRM) oscillations could result in SAFDL violations
 - APRM instrumentation averages out regional mode oscillations
- Large industry effort resulted in the Boiling Water Reactor Owners Group (BWROG) Long Term Solutions (LTS)



The Industry and Regulatory Position Has Evolved (cont'd)

- LTS are now fully implemented and armed at all BWRs
 - Long testing process
 - Complicated by
 - Methodology and parameter setting issues identified on two Part 21's
 - False positives due to system noise levels
- NRC staff closely follows implementation of stability solutions
 - Technical specifications reviews
 - Several plant audits
 - Confirmation of operator training on plant simulators
- Staff conducted a number of plant decay ratio measurements as introduction of new fuels and changes in operating strategy require it



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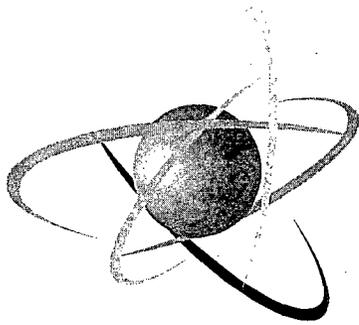
The Industry and Regulatory Position Has Evolved (cont'd)

- After LaSalle, Anticipated Transient Without Scram (ATWS)/Stability identified as a significant concern
 - Resolved by the Emergency Procedure Guidelines (EPG) ATWS Mitigation Actions
- Expanded operating domains (e.g., Maximum Extended Load Line Limits-Plus (MELLLA+) operation) pose new stability challenges
 - Industry has proposed enhanced LTS's
 - Detect & Suppress Solution/Confirmation Density Algorithm (DSS/CD)– GE (approved)
 - Enhanced Operation III (EO3) – Areva (under review)



Regulatory Perspective - Summary

- The industry and staff recognize the relevance of stability for safe BWR operation
- Positions and solutions have evolved as
 - More information becomes available
 - Design/operating changes
 - More aggressive cores and fuels
 - Expanded operating domains

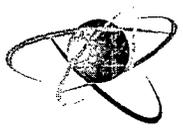


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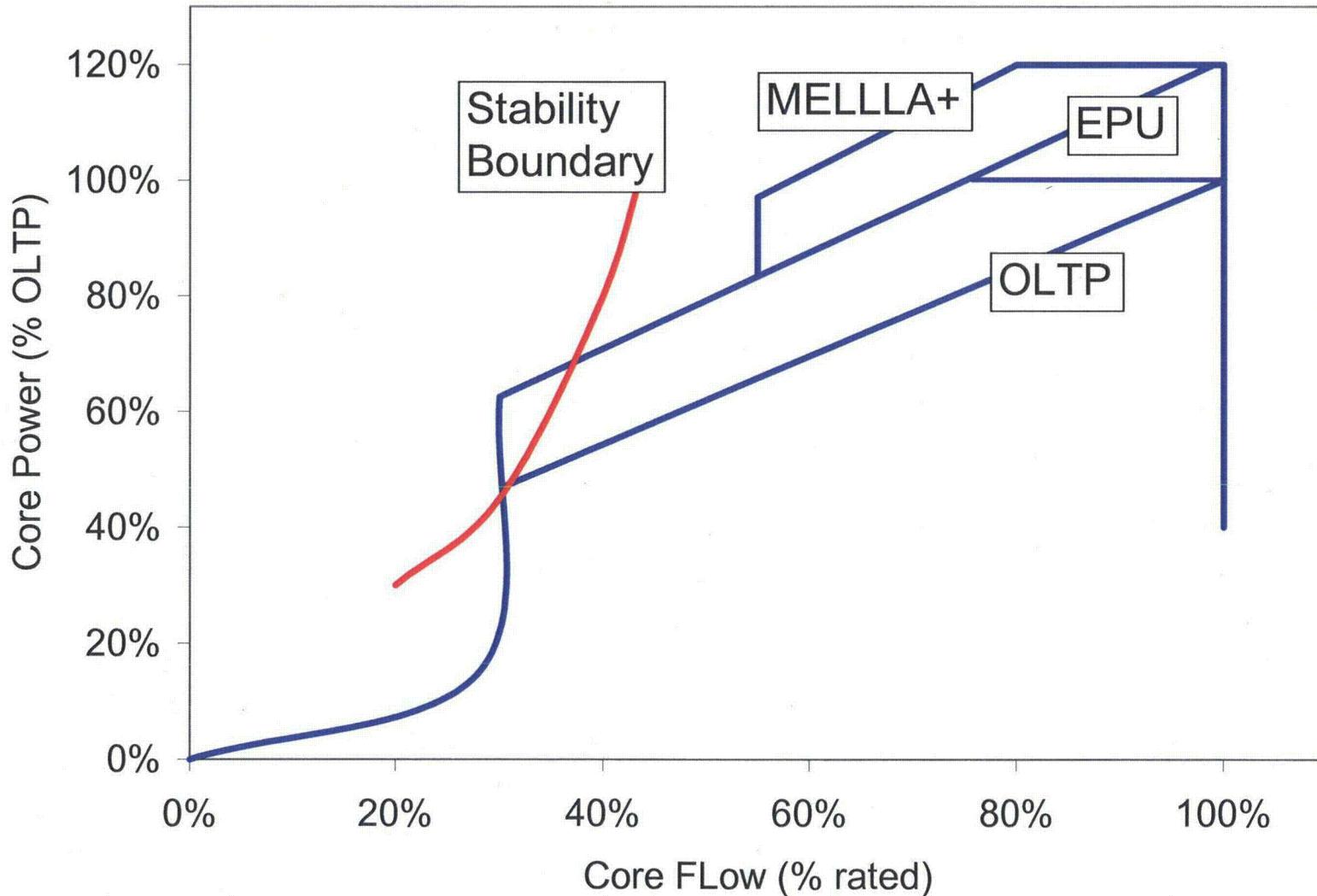
Stability Overview, Events, and Regulatory Implementation

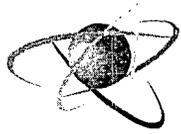


Instability Modes

- On operating BWRs, two instability modes have potential to challenge SAFDLs at power
 - Control system instabilities
 - Density wave instabilities
- Control system instabilities are handled by plant I&C maintenance
- Density wave instabilities are detected and suppressed by the Long Term Solutions (LTS)

