

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards
546th Meeting

Docket Number: (n/a)

PROCESS USING ADAMS
TEMPLATE: ACRS/ACNW-005
SUNSI REVIEW COMPLETE

Location: Rockville, Maryland

Date: Thursday, October 4, 2007

Work Order No.: NRC-1797

Pages 1-245

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

October 4, 2007

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

546th MEETING

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THURSDAY,

OCTOBER 4, 2007

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ROCKVILLE, MARYLAND

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The Committee met at the Nuclear
Regulatory Commission, Two White Flint North,
Room T2B3, 11545 Rockville Pike, at 8:30 a.m.,
William J. Shack, Chairman, presiding.

MEMBERS PRESENT:

- WILLIAM J. SHACK Chairman
- MARIO V. BONACA Vice Chairman
- SAID ABDEL-KHALIK Member-At-Large
- GEORGE E. APOSTOLAKIS Member
- J. SAM ARMIJO Member
- SANJOY BANERJEE Member
- DENNIS BLEY Member
- MICHAEL CORRADINI Member
- OTTO L. MAYNARD Member

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1 MEMBERS PRESENT: (cont'd)

2 DANA A. POWERS Member
3 JOHN D. SIEBER Member
4 JOHN STETKAR Member

5 NRC STAFF PRESENT:

6 TANNY SANTOS, Designated Federal Official
7 STEVE ARNDT
8 BELKYS SOSA
9 GURIJA SHUKLA
10 JACK GROBE
11 MIKE WATERMAN
12 DAVID BEAULIEU
13 WARREN LYON
14 AL CSONTOS
15 TED SULLIVAN
16 TIM LUPHOLD
17 DAVE RUDLAND
18 GARY HAMMER

19 ALSO PRESENT:

20 KIMBERLEY KEITHLINE
21 GORDON CLEFTON
22 JIM RILEY
23 GLENN WHITE
24 DAVID STEININGER

25

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

(8:31 a.m.)

CHAIRMAN SHACK: The meeting will now come to order.

This is the first day of the 546th meeting of the Advisory Committee on Reactor Safeguards. During today's meeting, the Committee will consider the following: digital instrumentation and controls project plan and interim staff guidance; a draft generic letter on managing gas intrusion in ECCS, decay heat removal, and containment spray systems; dissimilar metal weld issue; draft ACRS report on the NRC Safety Research Program; and the preparation of ACRS reports.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Tanny Santos is the Designated Federal Official for the initial portion of the meeting.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's session. A transcript of portions of the meeting is being kept, and it is requested that speakers use one of the microphones, identify themselves, and speak with sufficient clarity

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1 and volume, so they can be readily heard.

2 I will begin with some items of current
3 interest. We have a new member of the ACRS with us
4 today, Dennis Bley. Welcome aboard, Dennis.

5 MEMBER BLEY: Thank you.

6 CHAIRMAN SHACK: We also have a returnee.
7 Jack Sieber is back with the Committee after an
8 absence, so welcome back, Jack.

9 MEMBER SIEBER: Okay. Thank you.

10 (Applause.)

11 MEMBER APOSTOLAKIS: That was for both,
12 right?

13 CHAIRMAN SHACK: Mr. Dave Fischer, who has
14 been with the NRC for 26 years, of which about two
15 years have been with the ACRS staff, is retiring at
16 the end of October. For the past two years, he has
17 provided outstanding technical support to the ACRS in
18 reviewing numerous technical issues, including the
19 technology-neutral framework for future plant
20 licensing, proposed revisions to 10 CFR Part 52,
21 proposed regulatory guide and combined license
22 applications, risk-informed and performance-based
23 revisions to 10 CFR 50, early site permit
24 applications, and revisions to regulatory guides
25 applicable to future plans. And probably the hardest

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1 job of all is he had to read Tom Kress' handwriting
2 all that time.

3 (Laughter.)

4 His hard work, dedication, attention to
5 details, professionalism, and outstanding technical
6 support to the Committee are very much appreciated.
7 Good luck in your future endeavors.

8 (Applause.)

9 I should also note that our distinguished
10 colleague, Dr. Apostolakis, was inducted this week
11 into the National Academy of Engineering. Members of
12 the Academy are elected by their peers, and election
13 to the Academy is one of the highest professional
14 honors accorded to an engineer. So congratulations.

15 (Applause.)

16 Denny Ross, who had a long and
17 distinguished career in the nuclear industry, passed
18 away suddenly a little while ago. There's a good
19 writeup on Denny in the items of interest, though,
20 that I commend to everybody.

21 There is also some speeches in the item of
22 interest by Chairman Klein -- one, comments on some
23 items that we have been considering with GNEP, the
24 multi-national design evaluation program and its
25 possible relation to the technology-neutral framework,

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1 and he has another speech on digital I&C. There are
2 also some interesting SRMs related to the technology-
3 neutral framework and 50.46.

4 One other item -- Mr. Sam Duraiswamy is
5 being recognized for 30 years of government service.
6 Sam has been an extremely valuable member of the ACRS
7 technical staff, and is a walking Wikipedia of ACRS
8 experience and history in nuclear reactor regulation.

9 I, and all the members, are greatly
10 appreciative of his dedication and long service to the
11 mission of the ACRS.

12 (Applause.)

13 Sam gets a certificate and a pen in lieu
14 of a raise.

15 (Laughter.)

16 Our first item of business this morning is
17 digital instrumentation and controls project plan and
18 interim staff guidance, and our distinguished member
19 of the National Academy, Dr. Apostolakis, will lead us
20 through the discussion.

21 MEMBER APOSTOLAKIS: I had no --

22 (Laughter.)

23 Thank you, Mr. Chairman. We will hear
24 today from the industry, NEI representatives, and they
25 will give us their perspective on the work that is

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1 being done on digital I&C. And then, of course, we
2 will also hear from the staff on overall activities of
3 the Steering Committee, and, in particular, the three
4 interim guidance reports that they have issued on
5 diversity and defense in depth, highly integrated
6 control rooms, the communications issues, and the
7 human factors issues in highly integrated control
8 rooms.

9 Our I&C Subcommittee met with NEI and the
10 staff on the 13th of September, and again we covered
11 these issues. The members of the Subcommittee were,
12 in general, pleased with the progress that is being
13 made. There was only one issue that we discussed in
14 detail, and perhaps the Committee today also should
15 pay extra attention to it.

16 In the guidance on defense in depth and
17 diversity, the staff states that for 30 minutes after
18 the incident there should be no reliance on human --
19 on manual actions. Therefore, there should be a
20 backup system, if necessary, if appropriate.

21 The issue of the -- not in particular the
22 numerical value of 30 minutes -- I mean, people felt
23 that if you are to have a number, 30 minutes is as
24 good as any, and the staff has some rationale for it.
25 But the question was whether we needed a number at

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1 all, and whether there should be a process in place.

2 And in each case there should be an
3 evaluation of how things are progressing and whether
4 the operators in fact could intervene, say even before
5 30 minutes, and the analysis -- the analysis showed
6 that if they could do so reliably, then of course that
7 would be an acceptable -- an acceptable measure of
8 defense in depth.

9 And I would remind the Committee that
10 similar considerations were reviewed when we reviewed
11 the regulatory guide on manual actions in the case of
12 fire, where there was extensive discussion of manual
13 actions, the context within which they might occur,
14 and so on.

15 The staff came back and said, "Well, we
16 would expect to have a lot of give and take if the
17 licensee argued that the operators could intervene
18 reliably in a period less than 30 minutes." And we
19 are offering -- the 30-minute limit -- is a way out of
20 it. In other words, instead of spending time arguing
21 back and forth, we are telling the licensees that, you
22 know, if you do this by 30 minutes, then that would be
23 an acceptable way to proceed.

24 But the staff said that they would be open
25 to other approaches that would consider manual

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1 actions, even in less than 30 minutes. And they in
2 fact added a couple of sentences to the guide, which
3 I expect we will read later today, to make sure that
4 we all agree with what is being said there.

5 But in general, as I say, the Subcommittee
6 members were very pleased with the progress, and there
7 is also progress on that other recommendation that we
8 made to the staff some time ago to develop a
9 classification of the digital systems that will be
10 used in -- are being used or will be used in the
11 future in reactors, and also to collect failure data,
12 so that future activities will be informed by the
13 operating experience.

14 And with that, I would call upon NEI to
15 start the presentations. In fact, I believe this is
16 the last time we see Ms. Keithline. She is going back
17 to naval reactors.

18 MS. KEITHLINE: Yes, yes. Just the last
19 time you'll see me representing the commercial
20 industry.

21 (Laughter.)

22 Oh, we see you all from time to time at
23 naval reactors, and I'm going back to the Reactor
24 Safety Division, so --

25 MEMBER APOSTOLAKIS: Okay. That's

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1 something we are dealing with.

2 MS. KEITHLINE: But today it's still
3 digital I&C.

4 MEMBER APOSTOLAKIS: Okay.

5 MS. KEITHLINE: Okay.

6 MR. RILEY: Since you brought it up, if I
7 could make a quick comment. This is Jim Riley. I'm
8 Director of Engineering. Gordon Clefton, who is
9 sitting back here with a blue sportcoat on, is taking
10 over from Kimberley in --

11 MEMBER APOSTOLAKIS: Why don't you come --

12 MR. RILEY: -- the future.

13 MEMBER APOSTOLAKIS: -- up front?

14 MR. CLEFTON: She can handle it fine
15 today.

16 (Laughter.)

17 I'll be up there later this morning.

18 MEMBER APOSTOLAKIS: Okay.

19 MS. KEITHLINE: All right. Well, we
20 appreciate the opportunity to meet with you today to
21 share our perspective on what has happened on digital
22 I&C, and on what we think still should happen in the
23 future as we go forward.

24 The creation of NRC's I&C Steering
25 Committee and the task working groups has been very

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1 helpful in focusing the effort and driving some of
2 these issues towards resolution. We're encouraged by
3 the interactions we've had with the staff during the
4 past several months. They have listened to our
5 concerns, and in some cases have incorporated or
6 otherwise addressed our comments, and we appreciate
7 that.

8 The open dialogue we've had with the staff
9 has given us the opportunity to better understand what
10 is important to the reviewers, and why they are
11 concerned about specific things. Hopefully, with that
12 knowledge we'll be able to address those issues
13 earlier in the design and review processes.

14 Now, it would be nice at this point to
15 declare victory and announce that we're done and that
16 I don't really need to turn everything over to Gordon
17 Clefton. However, there is still really a lot left to
18 do in the digital I&C area. The interim guidance that
19 has been generated needs to be tested. You know,
20 we've really got to apply it and use it, and in some
21 cases we may need to further refine that guidance.

22 And there are other areas where we haven't
23 yet developed the guidance for where we still need to
24 do that to ensure that we have a predictable, cost
25 effective, timely, and safe implementation of digital

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1 technology.

2 As you'll see in the initial interim staff
3 guidance documents, the staff intends to continue
4 interacting with stakeholders to refine the digital
5 I&C ISGs, as we call them -- interim staff guidance
6 documents -- and to update associate guidance and
7 generate new guidance where appropriate.

8 Okay. So we've set up that basis for
9 continued interaction in this area, and industry
10 believes that that's very important to the success of
11 digital I&C and nuclear power applications.

12 Okay. So we're just going to jump right
13 in and start with one of the most challenging areas
14 and one where there really remains quite a bit to be
15 done. Task Working Group Number 2, the Diversity and
16 Defense in Depth, or D³ group, or D-cubed group as we
17 call it sometimes, they took on quite a challenge last
18 winter.

19 And this group has been working on seven
20 problem statements that really are all aimed at
21 answering two basic questions: When is diversity
22 needed? And what constitutes adequate diversity? As
23 many of us heard at the IAEA meeting in June, there
24 isn't a silver bullet or magic solution to dealing
25 with the possibility of common cause failures in

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1 digital systems.

2 Last week NRC issued interim staff
3 guidance to address these questions. Based on what's
4 in the ISG, we can probably check off a couple of our
5 problem statements as being completed. So there is
6 good progress that has been made.

7 There are a couple more problem statements
8 that will need to have some additional discussion I
9 think to make sure that we understand exactly what the
10 intent of some of the words is and how exactly it will
11 be implemented. But that's a -- we'll work through
12 that.

13 There are three problem statements that we
14 probably -- I'm pretty confident there will need to be
15 additional work, and those three are related to taking
16 credit for manual operator actions, the applicability
17 of common cause failures, and adequate diversity.
18 I'll discuss those in a little bit more detail.

19 And the use of risk insights in D³
20 applications, that's currently not a specific problem
21 statement for the D³ Task Working Group. It does fall
22 within the Risk-Informing Task Working Group, and we
23 think it relates in a very important way to diversity
24 and defense in depth.

25 So I'll say a little bit more about manual

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1 operator actions. This is the 30 minutes. The D³
2 interim staff guidance includes a 30-minute criteria
3 for determining whether an automatic diverse actuation
4 function is necessary, and the ISG says specifically,
5 "Manual operator actions may be credited for
6 responding to events in which the protective action
7 subject to a common cause failure is not required for
8 at least 30 minutes."

9 Industry is concerned that this guidance
10 could in some cases result in the need for automation
11 and complexity that might not really enhance reactor
12 safety. Our fundamental belief is that credited
13 manual actions taken to initiate protective functions
14 must be demonstrated. We've got to show that it's
15 feasible to take those actions in the times assumed.

16 Industry is recommending --

17 CHAIRMAN SHACK: Feasible and reliable,
18 right?

19 MS. KEITHLINE: Feasible and reliable.
20 Now, having said "reliable," I've read through the
21 NUREG for the fire protection --

22 MEMBER APOSTOLAKIS: 1852.

23 MS. KEITHLINE: -- NUREG-1852, and I
24 personally am not sure that I would go as far as that
25 draft went in terms of the reliability discussion, but

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1 feasible and reliable. Details to be worked out.

2 MEMBER APOSTOLAKIS: Don't throw that bomb
3 out and say --

4 (Laughter.)

5 -- let's go on. But there will be
6 another time for this I guess, so --

7 MS. KEITHLINE: Yes. The next thing -- I
8 was actually going to mention that at our Subcommittee
9 meeting Dr. Apostolakis did point out that that NUREG
10 -- NUREG-1852 -- discussed manual actions in response
11 to fires. And the basic approach is very similar to
12 what we've been talking about doing for digital I&C.

13 For I&C, the scenario is that a common
14 cause failure prevents the safety system from
15 responding when you need it -- for example, during a
16 loss of cooling accident. If we want to rely on
17 operators to back up the digital system, we need to
18 enable the operator to determine what actions are
19 needed, and then successfully execute those actions.

20 Okay. So that means the operator needs to
21 have a sufficient set of diverse indications so that
22 he will know he needs to take action. He also needs
23 to have good procedures to tell him what actions to
24 take, and he needs to be trained to recognize the
25 indications and properly execute the correct

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1 procedures.

2 Then, we need a way to validate our
3 assumptions. And in general concept, that's very
4 similar to what was done I believe for the fire
5 scenario.

6 And we'd like to continue working with
7 both the D³ -- the Diversity and Defense in Depth Task
8 Working Group and the Human Factors Task Working Group
9 to develop -- further develop an agreed-upon
10 methodology for making these assumptions about
11 operator response times.

12 The second bullet under --

13 MEMBER APOSTOLAKIS: Let me understand
14 what your position is. You are not -- you are not
15 really -- you didn't really state a definitive
16 position. You are just saying that you are
17 uncomfortable with the 30-minute limit, but you really
18 don't know what to do about it. Is that --

19 MS. KEITHLINE: Well, we would like to
20 have a process or a methodology similar in concept to
21 what's in fire, and we've got a white paper that we
22 submitted to the staff over the summer that describes
23 a similar process that could be used for digital I&C.
24 But because of the timing and the resource limitations
25 and the need to get interim staff guidance out, we

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1 haven't had a chance to work through that white paper
2 and that concept with the staff yet.

3 MEMBER APOSTOLAKIS: Do we have that
4 paper?

5 PARTICIPANT: Yes.

6 MEMBER APOSTOLAKIS: We do. I remember
7 reading --

8 MEMBER CORRADINI: We haven't seen it.
9 Have we seen it?

10 MEMBER APOSTOLAKIS: Yes.

11 MR. SHUKLA: I'll make sure that you get
12 it.

13 MEMBER APOSTOLAKIS: Okay. So right now
14 you're saying it would be nice to have a process. you
15 have made the first proposal.

16 MS. KEITHLINE: Yes.

17 MEMBER APOSTOLAKIS: And at some point in
18 the future we'll have to actually review it and see
19 how we can proceed.

