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UNITED STATES OF AMERICA
 NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

THERMAL-HYDRAULIC SUBCOMMITTEE

OPEN SESSION

+ + + + +

MONDAY

SEPTEMBER 21, 2015

+ + + + +

ROCKVILLE, MARYLAND

+ + + + +

The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 1:00 p.m., Sanjoy Banerjee, Meeting Chairman, presiding.

COMMITTEE MEMBERS:

SANJOY BANERJEE, Subcommittee Chairman

RONALD G. BALLINGER, Member

MICHAEL L. CORRADINI, Member

STEPHEN P. SCHULTZ, Member

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ACRS CONSULTANTS:

UPENDRA S. ROHATGI

KORD SMITH

DESIGNATED FEDERAL OFFICIAL:

ZENA ABDULLAHI

ALSO PRESENT:

ALSO PRESENT:

MIKE COOK, GEH

CRAIG GOODSON, GEH

CHARLES HECK, GEH

MAGGIE HWANG, GEH

CHRISTOPHER P. JACKSON, NRR

JOSE MARCH-LEUBA, ORNL*

CURT ROBERT, GEH

DIEGO S. SAENZ, NRR

ASHLEY SMITH, NRR

PETER J. YARSKY, RES

*Present via telephone

A G E N D A

Opening Chairman Remarks.....	4
Staff Opening Remarks.....	6
ACRS Member Remarks.....	128
Adjourn.....	132

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

(1:00 p.m.)

CHAIRMAN BANERJEE: This is a meeting of the Thermal Hydraulic Subcommittee of the Advisory Committee on Reactor Safeguards. I am Sanjoy Banerjee, Chairman of the Subcommittee, and the ACRS members in attendance today are Steve Schultz, Mike Corradini, and Ron Ballinger. We also have ACRS consultants, Upendra Rohatgi and Kord Smith. Zena Abdullahi is the Designated Federal Official for this meeting.

At the outset, I must apologize for starting late. We are missing a court reporter, and we will be recording this instead so that we can have it transcribed later.

So, at today's meeting GE will brief us on the TRACG ATWS instability methodology. Subsequently, we'll have discussion exclusive with the NRC Staff. During the session, the Staff will update us on the technical reviews related to the ATWS instability methodology and relative to experimental data.

This Subcommittee meeting will be closed to the public in order to protect information that is proprietary both to GE and

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1 other vendors. During the closed portion of this
2 meeting, we will request that GEH and NRC Staff
3 survey the attendees in the room and insure that
4 all participants are cleared for access to the
5 information being discussed.

6 In the closed session of this meeting
7 we request also that those that call in through the
8 closed bridge numbers identify themselves, when
9 prompted. We request that GEH and the Staff confirm
10 that the participants are, in fact, cleared for the
11 respective closed portion of the meeting. We also
12 request that the teleconference participants mute
13 their telephones during the meeting.

14 As the meeting is being transcribed, it
15 is requested that the attendees in this meeting use
16 the microphones located throughout this room when
17 addressing the Subcommittee. Participants should
18 first identify themselves and speak with sufficient
19 clarity and volume so that they can be readily
20 heard.

21 As an additional reminder, the
22 presenters' microphones should be turned off during
23 normal discussion, and only turned on when the
24 presenter wants to be heard.

25 Okay. With that, we'll now proceed with

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1 the meeting, and I call upon Chris Jackson, the
2 Branch Chief of Reactor Systems in NRR to kick off
3 the meeting.

4 MR. JACKSON: Good. Well, thank you. I'm
5 just going to open up the meeting and kind of give
6 you an outline as to what we're going to touch on.
7 This is one of the more interesting meetings, or
8 more unique meetings of the ACRS that we've had. We
9 have no licensing decision in front of us. We're
10 not on the docket, so that's kind of unique. But in
11 my opinion it's good in that we're talking
12 technical issues. We don't have an impending
13 licensing action or regulatory decision. There's no
14 outage scheduled related to this, so we can freely
15 discuss technical matters, so I want to thank you
16 for that.

17 You know, this MELLA+ with the extended
18 flow window has gone on a lot of time and we've had
19 a lot of exchanges, so I appreciate the opportunity
20 to talk to you all today. I think we've got a great
21 presentation. I've got Diego Saenz, my Staff member
22 here who's extremely knowledgeable. We've got Peter
23 Yarsky from the Office of Research who's also
24 extremely knowledgeable. Hopefully, we have Jose
25 March-Leuba on the phone who's been helping us for

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1 many years. I see Ashley Smith over there, as well,
2 who's been working on this for several years, as
3 well. So, we'll do our best to answer your
4 questions given that this is more information. If
5 we can't answer all your questions, we'll come
6 back. We will have more licensing, more traditional
7 type decisions in the future, but this is very
8 helpful for me.