Density Wave Instability is a Low-Flow High-Power Event

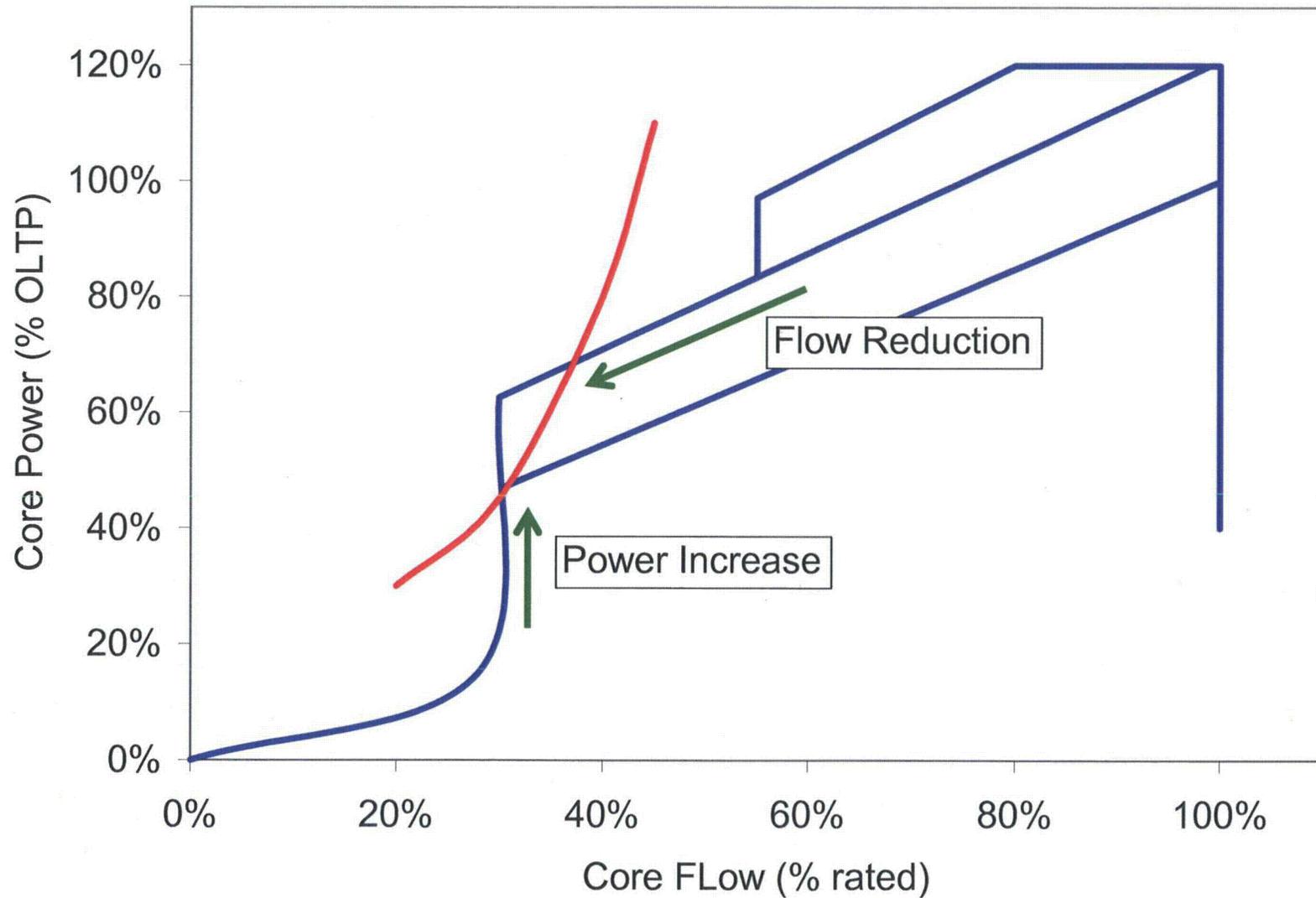




Three Modes of Density Wave Instability

- “Channel” instability: A single channel flow oscillates, but total core reactivity does not change significantly
- “Core” instability: Coupled neutronic-thermal-hydraulics oscillations
 - Core-wide instability
 - Regional instability (out-of-phase)
- All three modes have been observed

Two Types of Instability Events





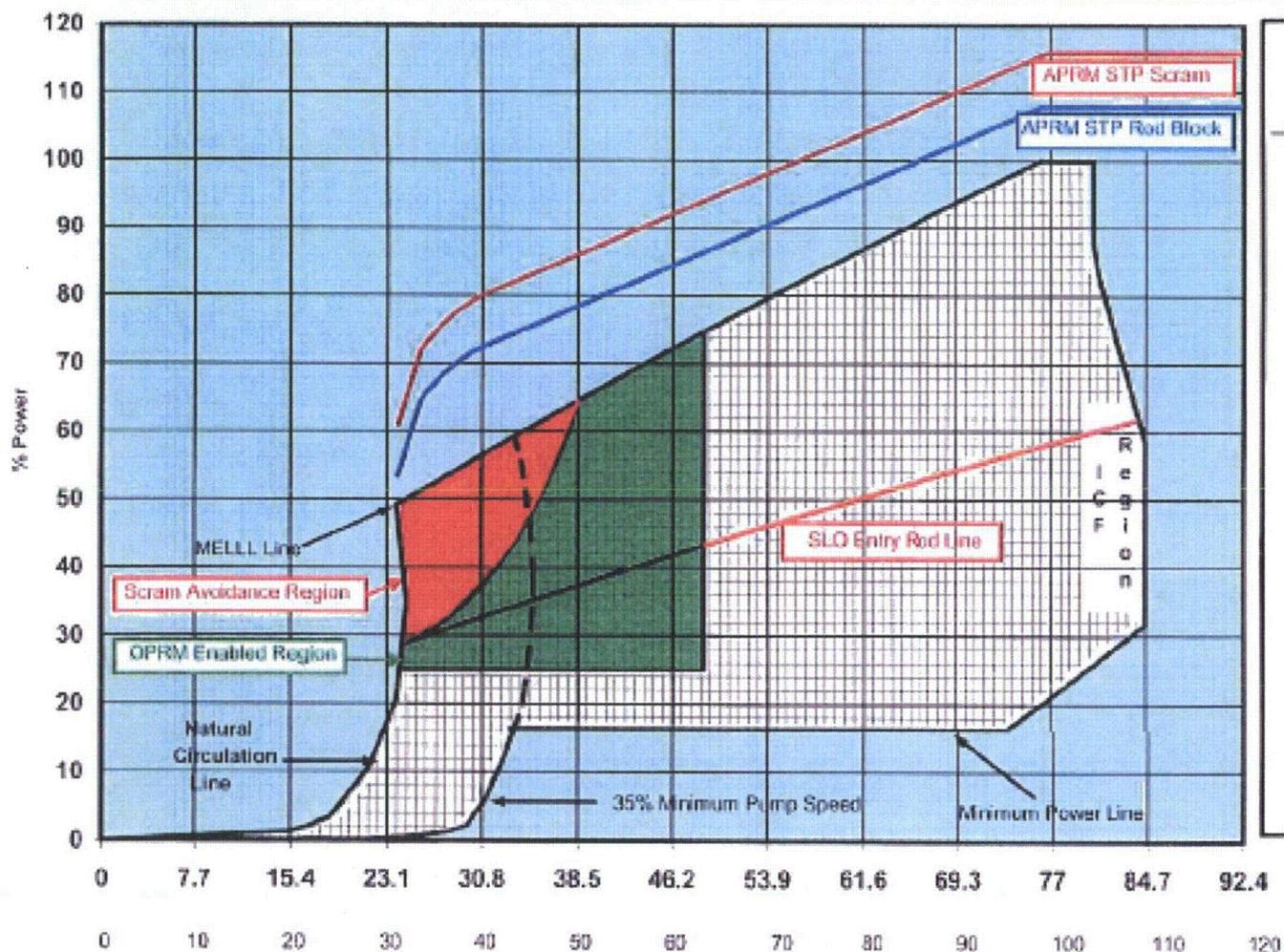
U.S. BWRs Have Experienced Six Instability Events

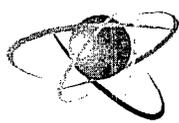
- Vermont Yankee (70's)
- Vermont Yankee Tests (Early 80's)
- LaSalle (1988)
- Columbia Cycle 8 (WNP2 1992)
- Nine Mile Point 2 (2003)
- Perry (04)

- Many events have been experienced in foreign reactors

BWR Fleet has Stability Awareness

This Figure supports Improved Technical Specification 3.3.1.1 and the Technical Requirements Manual

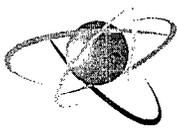




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A Large Industry-Wide Effort Followed the LaSalle Event

- Concern with regional (out-of-phase) instabilities
 - Left and right sides of the core cancel out; therefore APRM-based protection is blind
 - Part 21: local boiling transition even with APRM oscillations <10%
- Immediate action: Interim Corrective Actions (ICA's)
 - Operator to monitor LPRM oscillations
 - Reactor scram if both recirc pumps trip
- Long Term Solutions required



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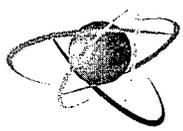
Long Term Solutions (LTS)

- GDC 12: “The reactor core and associated coolant, control, and protection systems shall be designed to assure that power oscillations which can result in conditions exceeding specified acceptable fuel design limits
 - are not possible or
 - can be reliably and readily detected and suppressed.”