20 MS. KEITHLINE: Right, yes.

21 MEMBER APOSTOLAKIS: Okay. Okay.

22 MS. KEITHLINE: On the second bullet under
23 remaining challenges, use of risk insights, industry
24 is concerned that the deterministic approach to
25 diversity and defense in depth might result in the use

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1 of automatic diverse actuation systems that do not
2 improve plant safety, and in some cases might actually
3 degrade safety, because of the increased complexity
4 and the potential for spurious actuations.

5 We believe that risk insights can help
6 determine where defense in depth and diversity are of
7 value from a plant safety perspective, and we've
8 talked about this in a way that's similar to some
9 discussions and maybe a concept that was -- that
10 influenced the development of the ATWS rule. Where
11 would these extra systems or functions really add
12 value? Where could you really show that they reduced
13 risk and improved safety?

14 And we began discussing this with the
15 Risk-Informing Task Working Group, and only introduced
16 the concept to the Diversity and Defense in Depth Task
17 Working Group. So this is another area where we need
18 to have some additional dialogue on what have we
19 learned about risk and safety, especially from what
20 we've seen in PRAs, and how can we apply that
21 knowledge to the decisionmaking process for diversity
22 and defense in depth.

23 The next two bullets here -- common cause
24 failure applicability and adequate diversity -- are
25 specific problem statements in the D₃ ISG, and these

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1 are -- these are areas where we think some additional
2 refinement may be appropriate.

3 Where the ISG addresses common cause
4 failure applicability, it says there are two ways to
5 eliminate the consideration of a digital common cause
6 failure. You can either build sufficient diversity
7 into the system, or you can make the system 100
8 percent testable. And there is some concern about
9 whether 100 percent testability is really achievable.
10 If it's not, then we'd need to build diversity into
11 the system. That sounds okay.

12 The example given is that for a four-
13 channel system you could use two channels that have
14 one type of digital system, and the other two channels
15 would have a diverse -- a different digital system.

16 It's not obvious that a hybrid system of
17 -- systems like that would really be the best
18 solution. And diversity is not the only means to
19 protecting against digital common cause failures.
20 Other methods -- and we refer to them as defensive
21 measures -- could be effective in precluding or
22 limiting digital common cause failures.

23 Industry is working on a white paper with
24 insights on the mechanisms of digital common cause
25 failures to help determine when a digital system

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1 should or might not be considered susceptible to
2 common cause failures.

3 And so we intend to over the next several
4 weeks or months -- I'm not sure what the exact timing
5 is at the moment, the paper is in the process of being
6 worked on -- be giving NRC staff a recommendation, a
7 white paper proposal, on further refining this
8 guidance on common cause failure applicability.

9 MEMBER APOSTOLAKIS: So you are proposing,
10 then, something that will replace this NUREG from the
11 '80s that tells you how to do the common cause failure
12 analysis? Or you are expanding on it? You are
13 becoming more specific? It's amazing that we are
14 still using a report from way back in '83 I think it
15 is or something like that. And, you know, are you
16 guys working on that, or is it something in addition
17 to that?

18 MS. KEITHLINE: Well, much of the focus --
19 specific focus has been related to the Branch
20 Technical Position 7.19. Mike Waterman might say more
21 about NUREG-6303. I think that's the one he's
22 referring to.

23 MEMBER APOSTOLAKIS: I think that's what
24 it is, yes. Yes.

25 MS. KEITHLINE: And so -- are you guys

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1 planning to talk about that at all?

2 MEMBER APOSTOLAKIS: Well, you can comment
3 now if you --

4 MR. ARNDT: We'll talk about it very
5 briefly. But it was actually a 1994 document. It was
6 developed --

7 MEMBER APOSTOLAKIS: Then it's okay,
8 Steve.

9 (Laughter.)

10 MR. ARNDT: No, it's not okay.

11 (Laughter.)

12 It needs work, but we are at both -- as
13 part of an ongoing research program to improve and
14 provide additional guidance associated with that, as
15 well as part of the ongoing work of the Task Working
16 Group planning to work with the industry on doing
17 that.

18 MEMBER APOSTOLAKIS: So that's really what
19 we're talking about, the methodology --

20 MR. ARNDT: Well, there's two issues.
21 There's, how do you define the attributes associated
22 with what is acceptable diversity? And, in addition,
23 when you look at things like sufficiently testable or
24 sufficiently simple, not required in diversity, that's
25 something in addition to that. Diversity is in --

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1 MEMBER APOSTOLAKIS: Well, you're already
2 starting with a great weakness of the structure list
3 defense in depth, aren't you?

4 MR. ARNDT: Yes.

5 MS. KEITHLINE: Okay. Moving on, the last
6 thing on the --

7 MEMBER POWERS: Can I sneak --

8 MEMBER APOSTOLAKIS: We just see what is
9 happening.

10 MEMBER POWERS: This is all rationalist
11 defense in depth here.

12 MEMBER APOSTOLAKIS: Oh, they're trying to
13 put some rationality into it. But right now they are
14 caught in the tentacles of structuralism. Dennis?

15 MEMBER POWERS: I forgot what I was going
16 to ask.

17 (Laughter.)

18 Pardon me. Excuse me.

19 MEMBER APOSTOLAKIS: It's okay, Dana.

20 MEMBER BLEY: I haven't read all the
21 history of what has been going on here, but are you
22 going to talk about -- or do we have documents that
23 talk about the alternatives you were referring to to
24 diversity? Explaining the --

25 MS. KEITHLINE: Like the example of the

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1 four-channel system with two channels of one type and
2 two of a different?

3 MEMBER BLEY: Okay. Well, you had said in
4 -- well, you called that a diverse approach, a kind of
5 diversity. But then you said, "We're not convinced
6 diversity is even the best way to protect against
7 common cause." You have defensive measures or
8 something like that. Have you provided information on
9 the kinds of things you're thinking about for those
10 measures?

11 MS. KEITHLINE: We've had discussions. I
12 believe that's addressed to some extent in a topical
13 report EPRI submitted a couple years ago, and we've
14 got a white paper being developed right now to address
15 that in more detail.

16 MEMBER BLEY: Do we have that EPRI
17 topical?

18 MEMBER APOSTOLAKIS: We probably do, yes.
19 We have -- yes, we have -- make sure that Dr. Bley --

20 MR. SHUKLA: I do not know, sir, but I'll
21 check.

22 MEMBER BLEY: Thanks.

23 MEMBER APOSTOLAKIS: I believe I saw it
24 some time ago.

25 MEMBER BLEY: Thanks.

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1 MS. KEITHLINE: All right. And then, the
2 last thing on this list is adequate diversity. The
3 problem statement for this group specifically -- it
4 included consideration of the following questions.
5 How much diversity is enough? Are there precedents
6 for good engineering practice? Can sets of diversity
7 attributes and criteria provide adequate diversity?
8 How much credit can be taken for designed-in
9 robustness? Are there standards that can be endorsed?

10 And these questions have not been
11 completely addressed yet in the interim guidance, so
12 this -- and there is research ongoing, so this is an
13 area that still needs some further refinement, we
14 believe.

15 And so my next slide is the path forward.
16 Most of these I've mentioned. We want to continue
17 working to develop that methodology for operator
18 response time assumptions. We want to develop a
19 process for considering risk, risk insights in D³
20 decisionmaking. We'd like to further refine the
21 interim staff guidance in some areas. Ultimately, we
22 believe it would probably be a good idea to revise
23 Branch Technical Position 7.19.

24 Now, to do these things, there are a
25 couple efforts underway that will support these

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1 efforts, we believe. One is that the staff, Mike
2 Waterman in particular, is working on and probably
3 getting close to completing some research on adequate
4 diversity. And Mike may say something about that
5 later this morning, but that will help address some of
6 these issues we think.

7 Also, industry and NRC are both working on
8 reviewing operating experience data. What are we
9 learning from digital system failures? And I have the
10 next slide to talk a little bit about that -- what
11 we're doing, the industry is doing.

12 EPRI is working on a project to review
13 digital I&C operating experience in U.S. commercial
14 nuclear power industry. Bruce Geddes from Southern
15 Engineering Services is doing much of this work, with
16 assistance from Ray Torok, Vic Fregonese, Thuy Nguyen,
17 and Bell, -- our George Washington University student
18 -- who is an intern at NEI right now. She's here in
19 the audience.

20 MEMBER APOSTOLAKIS: That's the guy who's
21 doing the work.

22 (Laughter.)

23 MS. KEITHLINE: So far this group, with a
24 lot of help from Bell, has reviewed operating
25 experience reports for more than 300 events that

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1 occurred between 1987 and this year roughly.

2 Bruce created a database for capturing the
3 characteristics of each event, including the cause and
4 corrective action, as reported by the plant. So we're
5 starting with the documents that were generated by the
6 plant, reporting the failure. What did they say about
7 cause and corrective action?

8 The database also identifies the plant
9 system involved, its safety classification, whether or
10 not the event was really due to a digital failure, or
11 whether it was a non-digital failure in a digital
12 system, whether it was a common cause failure, and
13 what -- we get into defensive measures or diversity
14 attributes could be or could have been employed to
15 reduce or prevent such an event.

16 MEMBER CORRADINI: May I just ask a
17 clarification?

18 MS. KEITHLINE: Yes.

19 MEMBER CORRADINI: So these are like
20 feedwater systems, turbine systems, secondary systems
21 primarily?

22 MS. KEITHLINE: Those are the systems that
23 mostly exist, yes.

24 MEMBER CORRADINI: So is this something
25 that is -- since it's a student, available in such a

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1 manner that others can look at it, or is this
2 something that is being held internally to the NEI?

3 MS. KEITHLINE: It will be. It will be
4 made available. Right now we're in the process of
5 writing a draft report and rewriting it. Some of the
6 information has come from the INPO database. We
7 didn't find it all through the NRC databases. So
8 we're working with INPO to make sure we know what
9 information needs to be removed from those events --
10 plant names specifically, maybe a couple other things
11 -- so that it -- we can share it with others.

12 We've been discussing what we've been
13 doing with the staff to make sure they have some idea
14 of what we're doing with the data, and we do plan to
15 make the white paper report available for wide
16 distribution when it's ready.

17 MEMBER CORRADINI: But let me just go one
18 step further. So if you're going to generate this in
19 some fashion that's going to be database or some sort
20 of simplified thing, the electronic version of being
21 able to search through the 300 would be also just as
22 nice as the report. So others might want to go back
23 in mine and look at it themselves.

24 MS. KEITHLINE: And we are discussing how
25 we could do that, whether we can remove enough

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1 information so that we'd be allowed to share it and
2 still have it be usable.

3 MEMBER CORRADINI: Okay.

4 MS. KEITHLINE: I would like to be able to
5 do that. That's still under discussion.

6 MEMBER CORRADINI: These different eyes
7 that the basic data would make for very useful I
8 think --

9 MS. KEITHLINE: Yes.

10 MEMBER BLEY: Another point. Since a lot
11 of what you've said up to now deals with measures for
12 dealing with common cause problems, is there any plan
13 for events that might be interesting common cause
14 events in this database to go back to the plants
15 themselves rather than just look at the database
16 records?

17 MS. KEITHLINE: We've talked about that.
18 When looking at these events, are there questions that
19 we would ask? Would we like to learn more than what
20 was just in the report?

21 Now, it turns out that some of the people
22 working on this were there for some of those events.
23 And so that's real nice.

24 Some of the events happened several years
25 ago, which makes it a little bit harder to be able to

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1 track down the knowledgeable people. We haven't
2 decided where there will be a -- maybe a subset of
3 particularly interesting events that we do want to dig
4 into more deeply and see -- some are more interesting
5 than others, and we have discussed whether we would
6 try to do that for some events.

7 MEMBER BLEY: Well, you'll find a lot more
8 -- I'll say more information, and maybe different, if
9 you do that.

10 MS. KEITHLINE: Yes. I'm a little bit
11 nervous about the finding different information.
12 We're using documents that have been generated by the
13 plants and gone through the proper approval cycles.

14 MEMBER BLEY: More is probably a better
15 word.

16 MS. KEITHLINE: Okay. So on this one we
17 have started and do intend to share more information
18 with the staff. We want our efforts in this area to
19 compliment each other, and we're going to document our
20 findings in a paper that we hope to distribute widely
21 in the near future.

22 MEMBER APOSTOLAKIS: A few months? Is
23 that what you mean?

24 MS. KEITHLINE: Well, we were hoping for
25 last month.

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1 MEMBER APOSTOLAKIS: Oh, okay.

2 MS. KEITHLINE: So I --

3 MEMBER APOSTOLAKIS: It's imminent.

4 MS. KEITHLINE: I'm hoping it's this
5 month, but I can't commit to that.

6 MEMBER APOSTOLAKIS: Okay.

7 MEMBER ABDEL-KHALIK: Is this a complete
8 data set?

9 MS. KEITHLINE: No, it's not the complete
10 data set. One interesting thing is in here you're
11 going to tell me that we should all pat Mike on the
12 back. Mike Waterman found some events that we have
13 not been able to find the documentation on yet. There
14 are over 500 events collectively that between Mike and
15 us we've been able to find, and there's quite a bit of
16 overlap between those two sets of data. But we're
17 still working.

18 He must be a really good researcher, and
19 we haven't found all of us, so ours so far includes
20 over 300 -- I think it's around 324 for the ones where
21 we have found the documents, the source documents.
22 We've got more work to do.

23 Okay. I'm going to probably go through
24 these pretty quickly, so that I give the staff enough
25 time to do their presentations. Just briefly, on

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1 three of the other task working groups, communications
2 -- this is Task Working Group Number 4. They had the
3 benefit of having a very clearly defined problem and
4 got a headstart on the effort.

5 This group is dealing with the need for
6 better guidance for interdivisional independence and
7 data communication. There is an IEEE standard,
8 7-4.3.2, that has an annex -- Annex Echo -- that
9 provides guidance for communications independence in
10 digital safety systems.

11 Now, Reg. Guide 1.152 endorses IEEE 7-
12 4.3.2, but it specifically did not endorse Annex Echo,
13 and in fact said that annex provided insufficient
14 guidance. So Task Working Group Number 4 developed
15 additional guidance that describes acceptable methods
16 for addressing data communications issues in digital
17 systems.

18 That interim staff guidance was issued for
19 use last week, and in general the industry is fairly
20 pleased with that guidance. Many of our comments and
21 concerns were addressed. There was a lot of dialogue
22 between the staff and industry on this one.

23 There may be a couple areas where we will
24 need to make sure we really understand how the
25 guidance will be implemented and interpreted, and

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1 we're going to continue to work with the staff to do
2 that, and, if necessary, to further refine the
3 guidance.

4 The IEEE Standards Association has a
5 working group that is working on a revision to the
6 Standard 7-4.3.2. They have been following what the
7 task working group has been doing, and they hope to
8 incorporate much of the newly-developed guidance into
9 the standard. Ideally, we'd like to be able to
10 incorporate that newly developed guidance into the
11 standard, and then have the next revision of 1.152
12 endorse the standard. That's our goal there.

13 Human factors -- this is Task Working
14 Group Number 5, and they have four problem statements
15 which are listed here. The first two problem
16 statements were determined to be the highest priority,
17 and have been the subject of most of the effort over
18 the last couple months.

19 The original plan was for industry to
20 provide reports or white paper recommendations on
21 minimum inventory and computer-based procedures before
22 new regulatory guidance was developed. And the idea
23 was that these reports -- and our hope was that these
24 reports could be endorsed by the NRC.

25 We submitted a report on minimum inventory

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1 in late May, and then the schedule was accelerated to
2 issue interim staff guidance by the end of September.
3 With that acceleration, we had to -- we and NRC had to
4 shift our efforts over to getting the near-term
5 guidance out, and so we haven't quite worked through
6 the more detailed minimum inventory report that we
7 submitted to them.

8 That has also delayed our work on the next
9 couple reports that we intend to submit -- computer-
10 based procedures and a graded approach to human
11 factors.

12 The remaining challenges for this group
13 are implementing the ISG. We've got an interim staff
14 guidance document out there now, and, of course, the
15 next test will be how useful, how well does it work.
16 You know, you really find that out when you try to go
17 use it. The group worked on it. Lots of dialogue,
18 comments, discussion back and forth. We think they
19 are pretty good. We want to make sure that they
20 really contain what the staff is thinking so we'll
21 know what they expect when we make a submittal and do
22 our design, and we'll see how that goes.

23 There are lots of longer term actions for
24 this group. There are some significant ones with --
25 that are, you know, resolving these issues, and then

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1 addressing graded approach to human factors and a
2 question about the safety parameter display system and
3 whether it needs to be a stand-alone console. So --

4 MEMBER BLEY: Excuse me. What's the
5 extent of actual operator participation in this group?

6 MS. KEITHLINE: We have some -- we don't
7 have current operators participating.

8 MEMBER BLEY: How far removed are the --

9 MS. KEITHLINE: How far removed? He's not
10 here. Chris Kerr from Exelon has given us excellent
11 operator perspective with some comments in these
12 discussions back in August, things that we were
13 considering doing, putting into the guidance, and he
14 said, "You know, if you do that, this is what's going
15 to happen in the control room during an event." And
16 that's not really what you want to have happen, is it?
17 And so we incorporated that.