9 All right. My name is Chris Jackson.
10 I'm Chief of the Reactor Systems Branch. I wanted
11 to just give you a high-level background as to what
12 we're ---

13 CHAIRMAN BANERJEE: Do we have these
14 slides, Chris, somewhere?

15 MEMBER BALLINGER: I'm trying to find
16 them. I can't.

17 CHAIRMAN BANERJEE: Oh, you sent them -
18 -- we have them by email.

19 MS. ABDULLAHI: You have it by email,
20 but I don't have a hard copy.

21 CHAIRMAN BANERJEE: You haven't a hard
22 copy, okay.

23 MR. JACKSON: We can get them for you.
24 They're pretty high-level.

25 CHAIRMAN BANERJEE: Yes.

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1 MR. JACKSON: Okay. So, extensions of
2 the BWR operating domain, we've been working on
3 this for close to 10 years. There was a Topical
4 Report for MELLA+ for GEH. Plants have started to
5 implement that. AREVA, the other vendor, is
6 marketing their own solution called the Extended
7 Flow Window. And, obviously, operating at high
8 powers at lower flows puts you closer to the
9 instability region. It doesn't necessarily make you
10 --- the consequences worse, but it puts you closer
11 to the instability. So, if you looked at the ATWS
12 Rule back in the day, it didn't require any
13 analysis whatsoever. It didn't require a continuing
14 analysis as the plant made changes or changed
15 fuels, changed power levels. It just required
16 hardware. But because this license amendment
17 request puts them closer to the instability region,
18 we've asked them to recalculate ATWSI with the new
19 result.

20 So, this is kind of an interesting
21 regulatory decision that we haven't made in many
22 years, and the decisions we made in the past were
23 based on the analysis and code, and techniques we
24 had at that time. All right, so that was Background
25 1. Here's Background 2.

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1 All right. Just for high-level, the
2 acceptance criteria for ATWS is coolable geometry.
3 You know, if you go back to the NEDO from 1995, the
4 document that kind of was the basis for all our
5 decisions, you know. It allowed peak clad
6 temperatures to remain below 2200 for all but the
7 hottest fuel rods, so we actually let a small
8 number of assemblies to exceed 2200. So, we used
9 2200 as a surrogate for coolable geometry,
10 recognizing that some pins or some small amount of
11 elements could go out 2200.

12 And in our ATWSI calculations or MELLA+
13 applications, we've actually backed off of that
14 based on recognized uncertainties in the TRACG
15 methods that are used, so we are now using a Tmin
16 basis which is several hundred degrees below 2200,
17 so we are applying another kind of layer of
18 uncertainty as we work through some of those
19 uncertainties. And we're trying to fill the
20 technical basis or technical gaps there in those
21 uncertainties.

22 So, why are we here today? We're here
23 today because ACRS asked us to be, obviously, but
24 this stems from a statement that was in the Nine
25 Mile Point MELLA+ letter. So, the ACRS reviewed

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1 Nine Mile Point MELLA+ in the NRC SER and
2 recommended we approve it, but they included the
3 statement, "As more dryout, post dryout, and
4 rewetting data becomes available at higher rod
5 temperatures in oscillatory flows, the Staff should
6 confirm the adequacy of a fixed Tmin transient flow
7 boiling calculation "dryout temperature
8 predictions." So, this is kind of the statement
9 that we used to focus our whole presentation. We've
10 got General Electric here to come talk about what
11 they do, and how they do it, and their technical
12 rationale for that. We'll talk about how we're
13 dealing with this, and how we're addressing some of
14 the uncertainties we've identified through the
15 years.

16 Then just to provide a very high level,
17 here's just a simple boiling curve out of a
18 textbook, and I want to just kind of highlight how
19 we do this. You know, if you look at this boiling
20 curve, you know, everything to the left of this,
21 this is normal operation and AAOs, you know, so as
22 you're following this curve, this is where they
23 make their power. This is your transients, your
24 accidents. We deal with these on a cycle by cycle
25 basis. We apply 95-95. There's an enormous amount

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1 of technical basis and data supporting this, and
2 TRACG. All of the codes that we have are approved
3 very explicitly in this region here.