Long Term Solutions – Organized in two categories

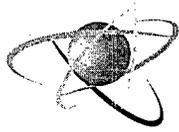
- Prevention (anticipatory scram)
 - Option E1A
 - Option ID
- Detect & Suppress
 - Option II
 - Option III
- All options developed by BWROG and publicly available
 - Documented in NEDO-31960A “BWR Owner's Group Long-Term Stability Solutions Licensing Methodology,” Nov 95
 - Approved for operation at Original Licensed Thermal Power (OLTP) operation



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LTS for Extended Operating Domains

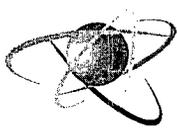
- Two LTSs address stability challenges for operating in extended operating domains (e.g., MELLLA+)
 - DSS/CD
 - NRC reviewed and approved for MELLLA+
 - GE Proprietary
 - Enhanced Option III (EO3)
 - Under staff review
 - Areva Proprietary



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Each Plant Must Implement an LTS

- Option E1A
 - Grand Gulf, River Bend
- Option ID
 - Vermont Yankee, Pilgrim, Fitzpatrick, Duane Arnold, Monticello & Cooper
- Option II
 - Nine Mile Point 1 & Oyster Creek
- Option III
 - Browns Ferry, Brunswick, Clinton, Columbia, Dresden, Fermi, Hatch, Hope Creek, LaSalle, Limerick, Nine Mile Point 2, Peach Bottom, Perry, Quad Cities, & Susquehanna



U.S.NRC Long Term Solution: E1A

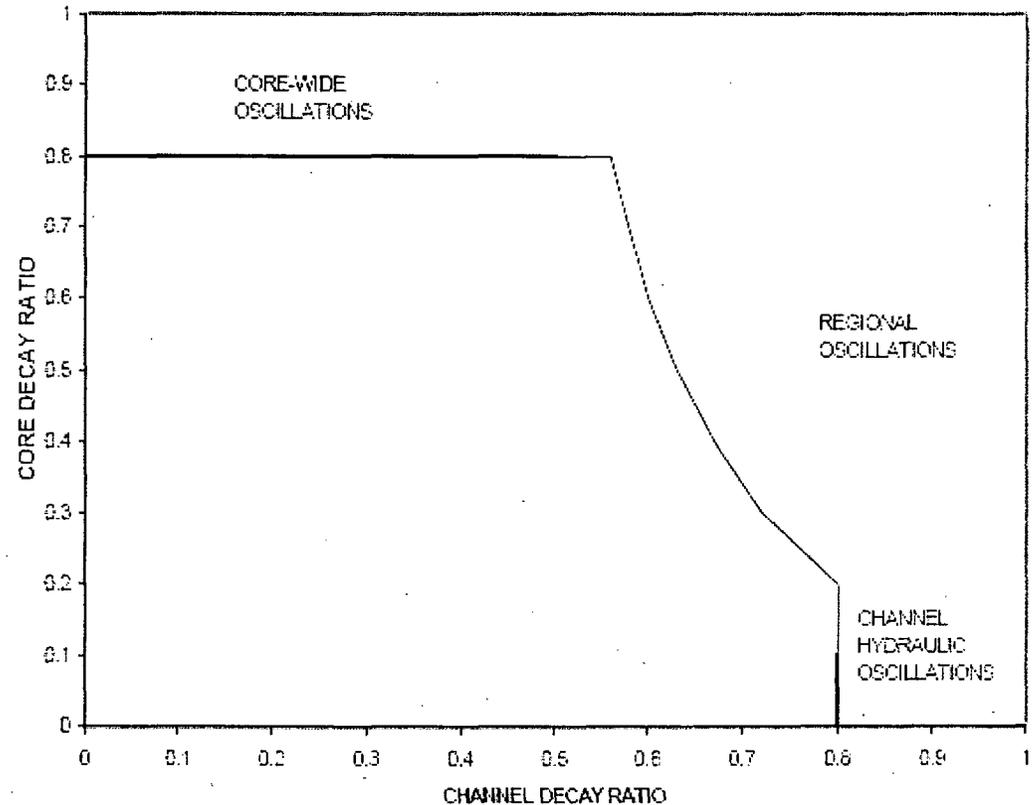
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- E1A defines a cycle-specific Exclusion Region (ER)
 - Instabilities not likely outside the ER
 - Automatic scram upon entry to ER
- Defense in depth
 - Period based detection algorithm (PBDA)
 - Buffer regions
- ER defined by analysis
 - Conservative generic power distributions
 - Cycle-specific data (confirmation analyses)
 - Well-defined analysis procedure in E1A LTR

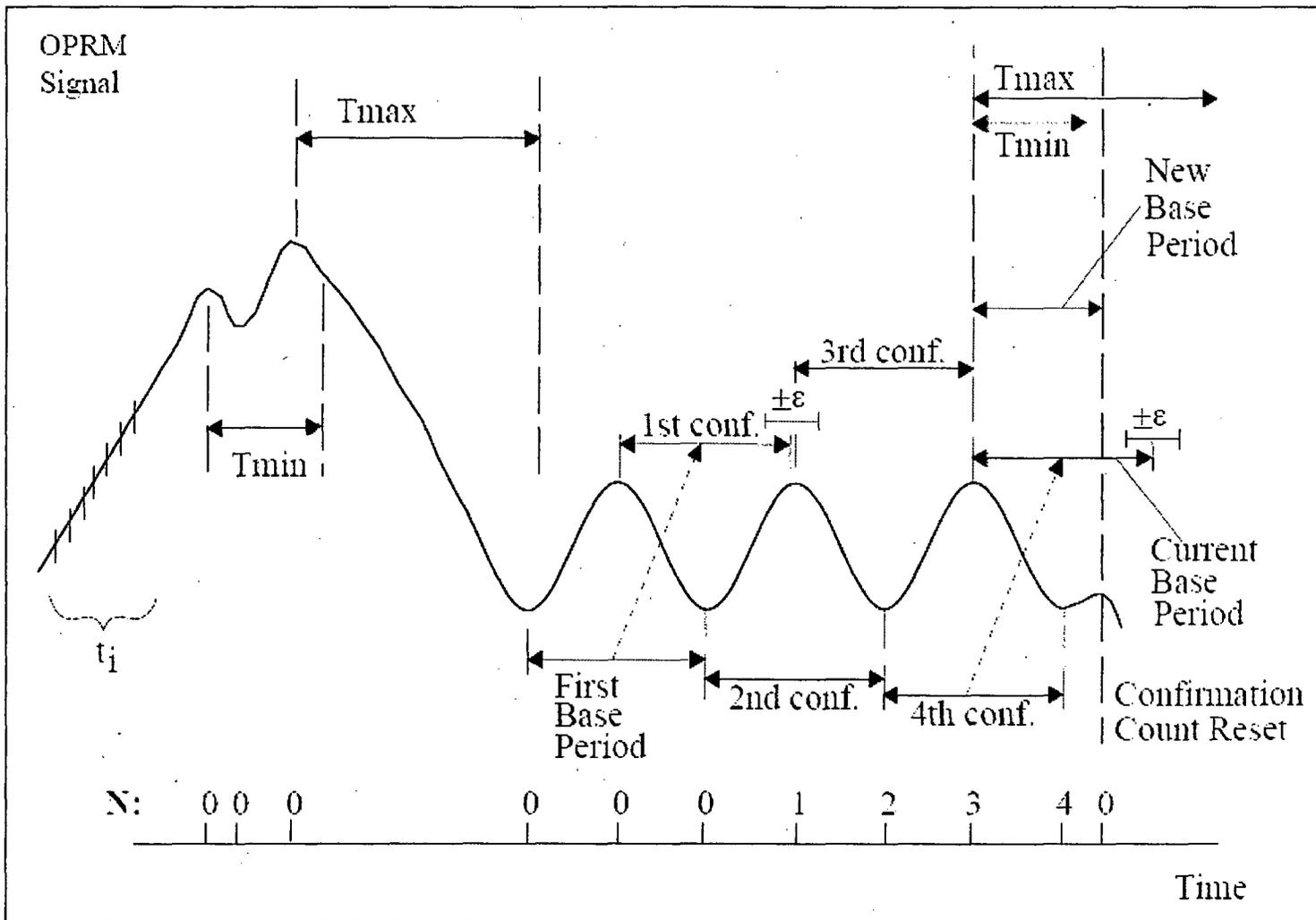
Tools for Calculating Regional Out-of-Phase Decay Ratio Were Not Available