18 There are probably opportunities as we go
19 forward to engage additional operators.

20 MR. RILEY: Yes, I'd like -- that's a good
21 point, and what I'd like -- I'd like to take that away
22 as an action. We'll check and see where we are with
23 respect to that and make sure we --

24 MEMBER MAYNARD: Well, aren't most -- a
25 lot of the members on your working group are from the

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1 industry. I'm sure they go back to their plants and
2 they work with folks at their plants, so you may have
3 people who aren't on the task force who are actually
4 providing quite a bit of input, too.

5 MS. KEITHLINE: Yes. We can probably do
6 more. One thing I should mention -- this particular
7 group is being picked up by another new person to NEI,
8 but not someone who is new to the industry. Russell
9 Smith comes to NEI from Comanche Peak, where he has
10 been the Director of Operations, and I think will
11 naturally make that linkage to the operators. But
12 we'll keep that in mind. That's important.

13 MEMBER BLEY: Just to follow that up --
14 one of the things we talked about earlier, in general
15 on all of the I&C issues, has there been an effort to
16 have operators involved in those issues as they
17 progress?

18 MS. KEITHLINE: Not as extensively as I'm
19 used to doing. However, some of this guidance has
20 developed very quickly. And we do have people with
21 operational backgrounds and linkages to all of the --
22 to all -- to plants involved in the discussions. But
23 that's -- as we said, it's something we can do more of
24 as we move forward.

25 MEMBER BLEY: I would hope that you would,

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1 yes.

2 MR. GROBE: This is Jack Grobe with NRR.
3 Kimberley, could you just share with the ACRS relative
4 fractions of vendor architect engineer type people
5 versus operating plant people that are on your working
6 groups?

7 MS. KEITHLINE: It varies from working
8 group to working group to task working group,
9 depending on the subject matter. We have -- we have
10 a pretty good mix of utility and vendor people on D³.
11 They are really active people. I'd say it's close to
12 50/50 utility people and vendor people. I could start
13 rattling off names, but I don't think that's a good
14 use of time right now this morning. We'll make sure
15 that we keep those utility people and reach out to
16 even more operational type people. Okay.

17 MR. RILEY: And there's a large number of
18 people involved in the D³ groups. There's a lot of
19 interest there, so we've got a pretty good cross-
20 section and a pretty good sampling at the same time.

21 MEMBER BLEY: I'm sure they'd be really
22 interested in participating.

23 MS. KEITHLINE: Oh, we have -- we have a
24 lot of them. We have very large distribution lists.
25 It is a very large group of people.

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1 Path forward on human factors -- as we
2 said, we're reviewing right now these final issued
3 interim staff guidance -- this document, and it may be
4 appropriate to refine it as we move forward in the
5 future.

6 We've got three reports that are either --
7 that are in progress. Two of them have not been
8 submitted yet -- on computer-based procedures and
9 graded approach. We would ideally like to get NRC
10 endorsement of those reports in the future as industry
11 guidance documents. And then, there may be additional
12 guidance that needs to be developed or modified.
13 There are some NUREGs out there, that type of thing.
14 So that's human factors. It's going forward.

15 The last one that I'm going to say
16 something about is cyber security. This is one of the
17 groups with near-term interim staff guidance being
18 developed. It's not quite out yet, but I'll just give
19 you a brief -- brief synopsis of what's going on.

20 Last October, industry met with the NRC
21 and discussed differences between the cyber security
22 guidance in Reg. Guide 1.152 and in industry document
23 NEI 04-04. Task Working Group Number 1 was
24 established to address these issues and to ensure that
25 the cyber security guidance provided by coherent and

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1 consistent.

2 These two documents came out about the
3 same time, at least the most recent revisions. NEI
4 04-04 contains information that is more programmatic
5 in nature, while Reg. Guide 1.152 contains guidance
6 that's more design-related.

7 But industry desires the ability to use a
8 single document for their cyber security programs, and
9 ideally they'd like to be able to say we could either
10 use Reg. Guide 1.152 or NEI 04-04. To resolve the
11 differences between the two documents, the task
12 working group has conducted a gap analysis to identify
13 areas where they overlap or are inconsistent with each
14 other. And based on that gap analysis, industry has
15 made some changes to NEI 04-04.

16 In August, the NRC staff expressed concern
17 regarding the ability to directly correlate the
18 topical elements that are in Reg. Guide 1.152, with
19 the programmatic guidance that's in NEI 04-04. So to
20 address that concern, industry has created a draft
21 cross-correlation table.

22 There was a public meeting last month to
23 discuss that table with the staff and industry, and
24 there will be another public meeting I think in about
25 two weeks to further discuss additional comments and

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1 how the table could be modified to be more useful,
2 especially more helpful to the reviewers, the NRC
3 reviewers, who are going to be the ones who need to
4 make sure that they've looked for the right things in
5 these submittals and with the cyber security plants.

6 And hopefully, when we get to the end on
7 this one, the NEI 04-04 will address the NRC's
8 concerns such that it can be used in lieu of Reg.
9 Guide 1.152 for cyber security. Reg. Guide 1.152 has
10 other things in it that need to be used for those
11 things.

12 And there will be an interim staff
13 guidance document developed, and then probably some
14 revisions to IEEE Standard 7-4.3.2, maybe the reg.
15 guide, and maybe the standard review plan as we move
16 forward.

17 And that's a quick summary of what's going
18 on in four of the task working groups. The staff will
19 say more, in more detail I'm sure, and be able to
20 answer even more of your questions.

21 MEMBER APOSTOLAKIS: Any questions for the
22 NEI representatives? Comments?

23 (No response.)

24 Well, this was informative, as usual. I
25 hope the members have noticed that NEI has started

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1 using slides. Our complaint in the past was that they
2 never did that. Now we have slides in full color.
3 Thank you very much.

4 MS. KEITHLINE: You're welcome.

5 MEMBER APOSTOLAKIS: And now we are
6 turning it over to the staff. Jack, are you going to
7 say a few words? Or we go straight to Belkys and
8 Steve, two familiar faces.

9 I understand Belkys is also leaving us.
10 Where are you going?

11 MS. SOSA: I'm going back to the EDO's
12 office. It was a rotation for me, so --

13 MEMBER APOSTOLAKIS: Okay. All right.

14 MS. SOSA: -- for four months.

15 MEMBER APOSTOLAKIS: So all the ladies who
16 appear before us today is for the first time -- last
17 time.

18 MEMBER POWERS: George, you've got to look
19 on it as they couldn't leave without visiting us.

20 MEMBER APOSTOLAKIS: They couldn't what?

21 MEMBER POWERS: They couldn't stand to
22 leave without visiting us.

23 (Laughter.)

24 MEMBER CORRADINI: Stan, too? I don't
25 think so.

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1 MEMBER APOSTOLAKIS: Can you have somebody
2 bring me the new version, please? I know you are busy
3 here. The interim guidance for D³ -- I really need it
4 in front of me.

5 (Pause.)

6 Okay. Let's go.

7 MS. SOSA: Good morning. My name is
8 Belkys Sosa, and I'm the Director -- I'm here as the
9 Director of the Digital I&C Task Working Group, as
10 George just mentioned. This was a rotation for me,
11 and I'm moving on. There will be a new director. Her
12 name is Patricia Silva, and she is with NMSS. She
13 comes to us after nine months in the Chairman's
14 office, and she will be --

15 MEMBER APOSTOLAKIS: Is she here today?

16 MS. SOSA: She is not here today.

17 I apologize. Some -- the D³ interim staff
18 guidance was revised on the 22nd, then the new version
19 came out on the 28th, and --

20 CHAIRMAN SHACK: So the 28th is the
21 current version.

22 MS. SOSA: That's correct, yes. It's the
23 latest, yes.

24 CHAIRMAN SHACK: I just wanted to make
25 sure I was up to date.

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1 MEMBER BLEY: It doesn't have a time stamp
2 on it, Bill.

3 MS. SOSA: Now, the purpose of today's
4 meeting is to provide the ACRS with an overview of the
5 digital I&C activities as well as the development of
6 the interim staff guidance.

7 This is an information briefing. A formal
8 ACRS review and approval is included as part of the
9 digital I&C project plan, doing the reg. guides or SRP
10 updates formal review.

11 The staff of course appreciates any
12 feedback or any comments that you have at this time.

13 MEMBER APOSTOLAKIS: We may write a
14 letter, Belkys.

15 MS. SOSA: Okay. Now, I'm planning to
16 provide a high-level view on the digital I&C project
17 plan, and the status of the interim staff guidance.
18 And Steve is going to cover the significant issues in
19 the interim staff guidance, as well as the status of
20 the staff's efforts to address the ACRS
21 recommendations on D³.

22 I'm pleased to report that the interim
23 staff guidance on D³ -- highly integrated control room
24 communications and human factors -- has been issued.
25 And you can find them on the website, hopefully.

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1 Now, regarding the digital I&C cyber
2 security ISG, as Kimberley mentioned, the staff --
3 essentially, the Steering Committee decided to hold
4 issuing that interim staff guidance until we complete
5 the correlation table that was mentioned. This table
6 is an important licensing tool, both for the staff as
7 well as industry. And we are looking at issue that at
8 the end of October.

9 The near-term activities are, again, to
10 develop interim staff guidance. The project plan
11 identifies the major milestones and the planned
12 deliverables at a very high level. The near-term due
13 dates are driven by the need to have interim staff
14 guidance in place to review the anticipated licensing
15 actions for operating reactors, new reactors, and fuel
16 cycle facilities.

17 The interim staff guidance is intended to
18 clarify staff position and expectations on a timeframe
19 that supports industry needs and will provide a
20 regulatory framework that assures a high level of
21 confidence in NRC staff's acceptance of an
22 application.

23 The longer-term objectives of the project
24 plan are to complete additional technical development
25 work, further refine the interim guidance as

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1 appropriate, and incorporate that guidance into
2 existing regulatory framework through the standard
3 revision processes, like the reg. guides and the SRP
4 updates.

5 The long-term focus of the project plan is
6 on the risk-informed TWB, the fuel cycle facilities,
7 the remaining human factor issues, and to continue to
8 refine and enhance the digital I&C guidance as
9 necessary through the task working group interactions.

10 Now, the development of interim staff
11 guidance is well underway. As I mentioned, we issue
12 ISGs on D³ communications and human factors at the end
13 of September. The website contains the draft ISG on
14 cyber security, which we plan to finalize by the end
15 of October. We plan to include the table with the ISG
16 as an enclosure.

17 Now, regarding the licensing process ISG,
18 the task working group, has developed a matrix to
19 identify the type of information that needs to be
20 provided on the docket, the information that should be
21 available for the staff to audit if they choose to do
22 so. A similar matrix will be developed for the new
23 reactors identifying the expected timing for that
24 information to be provided for COL or design
25 certification applications.

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1 The licensing process ISG is currently
2 scheduled to be issued at the end of November. We
3 expect to complete most of the interim guidance in
4 2007, with the exception of risk. We also expect to
5 continue working with industry through the task
6 working groups to develop recommendations to improve
7 or enhance the guidance through established processes.

8 Now, let me clarify it if I may. The
9 risk-informed ISG, which is scheduled to be issued in
10 March of '08, is to address modeling of digital
11 systems in PRA for design certifications and COL
12 applications. That's the guidance that we are
13 planning to issue in March of '08.

14 The remaining items -- risk insights on
15 the --

16 MR. ARNDT: As opposed to risk-informing
17 guidelines, the issue here is what is acceptable in
18 terms of level of detail and modeling assumptions for
19 the Chapter 19 required PRA analysis for --

20 MEMBER APOSTOLAKIS: Yes.

21 MR. ARNDT: -- different modeling
22 threshold than if you're going to actually ask for
23 regulatory relief once you've terminated your --

24 MEMBER APOSTOLAKIS: I am a little
25 confused, if you can clarify that a little. Maybe

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1 it's me.

2 MR. ARNDT: In terms of providing a PRA
3 that is complete and accurate and sufficient, the
4 guidance is it needs to be sufficient for the
5 regulatory application it's being used for.

6 In terms of is it good enough to make a
7 determination that you've looked at everything that
8 you need to in terms of, say, safety goal and things
9 like that, in terms of Part 52 applications, that
10 looks at sensitivities and have you captured all the
11 major failure modes, and issues like that.

12 If you're going to actually risk-inform a
13 particular regulatory application, like the D³
14 analysis, level of modeling detail, the amount of
15 scrutiny, the amount of completeness is a different
16 level. The part that we're going to hopefully finish
17 in March of next year is the prior one, not the latter
18 one. That's longer term applications based on work
19 that we're currently doing in the research area as
20 well as discussions we're having with NEI.

21 MEMBER APOSTOLAKIS: So in different
22 words, there is one issue which you already have a
23 problem on of how to bring digital I&C into the PRA in
24 general.

25 MR. ARNDT: In general.

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1 MEMBER APOSTOLAKIS: And obviously that's
2 not what we're talking about here. So what you are --
3 you will try to do with this document would be to see
4 what kind of risk information one could use
5 convincingly in the context of the interim guidance
6 that you are issuing, without really claiming that you
7 have brought --

8 MR. ARNDT: Correct.

9 MEMBER APOSTOLAKIS: -- the digital I&C
10 into the PRA.

11 MR. ARNDT: Correct.

12 MEMBER APOSTOLAKIS: There may be other
13 ways of bringing risk insights that will be useful in
14 determining, for example, whether you have sufficient
15 diversity or whether you need diversity.

16 MR. ARNDT: There are a number of
17 different potential applications of risk-informing in
18 the digital I&C area -- that being one.

19 MEMBER APOSTOLAKIS: Okay. Okay.

20 MR. ARNDT: But that's not what this is.
21 This is -- specifically is what the licensees are
22 proposing in their design cert PRA is sufficient in
23 terms of modeling the digital I&C.

24 MEMBER APOSTOLAKIS: So these will not
25 address the interim guidance documents that you are

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1 issuing now?

2 MR. ARNDT: No.

3 MEMBER APOSTOLAKIS: No.

4 MR. ARNDT: It's the follow-on ones, the
5 longer term applications. But this is very specific
6 to design cert PRAs.

7 MEMBER APOSTOLAKIS: Okay. So, then, this
8 we can use for the ESBWR design certification.

9 MR. ARNDT: Correct.

10 MEMBER APOSTOLAKIS: Okay, okay, okay.

11 Thank you.

12 MS. SOSA: Now, Steve is going to go into
13 the details of where we are regarding the ACRS
14 recommendations on D³. I'm just going to recap very
15 briefly here.

16 You may recall the Commission in the
17 June 22nd SRM directed the staff to incorporate the
18 ACRS recommendations on diversity and defense in depth
19 in the project plan, which we've done. The Steering
20 Committee approved the project plan July 12th, and on
21 September 28th the staff completed the near-term staff
22 assessment on D³.

23 A copy of the preliminary assessment on
24 inventory and classification was provided to the ACRS
25 staff on October 1st, and the staff is on schedule to

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1 complete a white paper identifying the potential
2 impacts on the ISGs and capture the assessment results
3 of inventory and classification and operating
4 experience by the end of December. A copy of this
5 paper will be provided to the ACRS.

6 The longer term efforts include continuing
7 with the assessment of operating experience to provide
8 insights to refine the guidance as necessary. The
9 staff is currently planning periodic updates with the
10 ACRS Subcommittee on I&C, and these information
11 meetings are designed to coincide with the development
12 of draft ISGs.

13 The next Subcommittee meeting is planned
14 for November, and we expect to discuss the licensing
15 process and the risk-informed draft ISG at that time.

16 MEMBER APOSTOLAKIS: Is this -- the
17 document you mentioned, is this the memorandum from
18 Mr. Ian Jung to Russell Sydnor?

19 MS. SOSA: Yes. There is an attachment,
20 which is the --

21 MEMBER APOSTOLAKIS: Yes.

22 MS. SOSA: -- breakdown. Now, at this
23 time, I'd like to turn the presentation over to Steve,
24 please.

25 MEMBER APOSTOLAKIS: So we will not

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1 discuss this today, or you will discuss it?

2 MR. ARNDT: I will discuss it.

3 MEMBER APOSTOLAKIS: Okay.

4 MR. ARNDT: All right. Thank you, Belkys.

5 As was mentioned earlier, my name is Steve
6 Arndt. I'm actually in the process of transitioning
7 from my old job in Research to my new job in NRR.