4 When you get beyond that we allow
5 plants to go beyond that in accidents, and when we
6 get the film boiling region here, this is data,
7 this is where we would be in like a LOCA regime
8 where you blow all the water out of the core. So,
9 we've got a lot of data in this region here from
10 LOCA tests and other things along those lines. So,
11 kind of in between those areas, that's the
12 transition region where we have less data. You
13 know, we assume that you go beyond transition
14 boiling in AOOs, that's unacceptable, in accidents
15 we allow it, but we deal with that on a different
16 basis. So, this is kind of the area I think we want
17 to discuss today.

18 You know, you consider this Tmin down
19 here, so it would Tmin --- this area is where you
20 want to figure out how to deal with that, and
21 that's kind of where we're going to focus our
22 discussion.

23 MEMBER CORRADINI: So, let me start with
24 a question. I always love this curve, except for
25 ATWS it's not representative, because at high

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1 pressures Tmin is not that low. It's actually quite
2 close to, so what I'm curious about is --- let me
3 ask my question because he told me to not ask too
4 many technical questions, and he'll shut me off.

5 CHAIRMAN BANERJEE: It's okay, this is
6 your first question.

7 MEMBER CORRADINI: Okay, thank you.

8 So, in terms of ATWS applications, the
9 only way to cross the CHF point is either by a
10 power increase, a pressure modification, or a flow
11 modification. So, it's not really LOCA-related
12 because then I have to deal with a reflood issue
13 and more two-dimensional heat transfer versus
14 essentially one dimensional at a spot. Is that a --
15 - am I correct in that understanding?

16 MR. JACKSON: I think so. So, where
17 you're getting at, and that's the exact point I'm
18 trying to make, is when you're dealing with ATWS
19 you are going back and forth out of this region
20 over, and over, and over again. And this is the
21 region that we don't have a whole lot of data, so
22 it's LOCA data which is way over here, and it's not
23 AAO data which is over here. It kind of bounces
24 back and forth, so you're between the film boiling
25 region and then when you rewet, you're back in the

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1 nucleate boiling region. So, you're kind of hopping
2 back and forth.

3 CHAIRMAN BANERJEE: I wanted to ask ---

4 MR. JACKSON: But you're at high
5 pressure.

6 CHAIRMAN BANERJEE: --- a question
7 earlier than what Corradini's --- so, in many
8 experiments like those done in the early days by
9 Jeff Hewitt and so on, when you get to relatively
10 high void fractions, the phenomena that leads to
11 high wall temperatures is that you simply don't
12 have a liquid film any more on the surface. So,
13 it's not typically that you've got a lot of liquid
14 and now you've got lots of bubbles being formed,
15 which then form a blanket, and something like that
16 which stops that wall from being cooled by the
17 liquid.

18 So, the phenomena is different in
19 dryout in the sense that the liquid film which is
20 maintained by a balance of entrainment versus
21 deposition is not replenished sufficiently fast
22 taking into account evaporation eventually. It just
23 vanishes. You start to get dry patches, and these
24 dry patches grow, and all sorts of things happen.

25 Now, when you start to wet that

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1 situation, as Mike said, there is the re-
2 establishment of the liquid film occurring, and
3 that's a complicated thing. In fact, I spent my
4 youth doing things like trying to study this, but
5 it's really --- there is no clear rewetting point.
6 If you really look at it, what it is is a sort of a
7 knee in the curve. So, the idea of rewetting being
8 a specific temperature is fiction. I mean,
9 depending on various local conditions and things,
10 you can get different matters happening that ---

11 MR. JACKSON: Well, I don't know if I
12 would say it's fictional.

13 CHAIRMAN BANERJEE: At least at the
14 high ---

15 MR. JACKSON: I would say that we're in
16 agreement ---

17 CHAIRMAN BANERJEE: It's a question of
18 interpretation. It's really the knee in the curve
19 that you're looking at.

20 MR. JACKSON: Right. I would acknowledge
21 that we have uncertainty in this region, and that
22 we need to come up with the analytical regulatory
23 way to deal with ---

24 CHAIRMAN BANERJEE: Now, the boiling
25 curve you've drawn is qualitatively correct.

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1 There's nothing wrong with it. It's a function of a
2 whole bunch of factors.

3 MR. JACKSON: Right.

4 CHAIRMAN BANERJEE: Including
5 convection, velocity, and all sorts of things.

6 MR. JACKSON: If we go back to the kind
7 of tasking sentence out of the ACRS memo, a fixed
8 T_{min} and transient low boiling calculation, and
9 although a fixed T_{min}, I'm not sure what --- but
10 that's the area. I mean, this is what the ACRS is
11 interested in, is this kind of region.