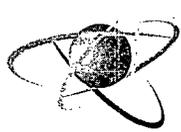
“Dog Bite” Correlation

- Correlation developed based on reactor experience
- Based on physics principles
 - Chan: Thermal-Hydraulics
 - Core: Neutronics
 - Regional: Both
- 2D map, core-wide vs channel Decay Ratio



E1A Period Based Detection Algorithm Looks For Signal "Periodicity"





U.S.NRC Long Term Solution: I D

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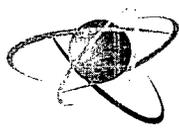
- I-D plants demonstrate by analysis that
 - Oscillation unlikely in regional mode
 - Small core (large eigenvalue separation)
 - Tight inlet orifice
 - Unfiltered flow biased scram provides protection for core-wide mode
- Defense in depth
 - Exclusion Region administratively enforced
 - Stability monitoring to enter buffer region
 - On-line stability calculation (SOLOMON)



U.S.NRC Long Term Solution: II

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- Option II plants demonstrate by analysis that the existing flow-biased scram provides protection for both core-wide and regional oscillations
 - Quadrant-based APRM scram
 - Unfiltered flow-biased scram
- Evaluated on a cycle-specific bases



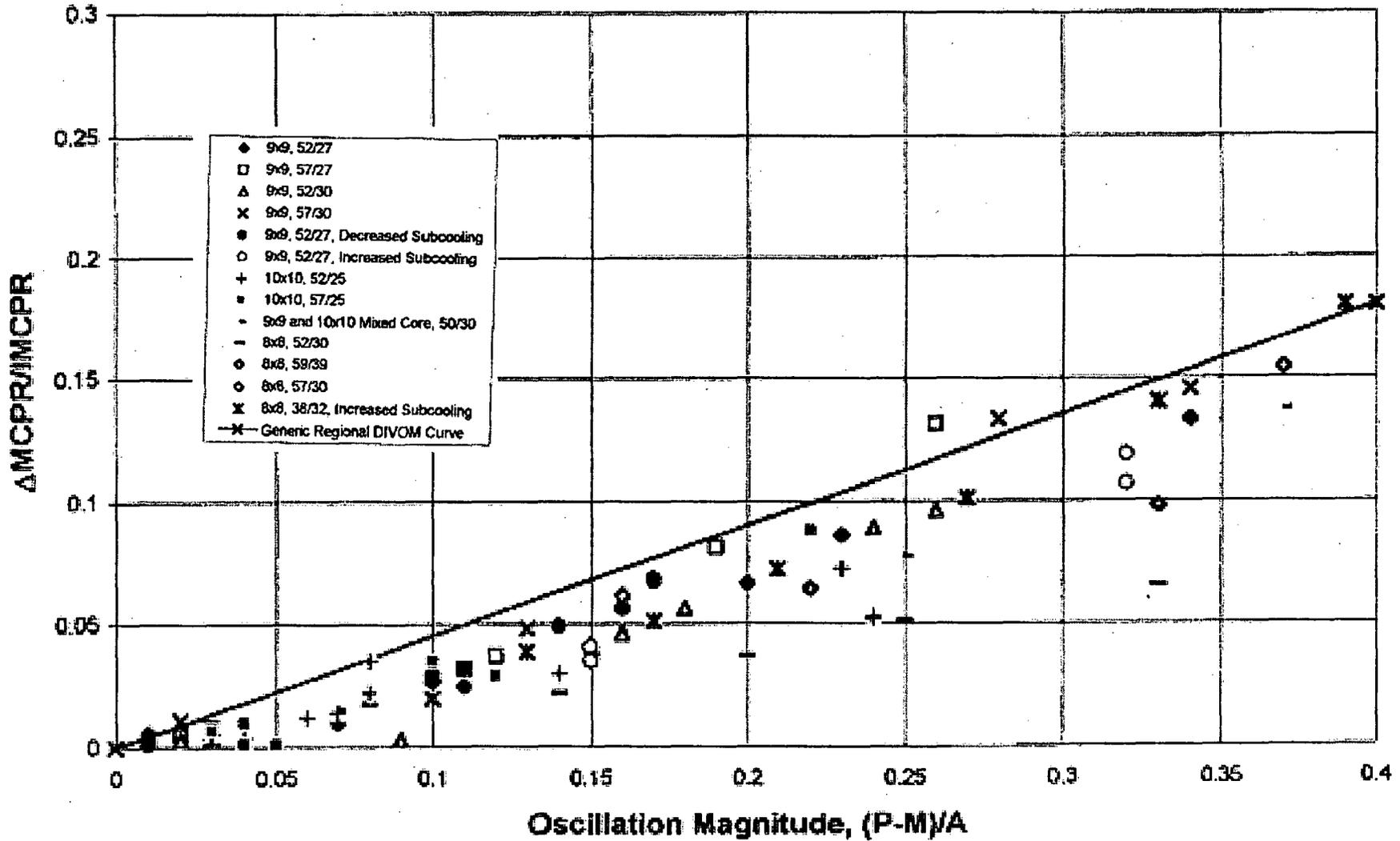
U.S.NRC Long Term Solution: II

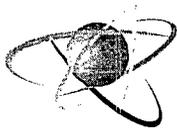
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- Option III plants modified their reactor protection system
 - OPRM (oscillation power range monitor) scram
- Licensing bases SCRAM is based on period based detection algorithm (PBDA)
 - If oscillations detected in two channels with amplitude $>$ setpoint, the reactor scrams
 - Setpoint calculated on cycle-specific basis
- Defense in depth
 - High amplitude oscillation (high-low-high)
 - High growth (DR $>$ 1.3)



DIVOM Correlation is Used to Correlate Oscillation Amplitude to Δ CPR

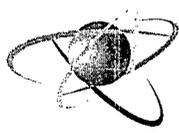




Solution III Implementation Issues

Generic DIVOM Deficiency

- Concern identified through GE analysis supporting EPU
 - Fixed/generic CPR Change vs. Oscillation Magnitude (DIVOM) may be non-conservative for high peak power bundles
- Concluded condition could exceed a safety limit
- GE/BWROG collaboration to revise DIVOM & stability setpoint methodology
 - GE/BWROG issued guidelines that require plant- and cycle-specific DIVOM evaluation
 - GE-NE-0000-0028-9714-R1, “Plant-Specific Regional Mode DIVOM Procedure Guideline,” June 2005
 - GE-NE-0000-0031-6498-R0, “Plant-Specific Core-Wide Mode DIVOM Procedure Guideline,” June 2005



Solution III Implementation Issues (cont'd)

Stability ICA Adequacy

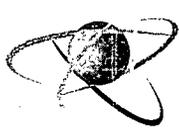
- Concern that Interim Corrective Actions (ICA) regions may be too small for current fuel/core designs and operating limits.
- Concluded ICA regions are adequate for safety limit protection
- GE recommended using Backup Stability Protection (BSP) regions to replace/supplement ICAs
 - Communicated in OG 02-0119-260, “Backup Stability Protection (BSP) for Inoperable Option III Solution,” July 17, 2002
- BWROG recommended that each plant assess the adequacy of their ICA regions



Solution III Implementation Issues (cont'd)