8 MEMBER APOSTOLAKIS: So we will not see
9 you again in this context here?

10 MR. ARNDT: Oh, you'll see me plenty in
11 this context. I'll be still working in the I&C area,
12 just a different office.

13 MEMBER APOSTOLAKIS: Oh, okay.

14 MR. ARNDT: Less research, more
15 implementation.

16 What I'm going to do today is rather
17 quickly go through some of the draft guidance, not all
18 of it -- because we spent more than a full day at the
19 Subcommittee associated with that -- but give you some
20 general overview of what the guidance is as well as
21 what it's not.

22 As Kimberley mentioned, and as was
23 discussed in the Subcommittee, each of these guidance
24 have specifically called out in the preamble the fact
25 that the methods described in the guidance are not the

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1 only methods that the staff may find acceptable. The
2 staff may also find other methods acceptable, but the
3 methods that are described in here are basically the
4 ones that we pre-looked at and we anticipate having
5 less issues associated with that.

6 Jack Grobe referred to it as the HOV lane.
7 We've looked at these issues, and we understand what
8 the ramifications are.

9 In cyber security -- I'll go through this
10 very quickly -- we originally -- this group was stood
11 up to look at some inconsistencies in the current
12 staff guidance between Reg. Guide 1.152 and the SRP.
13 Those inconsistencies were resolved with the SRP
14 update in March. The group then took on the task of
15 looking at the inconsistencies and additional
16 information that is needed to resolve issues
17 associated with the industry guidance, NEI 04-04, and
18 the reg. guide.

19 These two documents were developed for two
20 different purposes. Reg. Guide 1.152 is a design
21 licensing document associated with how do you design
22 a digital safety system. NEI 04-04 is an assessment
23 document. It's designed to assess the quality of
24 cyber programs at a plant. It's designed for a much
25 broader application. So there's naturally some

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1 inconsistencies associated with that.

2 And as was discussed earlier, the outcome
3 of this will be an ISG that will discuss this,
4 including a cross-correlation table that maps the
5 requirements from one document to the other. And
6 because the documents were written basically for
7 different purposes, it has been a bit of a challenge
8 to develop this cross-correlation table, but we're on
9 track to do that.

10 As Kimberley mentioned, diversity and
11 defense in depth, there is seven problem statements.
12 What we've done in each of these --

13 CHAIRMAN SHACK: Coming back to that for
14 a second, Steve. So from your point of view, you
15 don't think there's much chance they're going to have
16 one guidance document.

17 MR. ARNDT: Well, the documents are --
18 serve two different purposes.

19 CHAIRMAN SHACK: Yes. I mean, but I
20 thought Kimberley wanted them to be able to use
21 either/or, and you keep --

22 MR. ARNDT: Yes.

23 CHAIRMAN SHACK: -- see, you have an "and"
24 in here I think.

25 MR. ARNDT: Well, you could -- assuming

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1 that we are successful in coming up with a cross-
2 correlation table that adequately addresses all of the
3 issues, you could use NEI 04-04 for all cyber
4 applications.

5 As Kimberley mentioned, Reg. Guide 1.152
6 goes into a lot of other things associated with how
7 you design and implement a digital system. It's just
8 those particular provisions in that -- the most recent
9 version of 1.152. That's our goal.

10 MR. GROBE: If I could -- Jack Grobe, NRR.
11 The current version of NEI -- the NEI document is not
12 sufficient. The interim staff guidance will provide
13 guidance on what needs to be addressed in addition to
14 the current version of the NEI document to be
15 sufficient.

16 If NEI chooses to revise their document
17 and submit it, and we endorse it, then that could be
18 a one-stop shop. But the ISG will be the guidance
19 that we put out on the table.

20 MR. ARNDT: If you look at the last line
21 of the slide, the draft version is what we're talking
22 about -- if they update their draft, and if we find
23 that acceptable.

24 CHAIRMAN SHACK: But it's just one stop
25 for this aspect.

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1 MR. ARNDT: For this aspect.

2 CHAIRMAN SHACK: 1.152 will still be
3 covering other things.

4 MR. ARNDT: That's correct.

5 In the diversity and defense in depth
6 area, as Kimberley mentioned, there are seven areas.
7 The most challenging has been the adequate diversity
8 and manual operation issues. There are others, which
9 I'll go through relatively quickly. I won't go -- I
10 don't have a slide for BTP-19 Position 4, but that has
11 to do with the issue of clarifying whether or not you
12 can do diverse backup actuation at the system or
13 component level, and the position on that.

14 We'll talk a little bit about the effects
15 of CCF and CCF applicability. This has to do with the
16 issue of what is an acceptable design attribute and
17 what kinds of common mode failures you have to take
18 into account in your analysis.

19 Echelons of defense -- this is the issue
20 that we had with earlier applications, combining the
21 same hardware for RPS and SFAS. I won't talk about
22 that in detail, but the result of the ISG is basically
23 if you can meet the safety function, we've determined
24 you don't need to necessarily have different kinds of
25 systems doing RPS and SFAS, if you can still meet the

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1 criteria and adequate diversity and manual action.

2 The single failure criteria also I'm not
3 going to talk about in detail, but that has to do with
4 how do you define a single failure and common modes
5 software failure.

6 The big-ticket item, obviously, is the
7 issue of adequate diversity and manual action. This
8 basically looks at the issue of how much diversity is
9 acceptable, and when can you rely on manual action as
10 part of that.

11 The guidance is -- makes no distinction
12 between future reactors and operating reactors, relies
13 on our current process for evaluating the implications
14 of common mode failure. That's BTP-19 that was talked
15 about earlier that's part of the standard review plan.
16 It's part of Chapter 7 of the standard review plan,
17 and the related supporting documentation in NUREG-
18 6303.

19 That provides a mechanism by which
20 designers of the system can go through an analysis to
21 determine if additional diversity is necessary. And
22 it basically says you take the worst common mode
23 failure and you see whether or not your remaining
24 systems that are not diverse to those systems can
25 adequately protect you. And it has a set of criteria

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1 associated with that.

2 MEMBER APOSTOLAKIS: So we know now what
3 is adequate diversity, or is it a matter of judgment?

4 MR. ARNDT: It is a matter of judgment in
5 terms of how you credit certain things and what kinds
6 of particular diversity is considered acceptable in
7 the analysis. But there is an analysis procedure that
8 basically says you start here with these assumptions,
9 you go through this particular set of processes in the
10 Chapter 15 analysis, and you come up with an answer,
11 yes, it passes, or no, it doesn't. If it doesn't
12 pass, you have to go back and add an additional
13 diverse system.

14 MEMBER APOSTOLAKIS: But there is also
15 judgment as to what kind of common cause failure one
16 would assume, isn't there?

17 MR. ARNDT: And that's one of --

18 MEMBER APOSTOLAKIS: And that's a big one.

19 MR. ARNDT: Well, that's one of the things
20 that the ISG is trying to provide additional guidance
21 on. How do you define that, and how do you articulate
22 that particular finding? And we'll talk about that.
23 Give me a slide or two.

24 MEMBER APOSTOLAKIS: Okay.

25 MR. ARNDT: In terms of manual action,

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1 Kimberley stated it explicitly -- where protective
2 actions that should have been automatically performed
3 by the system, subject to the CCF, require less than
4 30 minutes to meet the acceptance criteria, then an
5 independent diverse automatic backup -- let's use the
6 same or equivalent function -- is provided.

7 Basically, you go through the analysis.
8 If you can't meet the acceptance criteria without a
9 manual action within the first 30 minutes, then you
10 need an automatic backup.

11 The ISG goes on to talk about some other
12 issues associated with that, but the automatic backup
13 does not apply to follow-on actions, and that you
14 need to have sufficient displays and controls, either
15 safety or non-safety, to allow the operator to make
16 those decisions.

17 But the real crux of the issue, as was
18 discussed earlier is, is 30 minutes a correct or
19 acceptable, or is it the best way to do it? One of
20 the issues here is of course that common mode failure
21 due to software is, by its very nature, an extremely
22 difficult thing to analyze and to predict, because if
23 you knew you had the problem you would have fixed it.
24 It's a context-based failure.

25 So one of the concerns we have is it's

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1 difficult to pre-analyze what kind of acute demands
2 you're going to have on the operators, and things like
3 that. So what we've determined, based on the amount
4 of burden that is likely to be placed on the operator,
5 the past regulatory decisions and engineering
6 judgment, 30 minutes is a good acceptance criteria for
7 this ISG.

8 MEMBER BLEY: Steve, I want to ask you the
9 same thing I asked NEI. Can you tell me about the
10 extent of involvement by people with operations
11 experience and human factors expertise in the
12 development of the staff position on this issue?

13 MR. ARNDT: I probably can't tell you all
14 of it, because there has been an enormous amount of
15 people looking at this across the agency and across
16 other agencies and other industries.

17 MEMBER BLEY: I'd say direct involvement
18 is --

19 MR. ARNDT: This was developed by the ISG,
20 which is chaired by Ian Jung, who is sitting in the
21 back of the room. There was representatives from all
22 of the different offices. There was interactions with
23 our human factors groups in both Research and NRR and
24 NRO. There was a significant discussion, both on what
25 the right number should be, but more importantly

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1 whether we know enough at this point to have a
2 performance-based criteria instead of a specific
3 number.

4 MEMBER BLEY: Is the idea here -- I know
5 one idea is the system should take care of itself
6 for --

7 MR. ARNDT: Right.

8 MEMBER BLEY: -- this time period. Is
9 there an embedded idea that operators should be
10 definitely hands off? And if that's the case, has
11 there been any discussion about the impact on operator
12 performance and keeping the operators engaged as you
13 implement this kind of a process?

14 MR. ARNDT: I would go back to your first
15 statement and rephrase it a little bit. It's not that
16 they should be kept out of the process. It's they
17 should not be relied upon to be able to diagnose and
18 take mitigative actions within this timeframe.

19 MEMBER SIEBER: Same as it is now.

20 MR. ARNDT: Same as it is now.

21 MEMBER APOSTOLAKIS: Same as what? What
22 did you say?

23 MR. ARNDT: Same as it is now.

24 MEMBER BLEY: It has been termed at times
25 in the past it ought to be absolutely you don't touch

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1 it. I just asking if that's the --

2 MEMBER SIEBER: Different plants do
3 different things.

4 MEMBER APOSTOLAKIS: And this refers to
5 both failure to actuate safety systems, and if they
6 actuate to deal with problems of running. I mean,
7 it's a blanket thing, you know.

8 MEMBER CORRADINI: So if I took away the
9 number, is there -- are you and industry on the same
10 page about how Jack just described it, which is --
11 which is that it's an approach where it's not the
12 operator has hands off, but the operator should allow
13 the systems to perform -- evaluate, monitor, and
14 respond accordingly over some time period to be
15 determined. If you took the number out of it, are you
16 guys on the same page on this?

17 MR. ARNDT: I'm seeing --

18 MEMBER APOSTOLAKIS: No, let's understand.
19 What do you mean taking the number out of it?

20 MEMBER CORRADINI: Well, in other words,
21 if it weren't 30 minutes, if it were something that
22 both of you could agree to the philosophy without the
23 quantitative number, are you on the same page about
24 how the operator performed? Because what Jack said to
25 me is most important, which is it's the same

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1 philosophy on the way the plants are running now.

2 MR. ARNDT: Well --

3 MEMBER CORRADINI: And if that's the case
4 and all you're doing is quibbling about what the
5 number should be, that's one thing. But if you're
6 philosophically running the plant differently with
7 this, then that's a different way in which the
8 operators are going to be trained. I want to
9 understand that.

10 MR. GROBE: This is Jack Grobe again. I
11 don't think we're quibbling on what the number should
12 be. The number was established based on what the
13 staff would find acceptable, which would minimize the
14 impact on the licensees. It's strictly a financial
15 decision on the amount of effort licensees want to put
16 into design analysis and dialogue with the staff.

17 The number is there, so that they
18 understand that if they choose, given their particular
19 plant design, to implement a design that does not
20 require operator action within the first 30 minutes.
21 Certainly not meaning that the operators are not to be
22 engaged, but it doesn't mandate operator action within
23 the first 30 minutes, that the staff would find that
24 acceptable with very limited review.

25 I agree 100 percent with NEI that we need

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1 to develop guidelines that if a licensee finds that it
2 would be beneficial to them to argue differently,
3 there needs to be a standardized approach on how to do
4 the human factors aspects of the analysis of the
5 operator action. And we're going to be working with
6 the industry to develop that. But taking the number
7 out is contrary to the purpose of the interim staff
8 guidance.

9 MEMBER CORRADINI: No, I didn't mean to
10 take a number. I'm trying to understand -- if you --
11 if you had agreed on the number, is the way the
12 operator is going to be trained for these advanced
13 plans similar to -- I'm just going back to what Jack
14 said, you agreed with, and I'm just making sure -- is
15 everybody on the same page about that?

16 MR. ARNDT: Yes. The issue here is I
17 think you're characterizing the decision criteria the
18 wrong way. This is a decision criteria on the design
19 decision. Whether or not you have an additional
20 diverse system does not have anything necessarily to
21 do with how you train the operators or the operational
22 philosophy. It's whether or not you have an additional
23 system or not.

24 MEMBER CORRADINI: And then, given the
25 system, the way you train operators will not change.

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1 MR. ARNDT: Correct.

2 MEMBER CORRADINI: Okay. I'm sorry.

3 MEMBER APOSTOLAKIS: This is not only for
4 advanced reactors, by the way. This is for all
5 reactors.

6 MR. ARNDT: This is for all reactors that
7 choose to do a digital system control room.

8 MEMBER SIEBER: And the operator's job is
9 to make sure the functions occur when they're supposed
10 to occur and under the conditions they're supposed to
11 occur.

12 MR. ARNDT: Correct.

13 MEMBER SIEBER: And if he were to do it
14 manually, he may do it a different way, different
15 control.

16 MEMBER CORRADINI: So let me ask you a
17 different question. So this is a -- this is something
18 that determines whether I have a diverse system,
19 whether I should have a second or additional systems.

20 MR. ARNDT: Correct.

21 MEMBER CORRADINI: And then, what -- well,
22 let me just stop there for a minute. I want to think
23 about it.

24 MEMBER SIEBER: Well, the operator follow-
25 on following the course of an accident, and perhaps

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1 actuating a device as a backup, is diversity in
2 itself. On the other hand, the 30-minute rule does
3 not allow you to take credit for that operator
4 rehearsing.

5 MEMBER CORRADINI: Fine. Thank you.

6 MR. ARNDT: Let me skip through the rest
7 of this relatively quickly, so we can have some time
8 for discussion. Another issue is the issue of
9 understanding the effects and how do we clarify what
10 is required regarding how you do that analysis, and
11 also associated with whether or not spurious
12 actuations are a significant issue associated with
13 that.

14 The primary concern here is undetected
15 failures within the digital system, and spurious
16 failures tend to be self-revealing. So that is not as
17 significant, in the opinion of the staff, as silent
18 failures or features to actuate.

19 MEMBER STETKAR: Steve?

20 MR. ARNDT: Yes.

21 MEMBER STETKAR: Let me ask you a question
22 on that. The statement here that says, "Spurious
23 trips and actuations are of lesser safety concern than
24 failures to trip or actuate." What's -- I'd like to
25 understand the basis for that statement. That seems

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1 contrary to what we've learned from extensive analysis
2 of fires.

3 I'm aware of some digital control systems
4 in Europe that actually stop high-pressure injection
5 under certain criteria --

6 MR. ARNDT: Yes.

7 MEMBER STETKAR: -- and prevent the
8 operators from actuating it. Spurious actuation of
9 that during a small LOCA would seem to be relatively
10 important. So I'm curious why this dismissal of
11 spurious actuations globally from a safety basis is a
12 premise.

13 MR. ARNDT: It's not intended to dismiss
14 it completely, just that it is of less concern than
15 some of the other concerns.

16 MR. WATERMAN: This is Mike Waterman. I'm
17 in the Office of Research. I was on the Task Working
18 Group for Diversity and Defense in Depth.

19 On the effects of common cause failure, we
20 took a look at it, and generally when a system is
21 spuriously actuated the operator knows fairly quickly
22 that he has a spuriously-actuated system, and he can
23 take steps to address that. It's when systems don't
24 actuate, or maybe they're indicated to have actuated
25 but didn't really actuate, that's when you get into

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1 issues of whether or not the operator actually can
2 respond in a timely manner to address it.

3 For example, if he thinks he has safety
4 injection going on because his indications on the
5 board say it actuated, and he is sitting there waiting
6 for his safety injection system to address the issue
7 that is going on in the plant, and nothing is
8 happening, then you get into the issues of, what does
9 the operator do then?

10 And so we sort of looked at spurious
11 actuations as not nearly as important to consider as
12 just failures to actuate where the operator may be
13 misled.