12 MEMBER CORRADINI: So, not to pick in
13 you, Chris.

14 MR. JACKSON: Right.

15 MEMBER CORRADINI: But I'm kind of with
16 him. So, let's say I'm in the BWR situation. I have
17 annular flow, dry --- CHF occurs because of film
18 dryout phenomena versus in a P situation where I've
19 still got a lot of liquid somewhere, and I just
20 vapor near the wall. So, I'm over here in that
21 cartoon picture.

22 Is rewet and T_{min} one and the same?

23 MR. JACKSON: We'll discuss --- is it
24 one and the same? We'll discuss --- we'll get to
25 some of that.

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1 CHAIRMAN BANERJEE: Setting traps, don't
2 fall into the trap.

3 MR. JACKSON: I'm going to say I don't
4 know, and I'm not sure that --- but I think as we
5 go through today with the GE presentation and our
6 presentation, we'll get to ---

7 MEMBER CORRADINI: Okay.

8 MR. JACKSON: All right. And then if we
9 just --- that was my slide, but if we go back to
10 what we're tasked with in the MELLA+ Topical
11 Report, in redoing the ATWSI calculation in
12 conformance or in a similar way that we did for
13 this NEDO calculation back in the late '80s and
14 '90s. That's our objective here, that's what we're
15 tasked with doing.

16 MEMBER CORRADINI: Can I ask another
17 question?

18 MR. JACKSON: You betcha.

19 MEMBER CORRADINI: So, Staff is ---

20 MR. JACKSON: The picture going to help
21 me, or hurt me, or ---

22 MEMBER CORRADINI: Well, I don't know.
23 Staff is using --- Staff is strictly looking at
24 whether it would General Electric, AREVA, or some
25 vendors' proposal, or is Staff doing calculations

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1 with TRACE as an audit function to see what their
2 best state of knowledge says relative to all of
3 this?

4 MR. JACKSON: So, we did do confirmatory
5 calculations with TRACE and compared them with what
6 we were getting from a similar calculation done
7 with GE. We presented those results to the ACRS ---

8

9 MEMBER CORRADINI: Okay.

10 MR. JACKSON: --- on Grand Gulf. So,
11 yes, we've done a one-to-one comparison ---

12 CHAIRMAN BANERJEE: I guess the issue is
13 that --- yes, we saw those in Grand Gulf.

14 MR. JACKSON: Not for the Grand Gulf
15 plant, though, for a hybrid.

16 MEMBER CORRADINI: I understand.

17 CHAIRMAN BANERJEE: Some sort of plant.

18 MEMBER CORRADINI: So, if we go ---
19 don'[t go back to the curve, but if I look at that
20 curve there is somewhere in some document somewhere
21 a set of TRACE calculations that show how that
22 curve changes with pressure and flow. Because, to
23 me, that's --- in an ATWS, that's what initiates
24 something going off from the good side of the curve
25 to the bad side of the curve. It's either a

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1 pressure change, or a flow change.

2 MR. JACKSON: Or a power change.

3 MEMBER CORRADINI: Or a power change
4 which is initiated normally by the other two. So,
5 where would some calculation like that exist that I
6 can look at, if such calculations exist? Parametric
7 calculation such as that.

8 MR. JACKSON: I don't --- I'm going to
9 call a friend ---

10 DR. YARSKY: This is Peter Yarsky from
11 the Research ---

12 MEMBER CORRADINI: I recognize you.

13 DR. YARSKY: I think what you're sort of
14 requesting is, you know, how have we in our TRACE
15 calculations looked at sort of plotting out like
16 where we think the heat transfer regime is during
17 prototypic ATWS instability situations, and sort of
18 functional as that in terms of flow rate.

19 I mean, the pressure is very --- is
20 essentially constant, so it's really this flow
21 variation that's really important. But I don't
22 think that we've produced that figure, so I don't
23 think there's something that we can point to during
24 ---

25 MEMBER CORRADINI: So, a pump trip is

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1 the flow version of what I was ---

2 DR. YARSKY: Well, it really is ---
3 because of the instability, the magnitude of the
4 flow oscillation is what becomes very significant.