OPRM T_{min} Acceptable Values

- T_{min} value discriminates T-H instabilities from other oscillations
 - Peak-to-peak interval must exceed T_{min} to be considered
 - LTR specifies “typical” range of 1.0-1.4 sec
- GE analysis predicts oscillation period can be < 1.4 sec at high core flow and concluded condition could contribute to exceeding a safety limit
- Established T_{min} setting of ≤ 1.2 sec (non-MELLLA+) for system operability
 - Recommend T_{min} setting = 1.0 sec
- Confirmed T_{max} setting ≥ 3.0 sec for system operability
 - Recommend T_{max} setting = 3.5 sec
- Allowed for plant-specific justification of adjusted values

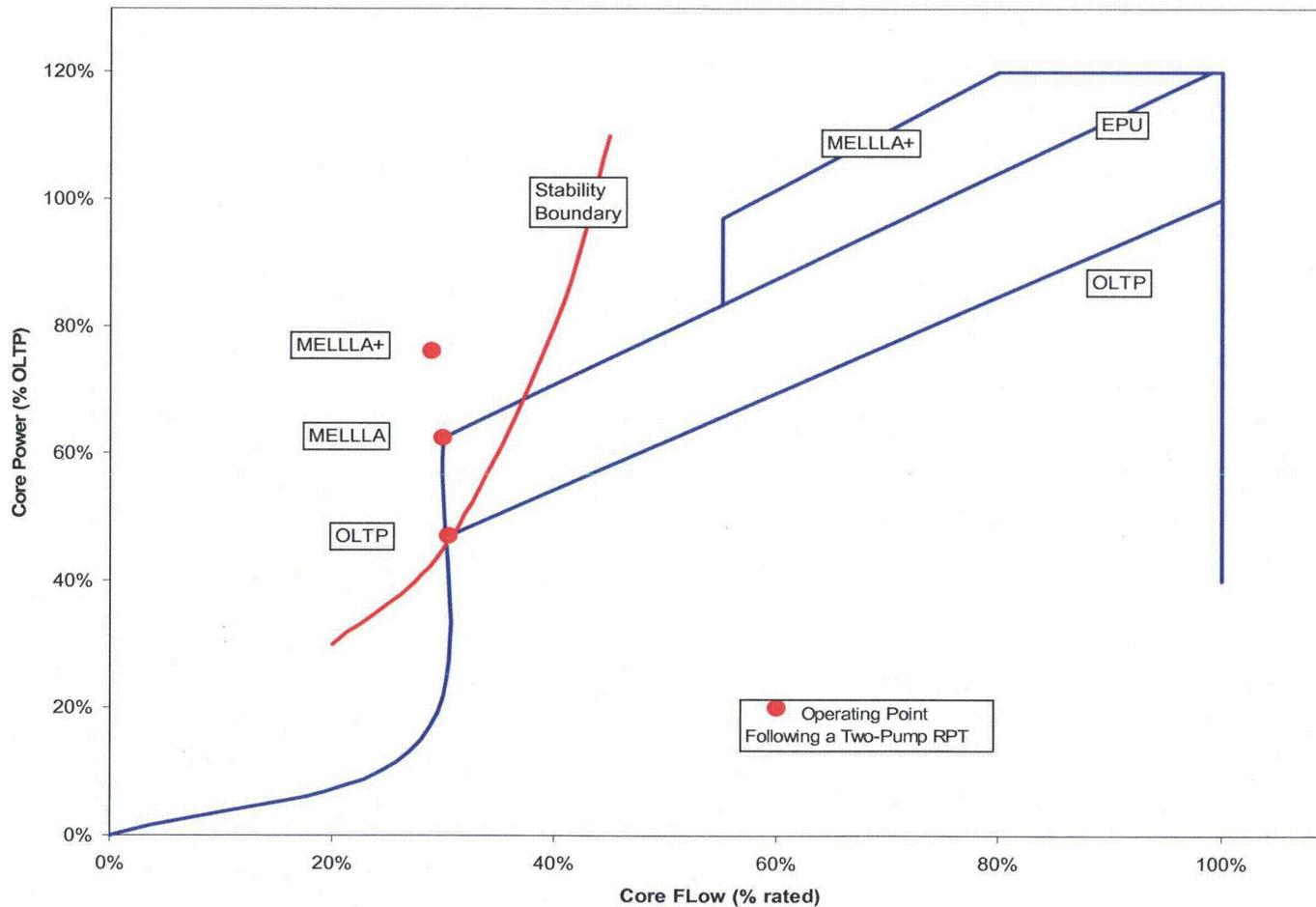


Solution III Implementation Issues (cont'd)

OPRM Corner Frequency and Period Tolerance

- Concern identified from NMP-2 event, 7/24/03
 - Safety limit was protected for the event
 - Experienced unexpected Confirmation Count (CC) resets in the period based detection algorithm (PBDA)
 - CC resets attributed to combination of corner frequency (3 Hz) and period tolerance (50 ms)
- Concluded condition could contribute to exceeding SAFDL
- Established recommended PBDA settings:
 - Period tolerance ≥ 100 msec
 - Cutoff frequency = 1 Hz
- System performed as expected w/ new settings in Perry event, 12/23/04

Extended Operating Domains Pose New Challenges to Stability

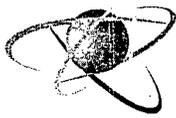




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Long Term Solution : DSS/CD

- DSS/CD (confirmation density) is similar to Option III
 - Based on OPRM
 - Licensing bases is PBDA
- It has a fixed (small) amplitude setpoint, but it requires a larger number of OPRM channels to confirm the oscillation
- Option III is installed as defense in depth
- Acceptable for MELLLA+ use because it will scram very fast
 - Proprietary implementation details



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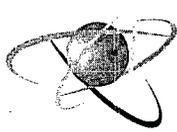
Long Term Solution: Enhanced Option III

- EO3 is a mixed D&S and exclusion region solution for different instability modes
 - Proprietary details
- Solution is under staff review



The staff has performed plant decay ratio measurements

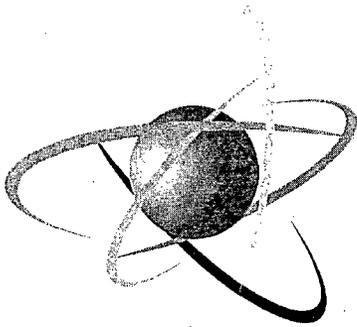
- Introduction of advanced fuels
 - Dresden 9x9 LTA – local stability tests
 - Grand Gulf 9x9 load – low-flow tests
 - Susquehanna – Collected noise data for analysis at ORNL for several cycles after introducing 9x9 fuel
- Single loop operation
 - Browns Ferry stability tests to determine the source of noise increase during SLO
- DSS/CD testing
 - Brunswick data for false DSS/CD positives



U.S.NRC Non-ATWS Stability Summary

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- The original reactor protection system did not guarantee SAFDL's for all instability modes
 - Long Term Solutions were developed, reviewed and implemented
 - Original LTS are publicly available (BWROG)
- LTS are generic enough to be applicable to new reactor designs (e.g. ABWR or ESBWR)
 - Specific review is required
- More aggressive fuel designs and extended operating domains require LTS applicability review
 - New proprietary LTS are being developed for MELLLA+



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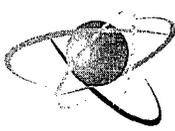
ATWS/Stability