14 MEMBER BLEY: I'm a little more concerned
15 not in terms of sitting there cold and something comes
16 on, I'm concerned about as an event is progressing the
17 system decides that I have a low pressure condition,
18 stops high pressure injection, tries to align low
19 pressure injection, and, in fact, prevents the
20 operator from doing -- reversing that process without
21 performing a reasonably large number of manual
22 interactions, and perhaps defeating the system.

23 That's not the same as spuriously
24 initiating high pressure injection when I'm operating
25 at full power. It's very much different.

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1 A similar concern would be conditions to
2 automatically isolate injection because of containment
3 parameters that are incorrect. Those tend to be
4 somewhat troublesome.

5 MR. WATERMAN: They do, but generally they
6 are also announced, annunciated, and the operator
7 working through it -- post trip, working through the
8 EOP, the operator typically watches the symptoms. And
9 if something spuriously actuates, he usually has
10 something in his EOPs or in his plant procedures that
11 will allow him to isolate that.

12 Generally, spurious actuations are fairly
13 obvious when they occur. It's the failures to actuate
14 that we felt were probably more serious concerns with
15 regard to the BTP-19 spurious actuation issue.

16 MEMBER BLEY: I see both points here. I
17 think there's a -- there's a class of events that I
18 think from the operator's point of view it's one of
19 the reasons I'd really like to see a lot of operator
20 involvement in the groups working on this.

21 We see them in existing plants with things
22 like pneumatic systems where things start acting funny
23 in the plant and not in obvious ways. And now we have
24 systems -- and I don't know how they'll actually be --
25 where some kind of a problem within one system can

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1 create more than one, or one serious one as John
2 mentioned, that really draw the operator's attention
3 trying to figure out what's going on.

4 And I would guess I would call those
5 things spurious actuations. Maybe you folks have
6 another name for them. But I think they can be really
7 important -- have really important impacts on how the
8 operators perform. Operators don't close off what's
9 happening and focus on one thing, quite the way
10 engineers do when we're looking at a problem.

11 MEMBER SIEBER: I think even more
12 important you may not have a parameter that links
13 directly to what that failure is. Maybe the operator
14 is scratching his head saying, "I'm not quite making
15 it here, but I don't know what's wrong."

16 MEMBER BLEY: Exactly.

17 MEMBER SIEBER: That's where the
18 mechanical and electrical and computer diversity is
19 important.

20 MEMBER STETKAR: Especially if they're
21 trained to really trust this new system that --

22 MEMBER SIEBER: Well, but they don't.

23 MEMBER STETKAR: They will be in the
24 future. I'm a little bit familiar with the way
25 operators are trained in Europe, and they really trust

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1 those systems. The system knows more than the
2 operator does.

3 MR. WATERMAN: That's why most --

4 MEMBER STETKAR: Unfortunately, that's the
5 attitude that I get.

6 MR. WATERMAN: And that's why most
7 countries in Europe have the 30-minute rule, right?

8 MEMBER APOSTOLAKIS: What did you say,
9 Mike?

10 MR. WATERMAN: That's why most countries
11 in Europe use the 30-minute response time rule. In
12 Germany -- Germany uses it, France uses it, Sweden
13 uses it.

14 MEMBER STETKAR: And it's why some risk
15 assessments have shown that spurious actuations within
16 that 30 minutes where the operators are locked out can
17 cause problems.

18 MR. WATERMAN: They're not really locked
19 out. It's more an issue of how much time do you give
20 the operator to understand exactly what went wrong
21 with what was supposed to work, so that he can take
22 the appropriate steps to address it.

23 If we rely on the operator to just simply
24 respond in two minutes, you know, what's the basis for
25 the common cause failure that justifies a two-minute

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1 response?

2 MEMBER MAYNARD: Well, I hope we don't
3 take a step backwards, though, and try to go back to
4 where the operator has to be able to know exactly what
5 went wrong before they can fix it, because that's what
6 got us in trouble before. The way the procedures and
7 the training is now you don't have to know what went
8 wrong. You can methodically step through, and you
9 take care of the --

10 MEMBER SIEBER: Well, if there is an
11 optimum course of action that has been pre-thought
12 out.

13 MEMBER MAYNARD: And so they don't always
14 have to know what's -- what went on or whatever. I
15 mean, I believe that the procedures and the training
16 can be such that it will deal with that.

17 And the 30 minutes in the U.S. hasn't been
18 a hard and fast that the current plants all had to
19 meet 30 minutes. And a number of them have actions
20 that it may be needed in 20 minutes or 25 -- have gone
21 through the regulatory process for approval and stuff.

22 But I am not at all a fan of locking the
23 operators out for -- to say you can't do anything for
24 30 minutes. I think that's absolutely the wrong thing
25 to do.

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1 MEMBER BLEY: Well, they are actually not
2 locked out, but they have to actively intervene,
3 typically with codes and things like that, that are
4 only available to the supervisors. And, you know,
5 it's an additional complication. They are not
6 completely locked out, but they can't just immediately
7 intervene either.

8 MR. WATERMAN: The 30-minute rule is not
9 designed to say, "Operators, you cannot touch this
10 system." The 30-minute rule was designed to say that
11 a plant ought to be robust enough to take 30 minutes
12 of operators not understanding what to do.

13 Now, if the plant is -- cannot withstand
14 an accident for 30 minutes without the operator taking
15 the appropriate actions, then it seems reasonable that
16 there ought to be a diverse actuation system in there
17 to back up what needs to be done. And that was why we
18 established the 30-minute rule. It wasn't to say,
19 "Operators, you can't do anything for 30 minutes."

20 It was to say, "Operators, if you're
21 really confused, and something outside design basis
22 can happen within that 30-minute timeframe, you're
23 backed up by a diverse actuation system." That is not
24 affected by the common cause failure that has got
25 everything messed up. That was what the 30 minutes

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1 was for. It's not to say when operators can or cannot
2 respond.

3 MEMBER APOSTOLAKIS: Have we discussed
4 this enough?

5 (No response.)

6 Okay.

7 MR. ARNDT: Thank you. I'll real quickly
8 finish this part of it up. Another big issue was the
9 applicability. Kimberley talked about this
10 extensively. The two issues associated with that are
11 internal diversity with a digital system and whether
12 or not that is acceptable.

13 The example that is used in the interim
14 staff guidance is, if you have a four-division system,
15 two divisions are of one particular kind of processor
16 and operating system, and things like that, and the
17 other are a different set, that may be sufficient
18 diversity, without having to have an external
19 additional system.

20 And there is examples of this in the
21 international community as well as other industries as
22 well. The other issue is if a system is sufficiently
23 simple to be fully testable -- and of course that's
24 something that we probably need to work on a little
25 bit more, because of the criteria associated with

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1 that. But the concept is you can design systems that
2 are extremely simple in terms of the hardware and
3 firmware that can be completely tested.

4 NEI's issue on defense measures associated
5 with basically systems or ability of the systems to
6 know that they are effective and can have a much lower
7 likelihood of failure in common mode associated with
8 fault tolerant design and number of closing is an area
9 that we're looking at in Research in a general sense.

10 Our big concern in that area is not that
11 these aren't good things to do. It's that we don't
12 think we are at the point now where we can
13 quantitatively credit those things, because we haven't
14 seen an update on what effect -- what the positive
15 effect would be and whether or not it might have
16 negative effects.

17 In this area, as was mentioned a couple of
18 times, we're going to continue to work with the
19 industry, particularly on this issue of diverse
20 strategies and adequate diversity strategies. Mike
21 Waterman is leading a research effort in that area.

22 We're proactively working in the area of
23 operator experience. And as we complete this, we're
24 going to hopefully update the standard review plan and
25 BTP-19 associated with any revisions that we might

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1 have.

2 MEMBER APOSTOLAKIS: The next seven slides
3 or so deal with highly-integrated control rooms, and
4 then you go on to operating experience, which is
5 really of great interest. Do you think there is
6 anything really significant you want to talk about in
7 these seven slides? Go to 19.

8 MR. ARNDT: We can skip through them if
9 you'd like. At the Subcommittee meeting, there was
10 not a lot of discussion --

11 MEMBER APOSTOLAKIS: Yes.

12 MR. ARNDT: -- associated with this. And
13 the information is provided in the draft guidance,
14 too.

15 MEMBER APOSTOLAKIS: So I would suggest we
16 go to 19.

17 MR. ARNDT: All right. As Belkys
18 mentioned earlier, one of the Committee's
19 recommendations to the staff and that was later picked
20 up by the Commission in an SRM was to make a
21 significant effort to look at operational experience
22 and also --

23 MEMBER APOSTOLAKIS: So that's what it
24 takes for you guys to listen to us.

25 MR. ARNDT: No. Let me finish.

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1 (Laughter.)

2 And to also look at an inventory
3 classification system of digital systems. What we did
4 was developed a little short-term action plan, which
5 is characterized by this chart, and we discussed it
6 with the Subcommittee chair, to take the current
7 operational experience evaluations that we are already
8 doing and have been doing for a number of years.

9 And look at what the information is
10 telling us right now. The first action, which is the
11 kind of center box there below the pink one, staff
12 assessment to look for major issues or common themes
13 in what we currently have. That was to be done by the
14 end of this month, which is the document that George
15 referred to earlier from Mr. Sydnor to Mr. Jung. That
16 was basically looking at all of the different things
17 we know and a preliminary look at an inventory
18 classification scheme.

19 The next step is to flesh that out better,
20 try and do a pilot inventory classification effort,
21 and then write a white paper on that. And then, look
22 at the longer term activities -- we're going to
23 continue the work on the classification scheme and
24 continue the operational experience and feed that into
25 the longer term activities.

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1 As we talked about earlier, the interim
2 guidance will be -- over the course of the next year
3 or year and a half -- turned into long-term reg.
4 guides and SRP updates. Longer term operational
5 experience will feed into those final documents.

6 So what we did, we looked at available
7 operational experience. There has been several
8 different studies of LERs, both by the NRC and by
9 other groups. There has been a look at the ISE
10 failures. This is the chart that Mike Waterman put
11 together and NEI is -- EPRI is working on. There is
12 an international database that we're starting up right
13 now. It's the computer systems important to safety,
14 or COMPSIS database.

15 We also looked at a number of external
16 non-nuclear databases, including the aerospace
17 industry and others, to see whether or not the kind of
18 information we were gleaning from our data was similar
19 to the kind of information they were getting from the
20 industry.

21 So based on our quick look of where we
22 were today, our findings basically were we've got some
23 challenges in terms of what data we can access, the
24 quality of the data, particularly in causal data.

25 There has been a number of LER studies on

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1 digital systems. There's a journal that's publishing
2 one in a few months on LER datas for the -- some CE
3 systems. There's data out there, but a lot of times
4 it's very difficult to extract the causal data, which
5 is the most important information.

6 The data is not always easy to quantify in
7 terms of whether or not we're getting exactly the same
8 failures and the exact same data sets. Kimberley
9 mentioned just correlating her data set and Mike's
10 data set has been a challenge. So it's difficult
11 challenge.

12 What we have found is there are both CCF
13 events out there, and there is also a lot of
14 precursors to CCF events. What we're trying to do is
15 integrate what we have found in nuclear, improve what
16 we are doing in terms of nuclear, and understand what
17 other industries are seeing in terms of common mode
18 failure and digital system failures in general.

19 We have an ongoing operational experience
20 program, which is an anecdotal review of failures as
21 they occur, as well as several efforts associated with
22 collecting and analyzing the data.

23 In terms of inventory classification, what
24 we've done is look at how inventory classification
25 schemes have been done in the past by other people and

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1 then try and understand whether or not we can use any
2 of that information for an inventory and
3 classification scheme in the nuclear industry.

4 There has been probably dozens of
5 different inventory and classification schemes
6 developed, and they are developed for different
7 purposes. For example, there is regulatory base
8 classification schemes, as simple as safety/non-
9 safety, and things like that. These have been
10 primarily developed for distinguishing classes of
11 systems for regulatory treatment.

12 One example of that, of course, is the
13 work we did in risk-informed grading of systems for
14 special treatment activities. Another way of doing it
15 is design-based. How do you design systems? And
16 there have been a number of studies associated with
17 that, associated with how important it is to have
18 particular characteristics in a system depending upon
19 the design application of that system.

20 Perrow did a study that's referenced in
21 our quick-look review that looked at how important
22 complexity of the system is to design performance, how
23 important coupling of the system is to design
24 performance.

25 The coupling aspect is particularly

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1 interesting in nuclear, because one of the issues that
2 we keep finding is, well, these things are so
3 independent, they have to make very simple decisions
4 versus systems that have more feedback. So you might
5 be able to categorize systems, like trip systems in a
6 load coupling type category and control systems and
7 feedback systems and high coupling category.

8 There has also been an operationally based
9 classification scheme associated with how do the
10 systems fail. NASA did a report here recently that
11 classified systems based on their predominant failure
12 modes, basically failures associated with
13 specification errors, failures associated with
14 improper or incomplete V&V failures associated with
15 translation errors, things like that.

16 So when we did the analysis, basically, we
17 tried to understand whether or not these systems had
18 the same basic kinds of failure modes, the same basic
19 kinds of issues that we care about. And what we found
20 was the systems were failing in similar ways than the
21 ones that we care about, both from the operational
22 experience we looked at and from the coupling
23 classification systems that we investigated.

24 So we took from that that using an
25 extension of what has been done in other industries is

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1 probably an acceptable way of doing that. So based on
2 that, we came up with a preliminary methodology that
3 is based on the complexity of the system.

4 MEMBER APOSTOLAKIS: But there is no
5 definition of complexity, Steve. What is complex?
6 What -- something that was complex 10 years ago may
7 not be now.

8 MR. ARNDT: Well, complexity has to do
9 with how you implement the function.

10 MEMBER APOSTOLAKIS: Still, I mean, if you
11 show me a system, I would be very hard-pressed to say
12 it's complex or it's not. The things that we can do
13 now, even with PCs, were unimaginable 20 years ago.

14 MR. ARNDT: Yes. The -- let me pull the
15 report, because I don't have the -- this right off the
16 top of my head. The kinds of issues we're talking
17 about in complexity is how complex or how large or how
18 many different functions does the software have. When
19 we talked in D³ space a few minutes ago about is it
20 sufficiently simple to be completely testable, that is
21 a very uncomplex system.

22 If it is not sufficiently simple to be
23 untestable, it is a more complex system, the
24 attributes associated with complexity are basically
25 binning it in two or three or four levels based on

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1 metrics that already exist. Like for software, there
2 is a metric called cyclometric complexity, and it
3 looks at how many branches and how many different ways
4 the software can actually perform. And there's a
5 metric for that.

6 MEMBER APOSTOLAKIS: But isn't it -- I
7 mean, to declare something as simple would have to
8 consider, it seems to me, the context within which it
9 is supposed to function.

10 MR. ARNDT: Absolutely. It --

11 MEMBER APOSTOLAKIS: So that you may have
12 a very simple computer code, you know, in -- say
13 scrambling the reactor under certain conditions, but
14 the number of conditions may be very, very large.

15 MR. ARNDT: Correct.

16 MEMBER APOSTOLAKIS: So it's not
17 completely testable.

18 MR. ARNDT: Correct.

19 MEMBER APOSTOLAKIS: Now, would that
20 system be simple or complex?

21 MR. ARNDT: It would probably be complex,
22 or at least halfway in between, simply because of the
23 function -- the functional complexity. This is a
24 functional complexity.

25 MEMBER APOSTOLAKIS: So it's not just the

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1 system itself; it's also the context within which you
2 expect it to function.

3 MR. ARNDT: Absolutely. A system that,
4 for example, can be tested completely. You can
5 demonstrate its simplicity, a system that has a lot of
6 internal diagnostics. It may be more robust, but it's
7 going to be a lot more complex.

8 MEMBER APOSTOLAKIS: Now, regarding your
9 proposed classification scheme, I still like the -- as
10 you mention on one of the pages here, that in the U.S.
11 nuclear industry I&C systems are also functionally
12 categorized as protection systems, engineered safety
13 features, actuation systems, control systems, and
14 monitoring implications.

15 MR. ARNDT: Correct.

16 MEMBER APOSTOLAKIS: And I like that. So
17 I think maybe what you need is some sort of a
18 hierarchical scheme, so you -- where you might start
19 at a higher tier with this classification, and then
20 each one of these will be categorized according to
21 these three attributes.

22 In other words, the categorization scheme
23 or classification scheme doesn't have to be simply in
24 the sense of 1, 2, 3.

25 MR. ARNDT: No.

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1 MEMBER APOSTOLAKIS: It can be some sort
2 of hierarchy, you know, if you have a monitoring
3 indication system which happens to be, you know,
4 Category B. Something like that.