5 MEMBER CORRADINI: Okay.

6 CHAIRMAN BANERJEE: But, also, there's a
7 huge void oscillation.

8 DR. YARSKY: Yes.

9 MEMBER CORRADINI: But the initiator ---
10

11 DR. YARSKY: Which is also ---

12 MEMBER CORRADINI: --- is either flow
13 or pressure.

14 DR. YARSKY: --- significant, but
15 related to the flow oscillation.

16 CHAIRMAN BANERJEE: Yes.

17 MEMBER CORRADINI: It's either due to
18 flow or pressure, so you have done them for flow?

19 DR. YARSKY: We've done the calculation.
20 I don't think that we've plotted the result in the
21 way that I think you want us --- that you want to
22 see it, is what I'm saying.

23 MEMBER CORRADINI: Well, where I'm going
24 with this is, since we've seen a lot of things and
25 I can't remember who showed it, so I can't say what

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1 I saw, because I'm not sure who showed it. But it
2 sure would be instructive, because I want to --- I
3 actually want to see what the fuel experience is as
4 I go through this transient. And then map onto that
5 what you've decided at least in the audit world
6 what you think you believe as to the physics that's
7 going on. That's where I'm still struggling,
8 because I'm still struggling with the concept of
9 rewet versus Tmin, versus Tquench.

10 DR. YARSKY: Right.

11 MEMBER CORRADINI: So, I'll stop for
12 now.

13 CHAIRMAN BANERJEE: Okay. Chris, please
14 continue.

15 MR. JACKSON: Good. That's all I had. I
16 think some --- I could put up the picture of the --
17 -

18 CHAIRMAN BANERJEE: I think you are
19 lucky that you are getting off.

20 MR. JACKSON: I'll be back with the
21 Staff in the next session, or the session after GE.
22 So with that, I'll introduce them.

23 CHAIRMAN BANERJEE: Okay. Thanks, Chris.
24 So, now we're going to --- are you going to
25 introduce GEH to us, and go into closed session?

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1 MR. JACKSON: Yes. I think we were in
2 closed session, but ---

3 CHAIRMAN BANERJEE: No, we were not up
4 to this point.

5 MR. JACKSON: Okay.

6 CHAIRMAN BANERJEE: So, let me verify
7 that we are either in closed session, or not in
8 closed session. If we are not in closed session,
9 that we will be going into closed session. So,
10 please verify that ---

11 *(Off the record comments)*

12 *(Whereupon, the above-entitled matter*
13 *went off the record at 1:28 p.m. to enter Closed*
14 *Session, and reconvened in Open Session at 5:47*
15 *p.m.)*

16 CHAIRMAN BANERJEE: So, we are back in
17 session, open session now.

18 And I'd like to know if the bridgeline
19 is now open for the public as well? It's open?

20 So, is there anybody from the public on
21 the bridgeline who would like to make a comment?
22 If so, please identify yourself.

23 Since nobody is on the bridgeline at
24 the moment --

25 MS. ABDULLAHI: No, no, somebody

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1 quickly check, we just heard right, or was that any
2 of us connecting? Ask if somebody's on the
3 bridgeline.

4 CHAIRMAN BANERJEE: All right, but I
5 did.

6 MS. ABDULLAHI: Oh, okay.

7 CHAIRMAN BANERJEE: Is anybody on the
8 bridgeline? Public bridgeline?

9 Well, since nobody's on the bridgeline,
10 I think we'll move forward with the proceedings and
11 I'd like to ask any members of the subcommittee who
12 would like to make any comments during the open
13 session as to what they would like to say, you can
14 start.

15 Please, no proprietary information.

16 CONSULTANT ROHATGI: All the Tmin
17 correlations which have come out from low pressure
18 or LOCA type of analysis and are we trying to apply
19 them to ATWS?

20 And, the way there are a lot of
21 transients taking place and I think we need a
22 discussion, what causes Tmin, I mean because there
23 is maybe, Michael said the word compensating
24 phenomena, so we need a discussion from the vendors
25 on how the transient -- like film formation, heat

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1 transfer, conduction which will contribute to Tmin.

2 The other two is nobody talked about
3 contact anchor and I think if we had a paper where
4 they showed the contact anchor makes a big
5 difference in Tmin in 100 to 150 degrees.

6 And, all these data is about the
7 properties but nothing about contact anchors.
8 There is some discussion on that.

9 The other one was all these tests we
10 are doing, the size of the rod makes a difference.
11 The smaller the diameter, higher is Tmin.