U.S.NRC ATWS/Stability

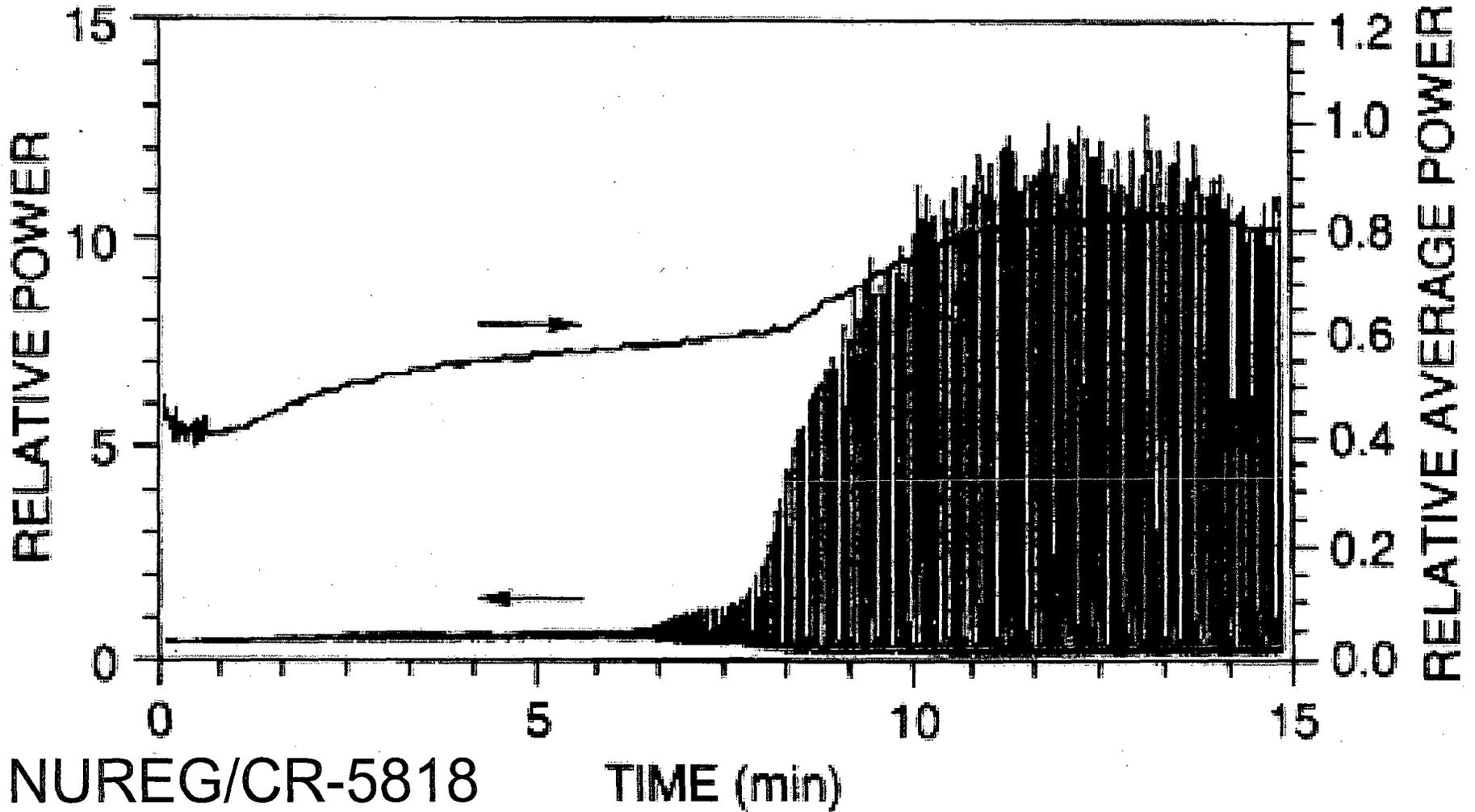
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- There are many types of ATWS events
- ATWS/Stability is a particular class of ATWS event where
 - Condenser is available (non-isolation)
 - Very cold water is fed into the vessel
 - Extreme amplitude oscillations develop (>1000% power oscillations)
 - Dryout and cladding failure occur
- ATWS/Stability is a serious concern because it is the default transient evolution (hands-off) in some plants



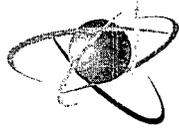
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Typical ATWS/Stability Evolution



NUREG/CR-5818

TIME (min)



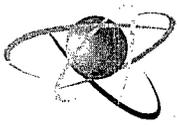
Balance of Plant Modeling is Crucial to Predict ATWS/Stability Events

- Feedwater heaters work with extraction steam from the turbine.
 - When the turbine trips, feedwater temperature cools down to condenser temperature
- In non-isolation ATWS with turbine trip, we may have the bypass fully open and
 - No overpressure or heat to containment
 - But cold feedwater increases subcooling and power rises to ~80% of nominal at natural circulation
 - Extremely unstable situation
 - Large amplitude limit cycle develops



Default (hands off) ATWS Event Sequence (in Some Plants)

- Turbine trip. Bypass opens, but temporary overpressure or water level sets a scram demand signal
- Scram fails -> ATWS
- Recirc pumps are tripped by ATWS rule
- Control system stabilizes water level with feedwater and pressure with bypass valve
- At this point everything is stable, and there is no “entry point” in the emergency operating procedures (except ARI)

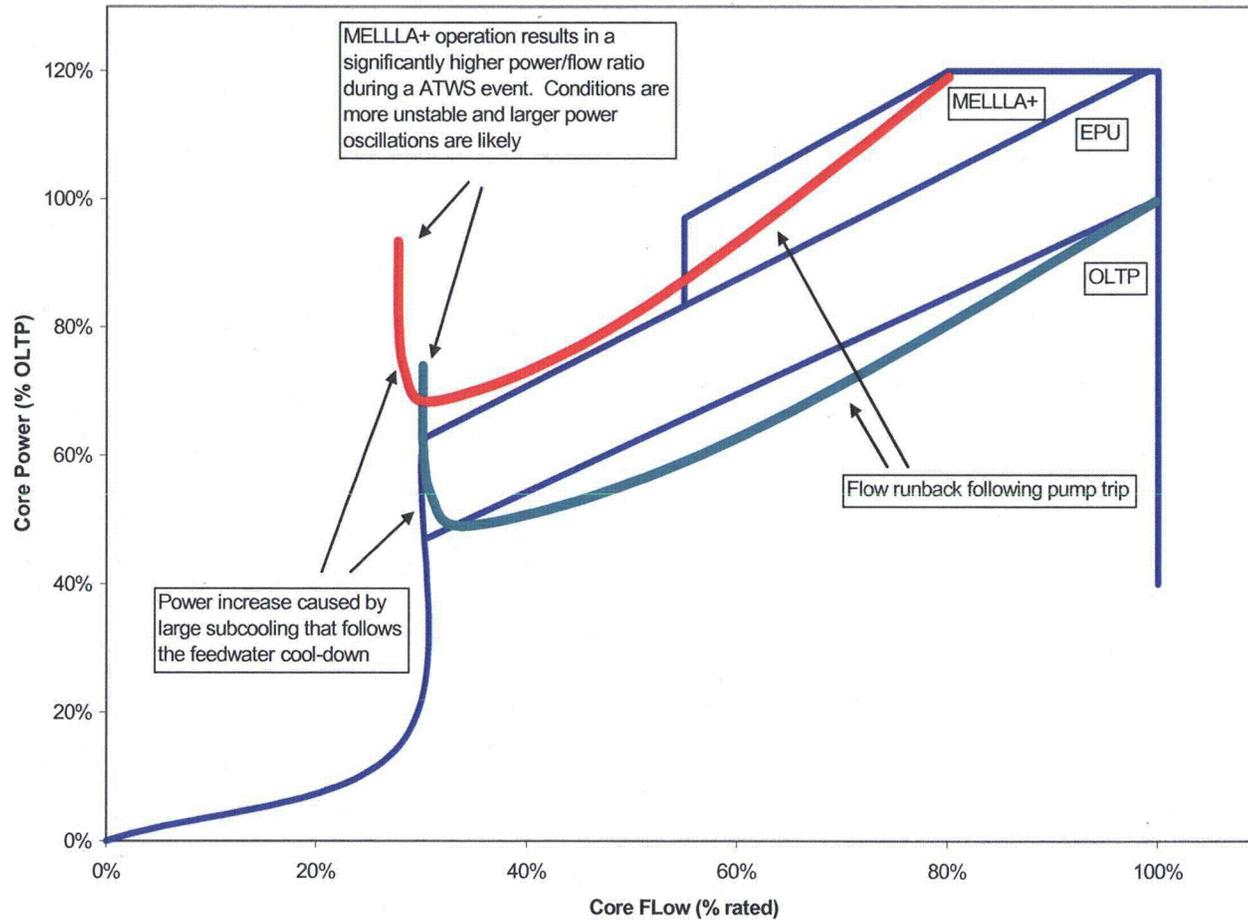


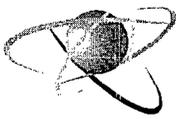
Default (hands off) ATWS Event Sequence (cont)