5 MR. ARNDT: Yes.

6 MEMBER APOSTOLAKIS: I mean, I'm not very
7 -- but I wouldn't want to lose this. I think this is
8 important -- to know what --

9 VICE CHAIRMAN BONACA: Well, one concern
10 I have is -- you know, regarding the data that you're
11 going to get is that, you know, the most reliable
12 source would be the LERs, but they are only relating
13 to events where you have regulatory significance. And
14 that's based on the classification of safety-related
15 or non-safety-related, which really goes counter to
16 importance here as you defined --

17 MR. ARNDT: Yes.

18 VICE CHAIRMAN BONACA: -- which is risk-
19 based. So I'm concerned that, you know, in older
20 systems where you have essentially feedback or control
21 systems, which typically are in balance of plant
22 applications, you may have no information that you are
23 drawing on to really get a better understanding of the
24 issue or where the concern is.

25 I don't know how you're going to get that

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1 information. I know there is the risk that you'll get
2 out there, but --

3 MR. ARNDT: The challenge with getting
4 information is broad, both in terms of operational
5 experience and categorization, and all sorts of other
6 things. What we're trying to look at is not only LER
7 data but maintenance rule data, EPIX data, corrective
8 action program data, and a number of other areas.

9 We're talking with Benny Lyon about
10 getting access to some corrective action program data.

11 But as George pointed out, the point of
12 doing this exercise I think is, one, to get more
13 information on insight. If we actually end up with
14 something that we can use on a regulatory
15 decisionmaking criteria, so much the better.

16 But the primary idea is to get -- gather
17 the insight associated with it. And I think we're
18 starting to get that as we go anyway, and it is an
19 evolutionary process. And as we start actually trying
20 to pilot this in terms of actual systems, we may lean
21 additional things.

22 MEMBER APOSTOLAKIS: So this is just a
23 progress report. I mean --

24 MR. ARNDT: Yes.

25 VICE CHAIRMAN BONACA: Yes. Corrective

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1 action --

2 MEMBER APOSTOLAKIS: And this is really
3 something that we should spend some time on at the
4 Subcommittee meeting.

5 MR. ARNDT: We can put the more detailed
6 review --

7 MEMBER APOSTOLAKIS: Okay.

8 VICE CHAIRMAN BONACA: What is our
9 preliminary comment? Sorry.

10 MEMBER BLEY: Steve, has the focus of this
11 group been strictly on the digital -- the new digital
12 system itself or the whole system in which it
13 operates, including out to the sensors, that sort of
14 thing? One thing I don't see up here that I know has
15 caused many problems in the past is if -- if you're
16 not actually sensing what you're trying to monitor,
17 but you're doing a lot of signal processing on it, and
18 algorithms, then problems in processing the algorithms
19 create a lot of confusion either to the systems or to
20 the people using them. And I don't see that kind of
21 thing in the list.

22 MR. ARNDT: The exercise here was
23 particularly the digital system, but it can be
24 certainly expanded to that. One of the issues
25 obviously in digital systems is the setpoints and the

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1 trip points and the -- how do you -- whether or not
2 that can be done on a common input parameter.

3 It goes back to some of the stuff we
4 skipped in the earlier presentation associated with,
5 how do you look at the communication data, and things
6 like that? And that's indeed included; the actual
7 sensors themselves are not.

8 MEMBER APOSTOLAKIS: But that's why also
9 in support of that I would like to preserve the
10 functional categorization --

11 MR. ARNDT: Sure.

12 MEMBER APOSTOLAKIS: -- that we mentioned
13 earlier. So I can see some sort of a hierarchical
14 structure here that focuses on individual --

15 MEMBER BLEY: And all of this is aimed at
16 applying to, I would assume, any systems that include
17 digital parts, hybrid systems of one sort or another.

18 MR. ARNDT: Yes. At the risk of cutting
19 this off, let me finish up, so we can have a general
20 discussion. The preliminary assessment was done based
21 on what we know today.

22 MEMBER APOSTOLAKIS: I have a problem. At
23 the risk of --

24 MR. ARNDT: While you look for that, let
25 me finish my statement, and then --

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1 MEMBER APOSTOLAKIS: Finish your
2 statement.

3 MR. ARNDT: Based on what we know today,
4 in terms of operational experience and inventory
5 classification, we did not see anything that would
6 make us change what we proposed in the interim staff
7 guidance for D³. As we continue to work in this area,
8 both in terms of operational experience and inventory
9 classification, as that original chart said, we plan
10 on providing input to the long-term guidance
11 associated with BTP-19, the reg. guides, etcetera.

12 But as of this minute, actually as of last
13 week when we were trying to put out the draft interim
14 staff -- the interim staff guidance on D³, the group
15 that was working on this provided to Ian basically
16 their recommendation, that we haven't learned anything
17 that would make us do something differently in D³.

18 MEMBER BLEY: Quick question. You
19 mentioned that NASA study on categorizing failure
20 modes. Is that a public study? And do we have it?

21 MR. ARNDT: It is not a public study.
22 There is a short discussion of it at the Commission
23 meeting on -- when was the Commission meeting?

24 MEMBER APOSTOLAKIS: Do you know how my --
25 do you know -- I know him, and you know me, so --

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1 MEMBER BLEY: I think that will be
2 important for us to look at, because it sounds like
3 that --

4 MR. ARNDT: The primary purpose of that
5 report was to look at -- try to come up with an
6 analysis methodology. And the categorization was
7 secondary to that, but it was an idea of -- what are
8 the failures we care about, and how do you categorize
9 them? And based on that, how do you develop an
10 analysis methodology?

11 MEMBER APOSTOLAKIS: There is one comment
12 I want to make on this memo to Mr. Jung.

13 MR. ARNDT: Yes.

14 MEMBER APOSTOLAKIS: But it's something I
15 really don't understand. You are making a big deal
16 out of V&V errors, and I find -- I have a hard time
17 understanding why. You say, "An example of the
18 software-based V&V error was reported," blah, blah,
19 blah.

20 The causes were -- first, a hardware
21 failure in the digital feedwater control card failed.
22 Two, a failure to implement in software a design
23 specification to have a redundant set of signals trip
24 the main turbine. And, third, a design error in
25 configuring the relays that were to provide the

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1 redundant trip signals.

2 And then, you declare this a V&V failure.
3 I mean, of course, it was a V&V failure, because it
4 didn't catch it. But that's not really what we're
5 after here. I mean, everything then is a V&V failure,
6 because, you know, there is some V&V done. And if you
7 don't catch an error, you don't catch an error.

8 I have -- and then, you go on -- maybe not
9 you personally, I mean, the memo -- the memo says
10 software failures comprised 33 percent of the total
11 number of digital I&C failures, and the majority
12 resulted from incomplete requirements and errors in
13 performing verification and validation.

14 The review validated the concern for
15 software-induced common cause failures. It seems to
16 me there is a jump there. How did you do that? Just
17 because there were incomplete requirements? It's not
18 clear to me that that results in a conclusion that
19 common cause failures do happen significantly -- at a
20 significant rate.

21 I think there is some loose language here
22 that needs to be tightened up. But in particular,
23 this V&V -- and later on, I mean, you say -- well, the
24 document says, "V&V is a big deal." Well, of course
25 it is a big deal, but what we are trying to understand

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1 here is the causes of failure, not that the last
2 safeguard failed. I mean, that's important, too, but
3 I -- I think this needs a lot of work.

4 That's all. And you don't have to
5 disagree with me. You don't have to agree with me
6 either.

7 MR. ARNDT: Okay.

8 MEMBER APOSTOLAKIS: All right.

9 MR. ARNDT: That works for me.

10 MEMBER APOSTOLAKIS: Okay.

11 (Laughter.)

12 Very good answer, Steve. I just wanted to
13 voice my concern, because this is a very recent
14 document dated September 28th, which I believe was
15 last Friday.

16 MR. ARNDT: Yes.

17 MEMBER APOSTOLAKIS: So, you know, when
18 you come back next time to discuss this in more
19 detail, I wanted to make it clear -- just saying
20 everything is V&V failure doesn't help me.

21 MEMBER BLEY: Tiny follow up on George's
22 point. I don't remember, was that in your list of
23 complexity issues, the ease with which good V&V can be
24 done on the software, which has to do with how it's
25 built?

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1 MR. ARNDT: The issue is really how
2 testable is it exactly, and that partially has to do
3 with V&V.

4 MEMBER BLEY: Okay.

5 MR. WATERMAN: This is Mike Waterman,
6 Research.

7 MEMBER APOSTOLAKIS: Okay, Mike.

8 MR. WATERMAN: If we see that we've got 25
9 or 30 percent of our errors are because of breakdowns
10 in V&V, then that would say in an appropriately
11 diverse system you probably ought to have some diverse
12 verification and validation, like an independent V&V
13 team, also looking at the system. That would be a
14 justification for that as opposed to just relying on
15 V&V.

16 MEMBER APOSTOLAKIS: And I agree. I agree
17 with that.

18 MR. WATERMAN: And so that's -- I think
19 that was the whole idea.

20 MEMBER APOSTOLAKIS: Failures as failures
21 of V&V.

22 MR. WATERMAN: Yes, and which means, well,
23 let's put in some diverse V&V on that, and -- so that
24 we can address that.

25 MEMBER BLEY: They aren't there because of

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1 the V&V, that's what you're saying, George. That's
2 right.

3 MEMBER APOSTOLAKIS: Yes.

4 MEMBER BLEY: they're there for some other
5 reason. They just weren't -- it would be good not to
6 have them in the --

7 MEMBER APOSTOLAKIS: They listed the three
8 reasons.

9 MR. WATERMAN: And I guess I'd like -- we
10 tend to -- we tend to make V&V the same thing as a
11 software quality assurance or life cycle development
12 processes. V&V is only a subset of that. You have a
13 lot of other things that go on in software quality
14 assurance, or even system quality assurance, such as
15 configuration management and issues such as that.

16 MEMBER APOSTOLAKIS: So unless --

17 MR. ARNDT: I'm going to let Belkys
18 summarize.

19 MEMBER APOSTOLAKIS: Okay.

20 MS. SOSA: Okay.

21 MR. ARNDT: Make her earn her keep.

22 MS. SOSA: In closing, the Steering
23 Committee and the task working groups are working
24 effectively. The project plan is in place. The
25 interim staff guidance developed to date is available

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1 on the website, and we plan to continue interactions
2 with stakeholders through the public task working
3 group meetings.

4 The staff is on schedule to complete the
5 near-term objectives of the project plan, and we will
6 continue to coordinate efforts with industry to
7 resolve digital I&C issues in the long term in order
8 to refine and enhance the guidance.

9 We appreciate the Committee's interest in
10 this area, and I also would like to mention that we
11 are planning to have an internal seminar for the staff
12 in November to roll out the interim staff guidance to
13 reviewers to make sure that implementation is applied
14 consistently for new reactors, operating reactors, as
15 well as fuel cycle facilities, digital I&C reviews.

16 And that concludes my presentation. Any
17 questions?

18 MEMBER APOSTOLAKIS: Any questions from
19 the members?

20 (No response.)

21 Thank you very much, Belkys and Steve. As
22 informative as ever, interesting. Yes?

23 MR. ARNDT: And I would like to
24 acknowledge that as the Subcommittee heard, but the
25 full Committee didn't, this was an effort of an

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1 enormous number of staff across all of the different
2 offices. We had seven different task working groups,
3 seven different leader -- managers, lead personnel, so
4 it's not -- certainly not just me and Belkys. I was
5 just the guy that volunteered to sit up there.

6 MEMBER APOSTOLAKIS: Now, for your
7 information, the Committee will discuss the
8 possibility of a letter this afternoon starting at
9 5:30, decide whether we want to write a letter or not,
10 and if we do what that letter would say.

11 And on that happy note, back to you, Mr.
12 Chairman.

13 CHAIRMAN SHACK: Superbly done,
14 Academician Apostolakis.

15 (Laughter.)

16 You've given us five minutes to spare, so
17 we have a break until 10:45 -- an extra long,
18 civilized break. So we'll recess until 10:45.

19 (Whereupon, the proceedings in the
20 foregoing matter went off the record at
21 10:23 a.m. and went back on the record at
22 10:46 a.m.)

23 CHAIRMAN SHACK: Back into session. Our
24 next topic is a draft generic letter on managing gas
25 intrusion in ECCS, Decay Heat Removal and Containment

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1 Spray Systems, and Professor Abdel-Khalik will be
2 leading us through that. Said.

3 MEMBER ABDEL-KHALIK: Thank you, Mr.
4 Chairman. Gas intrusion into ECCS, Decay Heat
5 Removal, and Containment Spray Systems can potentially
6 either damage them or degrade their performance when
7 called upon to perform their function. Despite the
8 design and operational measures aimed at preventing
9 them, and the high level of awareness regarding their
10 consequences, these events have continued to occur on
11 a relatively frequent basis. Hence, a generic letter
12 addressing this issue was issued for public comment
13 several months ago. The comments have been
14 dispositioned by the staff, who are now ready to brief
15 the ACRS on the final draft. Mr. David Beaulieu of
16 NRR will make the presentation. We will also hear
17 from NEI representatives. Mr. Beaulieu.

18 MR. BEAULIEU: Okay. Welcome. This is
19 -- I'm going to move rapidly through these slides
20 here to stay within the time frame, but, obviously,
21 feel free to ask questions. The outline here, we're
22 going to discuss background, purpose of the generic
23 letter, desired outcome, the principal concerns that
24 we've had with licensees, requested actions and
25 information, public comments, and a final

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1 recommendation for you folks to endorse this draft
2 generic letter.

3 The purpose of the generic letter, request
4 that licensees submit information that demonstrates
5 that NRC regulations are being applied to the subject
6 systems with respect to licensing basis, design,
7 testing, operability, and corrective actions to assure
8 that gas intrusion is maintained less than the amount
9 that challenge operability of these systems. And that
10 appropriate action is taken when conditions adverse to
11 quality are identified.

12 In terms of background, there's a long
13 background. Gas intrusion events have occurred since
14 the beginning of nuclear power, commercial nuclear
15 power in the United States. There have been numerous
16 previous generic communications in terms of
17 information notices, primarily, and related generic
18 letters and NUREGs.

19 In 1997, there was an event at Oconee Unit
20 3 where all high pressure injection was rendered
21 inoperable due to gas intrusion due to hydrogen from
22 an incorrect level indication on their volume control
23 tank, or their let-down tank, and they had no water
24 left. And they actually in opted two pumps and would
25 have in opted the third had they started it. So we

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1 left it to the industry in 1997 to tackle this issue,
2 and we decided we would not take NRC generic actions
3 at that time, and let the industry try to resolve the
4 issue. But since then, there's been 60 gas intrusion
5 events, and due to the number and the significance of
6 these events we -- it really does raise a real
7 concern that there is a possibility that this could
8 exist right now as speak at one or more plants that
9 the systems are inoperable, and they just simply don't
10 know it. Some of them have sections of piping that
11 have been filled with air since forever, and they've
12 never recognized it.

13 MEMBER MAYNARD: What are you calling a
14 gas intrusion event? In large piping systems you're
15 always going to have some gas intrusion and stuff.
16 What are you considering a gas intrusion event?

17 MR. BEAULIEU: Good question. In terms of
18 the design and licensing basis, the FSAR describes the
19 system either explicitly or implicitly as being filled
20 with water, so technically you could say that any gas
21 is an intrusion event. Realistically, does any gas
22 really matter? No, when it reaches a certain
23 threshold, a certain volume is when it matters.
24 Events are things that would be significant, that we
25 would be aware of them in headquarters through some

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1 means, reportability, significant enough to be
2 documented in an inspection report, licensee event
3 report. But that precise question, I'll be expanding
4 upon that and addressing that more a little bit later
5 about what's acceptable, and what's not acceptable,
6 and what the expectation is.

7 MEMBER CORRADINI: So can I just read
8 something that I have from the generic letter, because
9 this makes sense, but it's qualitative. It says
10 "Requested actions, each addressee", blah, blah, blah,
11 "should do testing, design operability and corrective
12 actions to assure that gas intrusion is maintained
13 less than the amount that challenges operability, and
14 that is validated to confirm operability." So
15 operability is the key attribute, and so my question
16 is, later, if you'd like, and then I'm going to ask
17 the same thing of NEI, I'm assuming for a generic
18 system, containment spray, decay heat removal,
19 whatever, there's a typical pump, there's a typical
20 line, so, therefore, there's a typical amount of gas
21 that either challenges operability or doesn't, so
22 there's go to be some quasi fuzzy line where I need to
23 cross. And so that's what I was looking for somewhere
24 in here to give guidance.

25 MR. BEAULIEU: And we will.

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1 MEMBER CORRADINI: Okay.