12 I think, other than that, it was a very
13 interesting presentation and I enjoyed and I
14 learned.

15 CHAIRMAN BANERJEE: Great. So, we'll
16 get you the document, some of these --

17 CONSULTANT ROHATGI: Oh yes --

18 CHAIRMAN BANERJEE: -- and we'll pass
19 it on to the staff and then they can deal with it.

20 Okay, Steve, do you have any comments?

21 MEMBER SCHULTZ: I don't have further
22 comments or questions. I did want to thank all the
23 presenters today. I thought the discussions were
24 well organized and learned a lot from them. Thank
25 you.

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1 CHAIRMAN BANERJEE: Mike?

2 MR. COOK: No comments, just thank both
3 GE and the staff for their presentations.

4 CHAIRMAN BANERJEE: Okay. Kord, do you
5 have anything?

6 CONSULTANT SMITH: I have no
7 substantive comments. I found the presentations
8 were very well put together. Nicely followed.

9 CHAIRMAN BANERJEE: Mike?

10 MEMBER CORRADINI: No comments. I'm
11 glad that I'm finally homing in on the differences.

12 CHAIRMAN BANERJEE: You did have a
13 comment which was how one could have a parabolic
14 curve through two sets of data events?

15 MEMBER CORRADINI: I wasn't sure I was
16 allowed to say such things.

17 CHAIRMAN BANERJEE: It's okay.

18 MEMBER CORRADINI: No, this is -- be
19 branded a heretic.

20 CHAIRMAN BANERJEE: Yes.

21 MR. JACKSON: We stopped branding
22 heretics years ago.

23 MEMBER CORRADINI: I thought metallurgy
24 was black magic. The hydraulics guys have got --
25 we've got nothing.

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1 CHAIRMAN BANERJEE: So, I think it
2 remains for me to close this, but once more before
3 I close the meeting and thank everybody, I want to
4 know if there is anybody on the public line because
5 apparently the line was muted previously? Is it
6 not muted now?

7 DR. MARCH-LEUBA: Jose March-Leuba from
8 Oak Ridge, can you hear me?

9 CHAIRMAN BANERJEE: Yes, we can hear
10 you, Jose.

11 DR. MARCH-LEUBA: I'm here.

12 CHAIRMAN BANERJEE: Yes, you're here,
13 so the line is non-muted now.

14 Do you have any comment, Jose, that you
15 want to make?

16 DR. MARCH-LEUBA: No, I don't.

17 CHAIRMAN BANERJEE: Okay. So, with
18 that, it remains for me to thank everybody,
19 particularly GE, for coming out and making an
20 excellent presentation. I think it was very
21 illuminating and we appreciated hearing from you
22 very much.

23 And, thanks, of course, to the staff
24 for always, your presentation was also very
25 illuminating and your plans to go forward, I think,

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1 will have very strong support.

2 So, with that, thank you all, again,
3 for coming and I'd like to close the meeting. Is
4 it proper to say adjourn the meeting? Adjourn the
5 meeting.

6 (Whereupon, the above-entitled matter
7 was concluded at 5:53 p.m.)
8
9

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ACRS Thermal Hydraulics Subcommittee

Use of TRACG to Support Maximum Extended Load Line Limit Analysis Plus (MELLLA+) Licensing Decisions

September 21, 2015

Introduction

Christopher Jackson

Chief

Reactor Systems Branch

Division of Safety Systems

Office of Nuclear Reactor Regulation

Background (1/2)

- Extensions of Boiling Water Reactor operating domains to lower core flows (i.e., Maximum Extended Load Line Limit Plus (MELLLA+) and Extended Flow Window (EFW)) provide additional operator flexibility and reduce the need for control rod maneuvers
- As part of License Amendment Requests (LARs) related to MELLLA+ and EFW the NRC staff reviews the transient calculations of Anticipated Transients without Scram with Instability (ATWSI)

Background (2/2)

- Acceptance criteria for ATWS is coolable core geometry
- From NEDO-32047-A (June 1995):

“Peak clad temperatures are calculated to remain below 1500 K (2200°F) for all but a limited length of the hottest fuel rods in a few fuel bundles.”
- Applied 2200°F as a surrogate
- In light of uncertainty, have applied T_{min} (based on Shumway correlation) as acceptance criteria
- Nine Mile Point 2 MELLLA+ ACRS Letter (July 2015):

“As more dryout, post-dryout, and rewetting data become available at higher rod temperatures and oscillatory flows, the staff should confirm the adequacy of a fixed T_{min} in transient flow boiling calculations and post-dryout temperature predictions.”

Boiling Curve

Heat transfer for water (@ 1 atm)

S-shaped graph when heat flux (q'') is compared to temperature.