- But ... power continues to rise as feedwater cools to condenser temp.
 - Natural circulation and 80% power almost guarantees unstable power oscillations
- Unstable oscillations develop
 - Extremely large (>1000%)
 - Periodic dryout/rewet (2 – 10 sec period)
 - Eventually a power pulse is large enough that prevents rewet.
 - Clad temperature rises sharply and reaches failure point (2200 F)



ATWS: First Recirculation Pumps Trip, Then FW Temperature Drops





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Severity of the ATWS/Stability Event is Plant-Dependent

- Bypass capacity
 - Some plants have 100% bypass
 - Others have as little as 20%
- Feedwater pumps
 - ATWS/Stability event requires motor-driven feedwater pumps
 - Most plants have a combination of steam-driven and motor-driven
 - Feedwater capacity is limited
 - Steam-driven plants rely on HPCI, but its capacity is also limited



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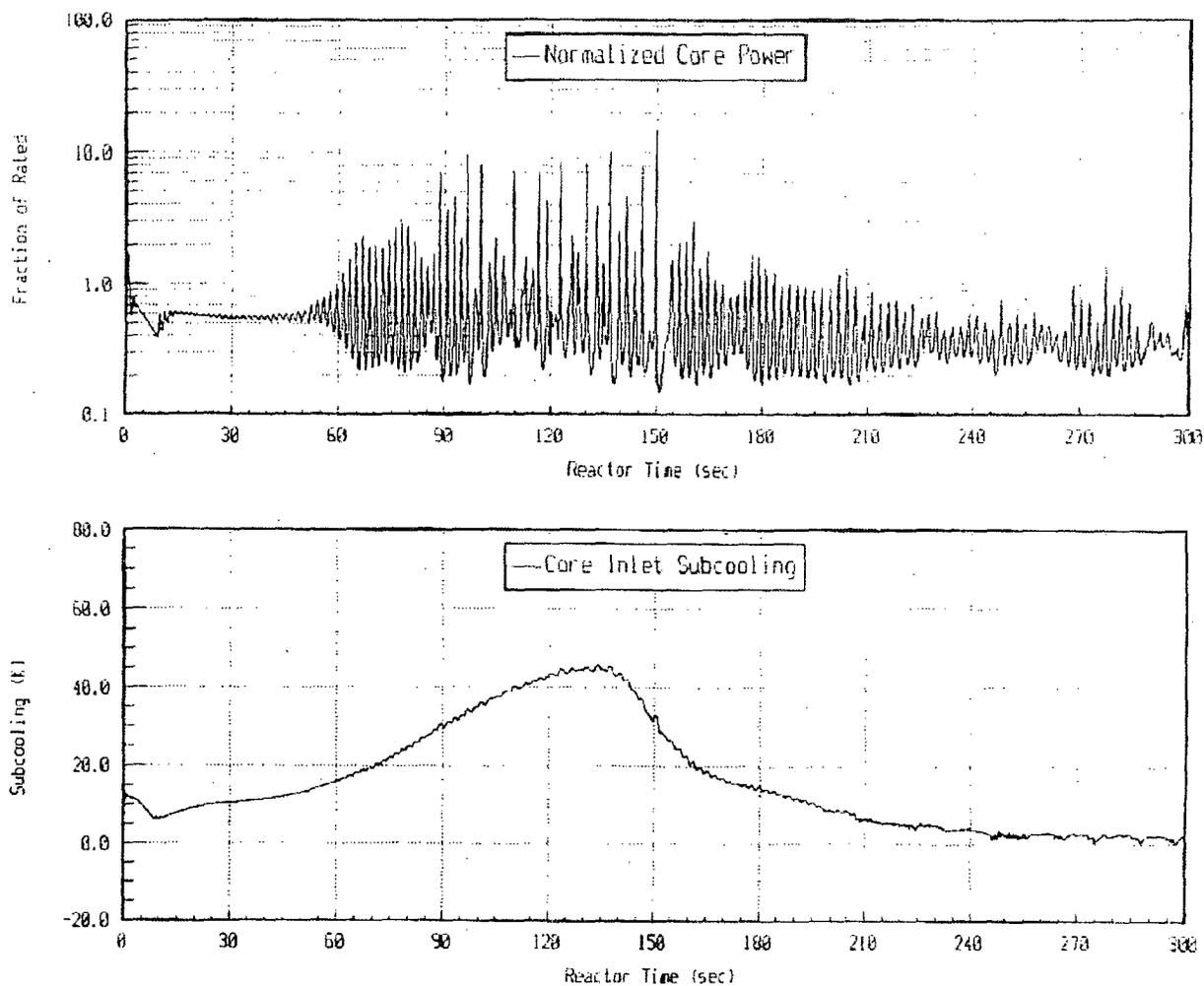
ATWS/Stability Was Deemed Unacceptable

- Main issue was that existing EPGs directed the operator to let the event grow
- Extensive study by industry, staff, with ACRS involvement resulted in EPG Rev 4
- ATWS/Stability Mitigation Actions:
 - Early boron injection if oscillations develop
 - Prior to EPG Rev 4, boron was only injected if the suppression pool was expected to over-heat
 - Immediate water level reduction below the feedwater spargers
 - Pre-heats core-inlet coolant
 - Condenses vessel steam



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Effectiveness of Mitigation Actions has been Demonstrated by Analysis



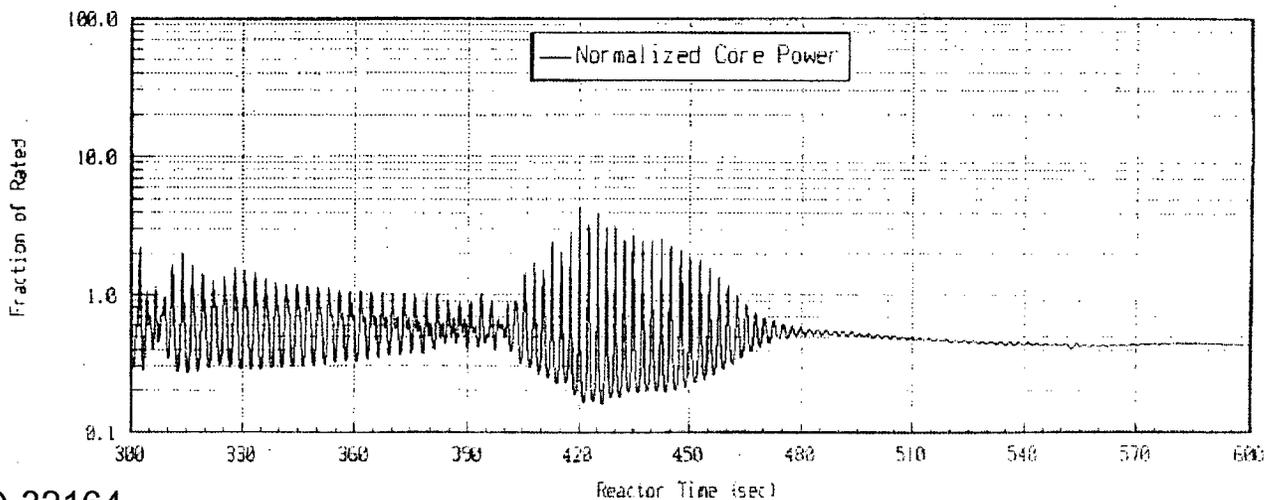
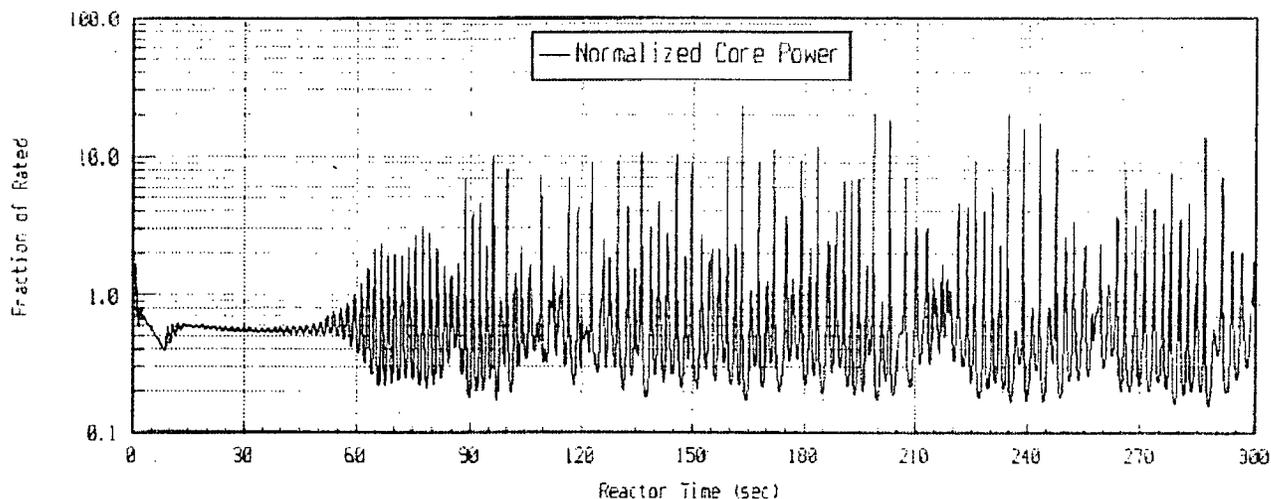
NEDO-32164