2 MR. BEAULIEU: I'll cover that in detail.

3 MEMBER CORRADINI: Okay.

4 MEMBER APOSTOLAKIS: You said earlier that
5 there are some plants where pieces of pipe have been
6 full of gas for years.

7 MR. BEAULIEU: Yes.

8 MEMBER APOSTOLAKIS: And I find that a
9 little strange. I mean, don't they do any tests at
10 all that would reveal these things? Not as a result
11 of the generic letter, I mean before, didn't we have
12 anything that -

13 MR. BEAULIEU: Well, we had a tech spec
14 surveillance requirement that says verify ECCS systems
15 are filled with water, and I'll be covering that. The
16 bottom line is that the licensee's efforts were not
17 complete with respect to that. They have -- I think
18 it was the TMI event where a certain dead leg was
19 identified, and Warren, if you wish to expand.

20 MR. LYON: Yes, Warren Lyon. Just a
21 couple of comments. You said typical. I'm not sure
22 there is such a thing as typical here. It depends on
23 a number of circumstances, the individual pump, its
24 location, the piping upstream, downstream, so those
25 are aspects, all of which would influence operability.

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1 In regard to can folks find some of these
2 things, in some of the testing that can realistically
3 be conducted you do not challenge the system in all of
4 its potential operability modes, so the testing that's
5 available doesn't really fully cover everything that
6 might happen. And in the generic letter, we've got a
7 couple of examples of exactly that kind of a
8 situation.

9 MEMBER SIEBER: If you look at the pump
10 manufacturers' curves, you'll find that they often
11 will test a pump with some level of gas or steam, or
12 what have you in suction, and most of the surveillance
13 tests pump at some low flow or shutoff head where
14 -- and that gas intrusion, the effect on discharge
15 pressure is not linear, and so it may work during the
16 surveillance test, and not work in actual performance.

17 MR. LYON: That's an excellent point, and
18 there was some industry tests a year or two ago you
19 may be aware of where they tested an actual high
20 pressure safety injection pump, and the test sequences
21 basically were at high flow rates so that gas
22 basically did not accumulate within the pump. And
23 they fed it some rather high void fractions, and it
24 didn't bother the pump a bit. Apparently, the first
25 stage or two compressed the gas, and it continued to

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1 work. Had they tested it at the low flow rates, they
2 basically, and we certainly concluded, the pump would
3 have failed.

4 MEMBER CORRADINI: Actually, you've gotten
5 to the point I was going to make, which is, it's not
6 the pressure head, it's the volumetric flow that
7 either is going to entrain the gas or not going to
8 entrain the gas, so that if I go into a high pressure
9 injection in the recirc mode for testing, which is the
10 typical way you do it, you shut off the outlet, and
11 you essentially have the small recirc line, you could
12 kill the pump pretty easily from gas, but if I had it
13 in a delivery mode as I want it, there's a lot of gas
14 that it could essentially just suck right through, and
15 work just fine.

16 MEMBER SIEBER: Maybe you could, maybe
17 not. An example that's not gas intrusion, but similar
18 properties is aux feed systems where you have a check
19 valve connection between the pump and the steam drum.
20 That check valve leaks, you end up heating up the
21 suction so that you have a steam pocket. It won't
22 pump. It won't run under those -- it'll turn but it
23 won't pump anything. That's not included in your
24 generic letter.

25 MR. BEAULIEU: You're right. It specifies

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1 the temperature above the local saturation.

2 MEMBER BANERJEE: Can I just make a point?
3 There has been a lot of pump testing done on the void
4 conditions, and it's mainly been done for LOCA, but
5 some of that might be applicable here. There are pump
6 characteristics drawn with various inlet voids, and a
7 lot of these tests were done by Ontario Hydro,
8 actually, but they were also sponsored by the U.S.
9 NRC. So there is information on void versus flow
10 characteristics pumps at different shutoff heads.
11 These were large centrifugal pumps, more like -- and
12 recirc pumps, not heat HPI pumps and things like that.
13 Might be useful to look at that.

14 MEMBER MAYNARD: I'd like to go back a
15 moment. Just my original question or point on this is
16 that I believe that there's enough events, enough
17 conditions out there that warrant some action. I
18 think you can discredit yourself sometimes if you try
19 to encompass everything that might have been found
20 with gas in it, and create room for arguments as to
21 well, those really weren't events, or whatever. I
22 think you need to focus on those things that are
23 potentially damaging situations, and I think it would
24 add more credibility to the discussion, rather than
25 just say that 60 gas intrusion events, that some of

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1 those may not have had any -

2 VICE CHAIR BONACA: But the central issue,
3 I think, is operability. Right?

4 MR. BEAULIEU: Right. The bottom line -

5 VICE CHAIR BONACA: Which is a very
6 specific definition in the law, and also it's plant-
7 specific, and pump-specific. I mean, putting the
8 burden on the licensee, I mean, to demonstrate that he
9 has operability.

10 MR. BEAULIEU: Hold that thought for just
11 one -- I'll get to that, specifically. Just to
12 continue in this order, so what is the desired outcome
13 of the generic letter that's in plain English. The
14 requested actions and requested information are
15 ultimately intended to achieve this, is that -- the
16 next slide, please. Okay.

17 We want periodic testing of the subject
18 systems that include measuring and recording of the
19 volume of gas voids at each point in the subject
20 systems that could impact operability. Venting of gas
21 voids to restore the subject systems to a filled
22 condition, which may necessitate installation of vent
23 valves. We'll get to that in a second. Vent valves
24 I think is a key. And then the location-dependent
25 acceptance criteria for gas void volume is exceeded,

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1 you would expect the licensee to initiate corrective
2 actions that provides reasonable assurance of
3 operability until the next surveillance. That could
4 involve accelerated test frequency to get their arms
5 around what is a rate that gas is being -- gas
6 intrusion is, and then vent it at a frequency that
7 maintains operability.

8 Secondly, would be identifying and
9 correcting the source of the gas. I say that's
10 somewhat secondary, if they maintain it, and the
11 system filled, precisely identifying and correcting
12 the source of the gas can occur at a later time, as
13 long as they keep the system filled, because, for one,
14 they may not be able to identify where the gas is
15 coming from right off to establish system operability.
16 And, secondly, they may not be able to correct the
17 source of the gas depending on plant conditions, might
18 be a valve that's inaccessible, it may be -- so,
19 therefore, I think an accelerated test frequency would
20 address that.

21 MR. LYON: In just one sentence, the
22 objective is to reasonable ensure these systems will
23 be operable if they are needed.

24 MR. BEAULIEU: Yes. In terms of the -

25 MEMBER SIEBER: If you increase the test

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1 frequency, you're saying that you're depending on the
2 gas intrusion to be a constant. You don't really know
3 that that's the case.

4 MR. BEAULIEU: Right. That would
5 necessitate that they would have -

6 MEMBER SIEBER: You have to have some
7 other warning.

8 MR. BEAULIEU: Well, yes, that they would
9 have to test it soon after to understand what is the
10 rate. It could be that it began leaking yesterday,
11 and the rate was enough to get to exceed the
12 acceptance criteria, so they have to get a handle on
13 the rate, or fix the source.

14 MEMBER SIEBER: You can't rely on the rate
15 being a constant.

16 MR. BEAULIEU: Correct.

17 MEMBER CORRADINI: I don't want to deter
18 you too much, but these 60 events that you wrote in a
19 letter as background, is there some place I can look
20 at the 60 events and understand the root cause? If
21 you give a number that big, I assume there's a
22 database that somebody can look at and say okay, this
23 happened, and this was the cause, and this was the
24 corrective action. Does such a thing exist?

25 MR. BEAULIEU: I -- the -

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1 MEMBER CORRADINI: Otherwise, I wouldn't
2 put that in your letter. That's just a suggestion.

3 MR. BEAULIEU: Warren is -

4 MR. LYON: Would you like us to provide
5 such a list?

6 MEMBER CORRADINI: Well, I mean, my logic
7 goes very simply, if there's four or five really big-
8 ticket items that clearly show there's a worry, and
9 there's a root cause, then I think that's fine. But
10 if you label 60, if I were on the other side, if I
11 were the industry, I'd want to find the 60, find the
12 root causes, and make sure all of them affect
13 operability. Otherwise, I'd challenge you on that.

14 MR. LYON: In our examples, we selected
15 sort of a range to span the various types of plants
16 and to provide ones that we recognized as being most
17 serious.

18 MEMBER CORRADINI: But the only reason I -
19 and can delay this or defer it, but I would like to
20 see it eventually, because I'm curious if the root
21 cause -- in all cases, did they affect operability,
22 and how?

23 MR. LYON: In all cases, no, they did not
24 affect operability. They more were illustrating
25 symptoms of real or potential problems.

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1 MEMBER ARMIJO: Were they all surprises,
2 or was this routine?

3 MR. LYON: I think you could say some were
4 basically routine. In the case of one of the plants
5 that we illustrate, they basically would just continue
6 to try to treat the symptoms, rather than getting to
7 the root cause and fixing it.

8 MEMBER ARMIJO: Okay. Thank you.

9 MEMBER SIEBER: The database is the
10 licensee event reports, those are really written
11 shortly after the event, and sometimes plant people
12 don't understand what the event was, so you have to
13 take those with a sort of grain of salt. And, also,
14 if it didn't result in inoperability, there's no
15 report.

16 MR. BEAULIEU: Good point.

17 MEMBER SIEBER: So you could have hundreds
18 of them rather than 70. And if they didn't result in
19 inoperability either during a surveillance test, or
20 when it was actually needed, you wouldn't get a report
21 after that. Might get a non-conformance in your QA
22 systems. That's about it.

23 MR. BLEY: Is there -- I don't see it
24 here, but was there any attempt to ask them to look
25 for evolutions, operations they do that have the

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1 potential to introduce gas on periodic basis?

2 MR. BEAULIEU: What you're going to find
3 is that -- and you notice that the generic letter does
4 not focus on prevention, it focuses on identification
5 and correction. And when you identify correctly,
6 prevention will take care of itself, because what you
7 find is that there are many different possibilities,
8 many different scenarios that could introduce gas.
9 And the reason these systems are particularly
10 susceptible is because of the system interactions,
11 because of multiple suction sources, and that's the
12 bottom line. And just because a system -- and it
13 affects good performing licensees, as well as not so
14 good performing licensees. Valves leak, and I think
15 it was Indian Point, three valves leaked in series to
16 introduce gas, so that, ultimately, efforts to -- a
17 total focus on prevention will ultimately be
18 unsuccessful because of things just like that, three
19 valves in series. A pump starts, a check valve
20 typically seats, this time when it didn't quite
21 reseal, things can and will happen like that, that are
22 not necessarily fault of the licensee. And testing is
23 something as a regulator that we can hang our hat on,
24 depending on varying degrees of licensee's effort to
25 solve this problem, prevent the gas intrusion.

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1 Ultimately, for the regulator, we can have confidence
2 that the systems can and will be operable, because
3 they are verifying through adequate testing that
4 they're operable. And from that perspective, if you
5 get to the principal concern slides, it's under
6 licensing basis.

7 The FSAR says either implicitly or
8 explicitly that the systems are filled with water.
9 Tech spec surveillance says verify, by definition
10 confirm to be true, so it establishes that the design
11 and licensing basis is that the systems are filled
12 with water. So, therefore, any amount of gas in the
13 system is considered a degraded or a non-conforming
14 condition, as legally -- whether it impacts
15 operability or not, is a different question. That's
16 also a problem. But any amount of gas is a degraded
17 or non-conforming condition, so that the licensee has
18 to be aware of when this gets to the point where it
19 renders the system inoperable. And what you'll find
20 is that the tech spec surveillances that are currently
21 in place, some plants do not have tech spec
22 surveillance at all, some cover only a portion of the
23 system, boilers, typically cover discharge piping.
24 And that -- and in spite of that, even PWRs, there are
25 sections of piping that, like I said, have been filled

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1 with air, essentially, since day one that licensees
2 have just recently identified.

3 MEMBER CORRADINI: So can I just -- I
4 mean, I don't mean to use this word too much, but I
5 -- my reaction to that as a bit of an alarmist sort of
6 statement, as the 60 in my mind is an alarmist
7 statement, so I'll be somewhat provocative about this.
8 And the reason I say that is, I would expect that the
9 evolution of gas being present is probably due many
10 times to maintenance, and potentially procedures on
11 how you have to vent after "buttoning-up" a system, as
12 well as they're there from the very beginning.

13 MR. BEAULIEU: If you look, you'd see that
14 there are a multitude of reasons. If it were that
15 simple that you could focus on certain reasons initial
16 system fill, the problem would have been solved years
17 ago. There are a multitude of reasons why -- how gas
18 gets in -

19 MEMBER POWERS: You had a superb
20 presentation at one of the ANS meetings by Duke Energy
21 showing when they had a gas accumulation in the high
22 spot, and it was an absolute detective story to figure
23 out where it was coming from. And it was, in fact,
24 simply coming because they were taking feed from a low
25 temperature source, putting it in the piping system,

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1 and it would sit there for a month and warm up, and
2 the gas would just come out a solution, collect in the
3 high spot. And they tried all kinds of things, and
4 eventually went to the expense of just taking it from
5 a pre-heated water source, and running 30 feet of
6 additional piping to get rid of it, because otherwise
7 it just came out too quickly. They just couldn't vent
8 fast enough, I mean, often enough to keep it from
9 coming down. And it was a major detective story. I
10 mean, the guys did -- it was one of the best examples
11 of a questioning attitude I'd ever seen in any
12 licensee presentation. These guys really went after
13 it like a dog after a bone.

14 MEMBER SIEBER: But you could have
15 situations where high point vents weren't installed.

16 MR. BEAULIEU: That's precisely a large
17 part of this problem.

18 MEMBER SIEBER: And in the early plants,
19 anyway, some of it was the piping was fit in the
20 field, and it was a matter of judgment where you put
21 the vents and drains. So there's nothing to operate,
22 and no way to detect it if you don't have a vent.

23 MR. BEAULIEU: Great point. Two licensees
24 that have undergone escalated enforcement activities
25 as a result of a true air intrusion event, one

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1 installed 17 vent valves, the other 21 additional vent
2 valves. And I think, in fact, if there were a
3 sufficient number of vent valves at every plant, that
4 we probably wouldn't be sitting here today. That
5 would largely resolve part of the problem. But you're
6 right, it was an initial design, precisely as you
7 said. They just didn't anticipate the vulnerability
8 of these systems to this.

9 There is no explicit requirement, like you
10 said field run, to install vent valves; however,
11 design control, we would expect adequate provisions in
12 the systems to satisfy the design basis, the design
13 basis that the system is filled, so it's indirectly
14 testing.

15 We require written test procedures. The
16 next slide. And we require them to record the results
17 of testing. The licensees do -- they are not really
18 -- they are not measuring the gas in most instances.
19 In the vast majority of instances, they don't measure,
20 they don't know how much gas that there is. They're
21 not measuring or recording it, or taking actions to
22 address it.

23 In terms of under the test control, the
24 -- we point out in here that Appendix B, Criterion 11
25 requires adequate test control. This includes tech

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1 spec testing, but is not limited to tech spec testing.
2 So that's why we did not wait and try to address this
3 problem through the tech specs. We have ample
4 regulatory basis to ask what we're doing right now,
5 and what's learned by the industry as a result of
6 this, there'll be a TSTF effort to modify tech specs.
7 And, in fact, maybe relax the 31 days. And it could
8 be a give-and-take, based on what's learned as a
9 result of this effort, so it actually will serve as
10 gathering data for what the tech spec should look
11 like.

12 The next slide, in terms of requirements.
13 Operability, obviously, tech specs require systems to
14 be operable. And under corrective actions, we -- the
15 key point here is that -- what you point out is gas is
16 so common, is that licensees treat it as an expected
17 condition, and not a non-conforming condition. The
18 tech specs and FSAR say that the system should be
19 filled. Any amount of gas is a non-conforming
20 condition. There are varying degrees. Criterion 16
21 addresses significant conditions adverse to quality,
22 so do we expect them to do an accelerated testing for
23 every blip of gas that they identify? The answer is
24 no.

25 So the requested actions - the next slide

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1 just state what the requested actions are, and the
2 requested information. And that's consistent with
3 what I've already discussed in more of a plain English
4 version of what this is, and the underlying
5 regulations of what we hope to achieve by this.

6 Under public comments, licensees point out
7 that studies will have to be completed in order to
8 develop realistic criteria regarding the amount of gas
9 that could impact operability. And, also, studies
10 will have to be completed in terms of gas detection
11 techniques, and the associated inaccuracies about the
12 ability to identify gas in different locations.