Figure 4-4. Level Control below Feedwater Sparger - Core Power and Inlet Subcooling

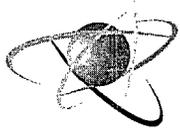


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Boron Injection Alone is Not as Effective as Water Level Reduction



NEDO-32164



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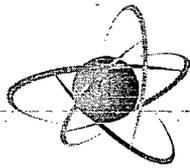
Implications to Extended Operating Domains

- Extended Operating Domains (e.g. MELLLA+) start the transient with a higher power/flow ratio.
 - Unmitigated consequences would be worst
- Licensees must demonstrate by analysis that mitigation actions are still effective
 - Mitigation actions are sufficiently effective to compensate for the increased power/flow ratio
 - Timing of operator actions is not affected (i.e. no unreasonable requirements on operators)



ATWS/Stability Summary

- ATWS/Stability is a class of ATWS events that may impact core coolability, if unmitigated
- ATWS/Stability affects primarily plants with large bypass capacity and motor-operated feedwater pumps
- BWROG EPG's Rev 4 and greater (e.g. EPG/SAGS Rev 2) incorporate effective mitigation actions
 - Water level reduction
 - Early boron injection
- Plant audits confirm that EPGs are correctly implemented in EOP's or EOI's
- Plant simulator events show operator awareness



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Protecting People and the Environment

Standard Review Plan 15.0 - Introduction

Samuel Miranda

NRR – Reactor Systems

February 28, 2007

1



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2007 Revision

- Include new reactor designs
- Add content
- Improve links to the regulations
- Update bases and references
- Simplify and clarify text

2



Summary of changes

- Add 10 CFR Part 52
- Define two event categories: AOOs and postulated accidents
- ATWS is a separate category
- Prohibit an AOO from becoming a postulated accident
- No requirement to consider an AOO coincident with a single failure

3



10 CFR Part 52

- Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants
- Basis for review of new applications in this SRP version and in future revisions

4



Added to SRP 15.0:

- Definition of event categories
- Acceptance criteria
- Examples of events and reviews
- Definition of terms

5



Constant Risk Principle

- If risk is defined as the product of an event's frequency of occurrence and its consequences, then the plant shall be designed such that risk is approximately constant across the range of AOOs and postulated accidents.

6



Two event categories

- Condition II, III and IV events are defined in two withdrawn ANS standards
- Use definitions of 10 CFR Part 50, App A
 - AOOs can occur during the plant lifetime
 - Postulated accidents are not expected to occur
- Apply AOOs and postulated accidents for new plants; optional for operating plants
- Retain Condition II, III and IV events for operating plants

7



ANS	RG 1.70	10 CFR 50, App A
II	Incidents of moderate frequency: might occur in a year	AOOs: one or more events in plant lifetime
III	Infrequent events: might occur in the plant lifetime	AOOs: one or more events in plant lifetime
IV	Limiting faults: not expected to occur	Postulated accidents: not expected to occur

8



ATWS is a separate category

- ATWS = AOO + consequential common cause failure of RPS
- ATWS is outside plant design basis
- ATWS is subject to 10 CFR Part 50.62

9



Non-escalation criterion

- An AOO must not develop into a postulated accident
- Establishes a barrier between AOOs and postulated accidents
- Based on ANS acceptance criteria
- Related to 10 CFR Part 50.59
- Discussed in RIS 2005-29

10



10 CFR Part 50.59

- (iii) Result in more than a minimal increase in the consequences of an accident previously evaluated in the final safety analysis report;
- (iv) Result in more than a minimal increase in the consequences of a malfunction of an SSC important to safety previously evaluated in the final safety analysis report

11



Combo-AOO requirement

- Delete this: An incident of moderate frequency in combination with any single active component failure, or single operator error, shall be considered and is an event for which an estimate of the number of potential fuel failures shall be provided for radiological dose calculations. There shall be no loss of function of any fission product barrier other than the fuel cladding.

12



Combo-AOO requirement

- This requirement is ill-defined and redundant
- An AOO coincident with an active single failure is like:
 - two simultaneous AOOs
 - AOO occurring during a TS action statement
 - a postulated accident

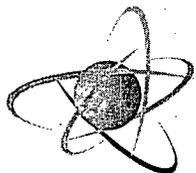
13



Features of the 2007 revision

- New reactor designs are included
- SRP Chapter 15.0 may be referenced in subsequent SRP sections
- Event categories and acceptance criteria are clarified, simplified and based on regulations

14



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- 1968 10CFR§50.34, Contents of Applications (Dec 17)
- 1969 ACRS consultant postulates an AOO with common-mode failure, ATWS (Feb)
- 1971 10CFR§50, App A, General Design Criteria (Feb 20)
- 1972 RG 1.70, Standard Format and Content, (Feb)
- 1973 ANSI N18.2-1973, Nuclear Safety Criteria for Design of PWRs (Aug 6)
- 1973 WASH-1270, ATWS for Water-Cooled Reactors (Sept)
- 1978 ANSI/ANS-52.1-1978 Nuclear Safety Criteria for Design of BWRs (Mar 16)
- 1978 RG 1.70, Standard Format and Content, Rev 3 (Nov)
- 1980 NUREG-75/087 SRP - references 10CFR§50.34 (May)
- 1982 SRP is in effect for plants docketed after May 17, 1982 (10CFR§50.34)
- 1983 ANSI N18.2-1973 replaced by ANSI/ANS-51.1-1983 (PWRs), and ANSI/ANS-52.1-1978 replaced by ANSI/ANS-52.1-1983 (BWRs)
- 1984 10CFR§50.62, ATWS Rule (Jun 26)
- 1988 ANSI/ANS-51.1-1983 and ANSI/ANS-52.1-1983 are reaffirmed
- 1996 NUREG-0800, Draft 3 (Apr)
- 1998 ANSI/ANS-51.1-1983 and ANSI/ANS-52.1-1983 are withdrawn
- 1999 10CFR§50.59, Changes, Tests, and Experiments (Oct 4)