13 We are well aware of this, and we
14 discussed this with the industry in advance; that,
15 hey, we're not going to answer these questions for
16 you, in terms of how much gas is too much gas, because
17 the reality is, and you discussed this somewhat
18 earlier, to try to determine for a given amount of gas
19 at a given location, and all the various
20 possibilities, there are literally thousands of
21 different possibilities of gas volumes at various
22 different locations, various pumps, various piping
23 configuration, the slope of the pipe, what is the
24 buoyancy, how much vertical drop is there, how much
25 flow rate is there, will the gas flow into it as a

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1 slug, or will it flow in as bubbles, and can the pump
2 handle a few bubbles, and not be able to handle a
3 slug? And then the criteria in terms of percentage of
4 gas that a pump can handle, you hear percentages
5 discussed in the technical considerations of 5
6 percent, 10 percent. Well, those percentages are a
7 continuous flow of gas, they're not a slug of gas.
8 So it might be experience like through vortexing
9 through examples. In most cases, what they identify
10 during a surveillance will not be a continuous source
11 of gas. So, therefore -- and then, another thing is
12 that to understand the complexity of determining how
13 much gas is too much gas, is one of the licensee that
14 was undergoing escalated enforcement had a known
15 quantity of gas at a known location, known
16 configuration, known pump manufacturer, so you think
17 that if you know everything, it would be quite
18 straightforward just to say was the pump inoperable,
19 or was it not inoperable?

20 I could tell you that the licensee found
21 it was not straightforward in terms of determining,
22 through developing specific modeling for that
23 configuration, and they found that they actually had
24 to do -- develop, what do they call it, an actual
25 fiscal configuration of it to try to test -

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1 MEMBER SIEBER: Model it.

2 MR. BEAULIEU: Model it, actually a
3 physical modeling of that configuration. And like I
4 said, and that's a case where everything is known, so
5 this just describes somewhat the complexity of
6 determining how much is too much, that licensees will
7 have to determine during this, as part of this
8 surveillance. But do they, at the end of the day, do
9 they really have to answer that question of
10 operability precisely? Maybe, maybe not. They have
11 to have an understanding of generally how much gas,
12 what it would take to in opt a pump, but the
13 acceptance criteria is an acceptance criteria for
14 initiating corrective action, so we would expect the
15 acceptance criteria to be much smaller from the
16 discharge pipe, at 15 cubic feet of gas is acceptable.
17 In reality, it would take to in opt a piping to water
18 hammer. Would we expect them to establish an
19 acceptance criteria of 10 cubic feet? No. You'd say
20 that's an opportunity -- that's a red flag that says
21 like when they expect zero cubic feet, the system is
22 supposed to be filled and you get 10, obviously, you
23 would expect and want a licensee to take corrective
24 action much sooner than that. So if they can
25 establish acceptance criteria that are conservative,

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1 and the precise point at which your pump would
2 actually become operable does not have to be,
3 necessarily have to be defined, as long as acceptance
4 criteria are -

5 MEMBER SIEBER: There's a whole range of
6 operating conditions that most of these safety-
7 significant pumps would operate under, like safety
8 injection pumps would be for low fill up to pretty
9 high flows. And the amount of void, or air pocket, or
10 whatever gas pocket that you can tolerate is different
11 depending on what the application is. So they have to
12 cover the full range of applications, as far as flows,
13 temperatures, and so forth are concerned in order to
14 determine what surveillance requirement they have to
15 meet so that it's operable every time that it's
16 needed. That's not a simple job.

17 MR. BEAULIEU: Right. And they could
18 specify in the procedure that the acceptance criteria
19 is not based on operability, it's based on the need
20 for corrective action, and exceeding it. It doesn't
21 necessarily mean the system is inoperable, unlike many
22 surveillances.

23 MEMBER SIEBER: That's right.

24 VICE CHAIR BONACA: This would be to over
25 call. What I'm trying to say is that, I mean, the

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1 licensee tends to be conservative. They don't know at
2 the beginning whether or not they're operable, they're
3 going to declare it inoperable. They have no choice.
4 So you want to make sure that you're preventing a
5 situation where people are over calling all the time.

6 MR. BEAULIEU: Well, you say declare
7 inoperable, but you've got to remember that at the end
8 of this surveillance, the important fact is that they
9 refill the system, so they re-establish operability at
10 the end of the surveillance, regardless, so whether
11 -- and then, also, prior to surveillance, that there's
12 always a presumption of operability, meaning that if
13 it passed its last surveillance, that we allow
14 licensees to presume it's operable until the next
15 surveillance. So if the licensee -- if this is the
16 first time that the licensee becomes aware that a
17 pocket of gas exists in the system, and not
18 necessarily they could have or should have known that
19 that gas existed, we don't necessarily hold the
20 licensee accountable, and beat him up for an
21 inoperable system. That's what surveillances do, and
22 surveillances -- so, therefore -- I guess that's it.

23 MEMBER BANERJEE: How do they know there
24 is gas in the system? What's their surveillance tool?

25 MR. BEAULIEU: That's the second question

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1 -

2 MEMBER BANERJEE: How do they find out?

3 MR. BEAULIEU: That's the second question
4 that we don't specifically answer for them in the
5 generic -

6 MEMBER BANERJEE: How do they do it now?

7 MR. BEAULIEU: That's a good question, how
8 do they do it.

9 MR. LYON: There's a number of techniques.
10 The primary technique is venting of high points.
11 Another one that's quite effective is to do ultrasonic
12 testing, and for that you don't have to have a vent.
13 And if you do it properly, you can get a good
14 volumetric determination of what is there. Then there
15 are additional number of things that can be done. We
16 identify some of those in the generic letter, to
17 qualitatively assess whether or not you've got gas in
18 your system. For example, you could start a pump, see
19 how its pressure develops as it's coming up to speed,
20 and from that kind of a characteristic, you can tell
21 whether or not there is gas downstream of that pump.

22 MEMBER BANERJEE: Do you have portable
23 ultrasonic detectors which can scan a pipe then? Is
24 that possible to use that?

25 MR. BEAULIEU: Yes.

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1 MEMBER SIEBER: The problem is that some
2 of these pipes where these pockets of gas form are not
3 accessible.

4 MR. BEAULIEU: That's one key point.

5 MEMBER SIEBER: So you can't get in there.
6 There are portable hand-held instruments that you can
7 use.

8 MR. BEAULIEU: Good point. That happens
9 to be my next slide, is that the -

10 MEMBER BANERJEE: Thank you.

11 MR. BEAULIEU: -- generic letter does not
12 consider ALARA, personnel safety, or accessibility.
13 That was the public comment, and the key is
14 accessibility. And the words that I specify here are
15 the words that the generic letter says, that we expect
16 all the piping to be tested, to confirm acceptance and
17 operability, unless it has been acceptably established
18 that some items can be excluded. If a particular
19 point is inaccessible, but they know an upstream
20 point, for example, is accessible, and that the only
21 way for gas to get there, they would always see it at
22 the upstream point, that's one way.

23 MEMBER SIEBER: Well, another way -

24 MR. BEAULIEU: That's -

25 MEMBER SIEBER: -- to avoid violating the

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1 ALARA principle, you may not want to do it manually,
2 you want to install some fixed device where you can
3 get a readout at a shielded location. So that may
4 cause a plant modification.

5 MEMBER MAYNARD: And some of these you can
6 just run the pump, as long as you can do it under the
7 design-basis conditions.

8 MEMBER SIEBER: Right. But most of the
9 surveillance tests on things like high head safety
10 injection pumps, and so forth, are not run at accident
11 conditions. And so, you're only approximating the
12 condition that the pump has to run under.

13 MEMBER MAYNARD: But I think the key, as
14 you're saying, it's up to the utility, the licensee to
15 come back with justification of why -

16 MR. BEAULIEU: In terms of how they're
17 doing it, and the accuracy, and why that accuracy is
18 good enough. And it would be dependent on where -- if
19 it's suction, you'd expect something more precise than
20 on the discharge. Mr. Maynard, do you have anything
21 else that -- Mr.?

22 MR. BLEY: Dennis Bley.

23 MEMBER CORRADINI: Bley, I'm sorry.

24 MR. BLEY: We've kind of danced around it,
25 and I've been hanging on your tech spec back there

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1 about periodically measuring and recording the volume
2 of gases. I was focused on the vents and things, if
3 you've installed all these 15 or 20 vents on modable
4 systems, if you had to go in and vent each one into a
5 bottle or something to measure it, that's not going to
6 happen. If we were forced that way, you'd probably
7 see some kind of automated venting system put in. The
8 ultrasonic test might get around that, or the
9 performance tests you mentioned, if you can do
10 something like that. Otherwise, I was going to say in
11 the beginning, we'll hear from the industry how
12 they've thought about dealing with this, but I think
13 it didn't sound very optimistic.

14 MR. LYON: Some of the folks actually do
15 attempts to measure the volumes as they vent, and some
16 of them can do it fairly successfully. But, as you've
17 correctly pointed out, it's not always straightforward
18 and easy.

19 MR. BLEY: And I suspect it's an ALARA
20 issue, and it's -

21 MR. LYON: In the case of an ALARA
22 consideration or something of that nature, our primary
23 responsibility is back to that basic, do we have
24 reasonable assurance the thing is going to work? And
25 if, as was just correctly stated, ALARA is a

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1 consideration, and it's a problem, then perhaps a
2 physical modification is necessary.

3 MEMBER ARMIJO: Would you like to make a
4 comment?

5 MR. RILEY: Yes. This is Jim Riley, NEI.
6 I just wanted to throw in, this is a very interesting
7 conversation, I mean that. I want to let you know,
8 Gordon, I hope, is going to have a couple of minutes
9 to talk about what the industry is planning to do, but
10 when we provided our comments on the generic letter,
11 we pretty much agreed that this was an issue that we
12 needed to look into. And we've already started to do
13 that. We've got the owners groups are both involved
14 in separate efforts, which Gordon will be talking
15 about to some degree. We've got a meeting set up at
16 NEI next week. We'll be working with David, and
17 Warren with others, to come up with a right solution
18 to this thing. And this is good input. I think we
19 have the right people looking at this to come up with
20 what is a difficult problem; because, as you're
21 pointing out, there's all kinds of possibilities here.
22 And what is a reasonable thing to do is an important
23 end result of this thing. And we will be working on
24 that with, what I expect to be the right people to
25 come up with some answers.

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1 MR. BEAULIEU: And, in fact, the rest of
2 my slides, I've really covered everything, that
3 information in the discussion, so at this point I can
4 shift it over to -

5 MEMBER ARMIJO: Before you do that, let's
6 ask if there are any additional questions to Mr.
7 Beaulieu? If not, we'll move on to industry comments,
8 and Mr. Clefton will make that presentation.

9 MR. CLEFTON: First, I'd like to thank you
10 for giving us an opportunity today. In a different
11 process, if you will, this is in infancy stage as far
12 as recovery and response, and such, so the industry is
13 mostly standing by to respond to the generic letter
14 response that's out there. We've been addressing the
15 issue on a case-by-case basis for 20 years, since
16 plants started, as was identified earlier. We're not
17 just limited to safety systems, we've got gas
18 intrusion and line-up, and fill issues that have been
19 in the problems from the time we started running the
20 plants.

21 As has been described in the discussion
22 today, it's an infinite number of possibilities of how
23 you can get gas in, and complications of how you can
24 test for it. As Jim pointed out, we've responded more
25 on an industry-basis, on an individual basis, I'm

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1 sorry, not a collective basis, and what we're planning
2 to do now, as I've worked with the pressurized water
3 owners group, and the boiler water owners group, is to
4 be able to bring the resources that we have, the
5 industry experience we've gained from the plants that
6 were used as identified items in the 60 examples. But
7 what we're finding is that there's a need for
8 classification, so we can address and fix things,
9 perhaps in a more organized manner. We've got dynamic
10 situations, we've got static situations, we've got
11 cold situations, we've got hot situations, we've got
12 examples that when I was in plants, we had field route
13 event, and drain valves, PNIDs if you're familiar with
14 them, they show them on the same side of the line.
15 Well, a field operator looked at that one time, and he
16 put the vent and the drain line side by side.

17 (Laughter.)

18 MR. CLEFTON: We found it in doing a walk-
19 around in early construction. That was atrocious,
20 that nobody even considered, and they never looked at
21 a high rise point. These were folks that were not
22 engineers, putting welders to work out there. They
23 were putting weld dust, nut sets on the bottom side.
24 It was atrocious. I spent some time at a utility
25 where we put 21 vents into a high system. We assigned

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1 a system engineer, an opportunity to go out and walk
2 down their system to identify the high point vents.
3 We, as an industry, have struggled with a one-size-
4 fits-all measure capability, because as soon as you
5 decide you're going to use ultrasonic measuring, you
6 have to have a clean attachment point shiny on there.
7 Well, when you've got four inches of insulation out
8 there, that's a problem. And you can't get to it, so
9 we -- I think everybody in the room can recognize that
10 we don't have a simple solution for anything that's
11 out there.

12 We plan to gather the task force here. We
13 talked about the operational challenges here. We've
14 covered those. I'll talk a bit about the B and the
15 Ps, and then the industry activities. We've
16 collectively boxed ourselves in, painted ourselves
17 into the corner of the room. If you look in the
18 standard tech specs, it says, "ECCS system will be
19 maintained full." That sounds pretty simple until you
20 come up with a definition of what's full.

21 MEMBER CORRADINI: In the computer world
22 when they say there's no void, they use 1 percent as
23 the numerical void value.

24 MR. CLEFTON: Exactly. And so, if we open
25 up the tech specs and go back to the basis, we'll find

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1 that the first opening sentences say, "Normal
2 operation of fluids in pipes result in gases coming
3 out of solution and that air voids are expected."
4 Well, you go back to the thing and it says "full",
5 it's unacceptable. So we've got to come back -

6 MEMBER SIEBER: Well, it's full. The gas
7 will fill -

8 (Laughter.)

9 MR. CLEFTON: As mentioned, we've got the
10 tech spec task force working on better words for the
11 word "full". But, collectively, we're all sharing the
12 fault when that was released, that we defined
13 something that was not capable of doing, not possible,
14 and so we need to fix that. But the basis says it's
15 normally expected, as David has pointed out, we need
16 to define what's acceptable, and what's not. The
17 operability is a key item here. A little bit of belch
18 or burp, or even a small void going through doesn't
19 hurt us. But as Warren and I've talked, if it's in
20 the suction line and there's multiple high points, and
21 it's all going to collectively end up in the pump,
22 we're going to air bind the pump. Now whether that's
23 a positive displacement pump, as the case of Ocone, or
24 whether we've got other styles of pumps, multiple
25 stages, horizontal, vertical, any one of those can air

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1 bind to this degree. But as we've pointed out, you
2 can get a lot of bubbles going through there without
3 affecting performance. And when you go back to the
4 original pump curves, they'll give you a percentage
5 that's acceptable for pump operation, but that may not
6 even approach what's operability limits. So we're
7 challenged to decide what's full, and what is
8 acceptable limit. Operability is our key aspect
9 there.

10 As you pointed, we would declare it
11 inoperable if we thought there was a question of it.
12 Now we all know in reality, operators are going out,
13 they're opening the valve until they see water
14 spraying out, some hits the floor, and they turn it
15 off, and that's for the ones they can get to. Now
16 we've made conscious efforts in the industry to go out
17 and find high point vents, and find what we can do
18 there, but it's still open the valve, spray it on the
19 ground, because unless you've watched an engineering
20 lab technician go around and take a pressure
21 temperature volume measured gas from the system and
22 then record the temperature, the volume, the flow, and
23 then bring it back to the lab and do the pressure
24 volume molecular controls, that's a major effort.
25 And, realistically, that's not going to happen out

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1 there. We're not going to be able to get that type of
2 reconstruction. And that was only a snapshot at that
3 moment, because if somebody went to a two-pump
4 operation, or opened by the bypass, it just changed.
5 So we've got to look at what we can use as a
6 collective solution, a generic solution.

7 We're gathering the forces of the industry
8 to bring resources that have solutions that have
9 worked at sites, starting on the 11th, and then we'll
10 be sharing that again with Warren and folks on the
11 12th.

12 Accessing, we talked about, we talked
13 about the trending and the tracking. One of the
14 concerns that came up in the generic letter is it said
15 we needed to record. Well, an operator is going out
16 and turning the valve until it opens, water hits the
17 floor, he doesn't record how much gas came out of
18 there, and tracking of it is -- that would be a major
19 effort, and affect their operability.

20 MEMBER ARMIJO: But he could record the
21 time it was venting in one of the -

22 MR. CLEFTON: And what we found is when
23 the utilities came back to put in a ball valve with a
24 known orifice size, and it was top notch. And he
25 would open it with a ball valve, with a stop watch,

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1 and it was a better estimate, but it wasn't totally
2 accurate.

3 MEMBER SIEBER: You still have to use the
4 Perfect Gas Law to get to the answer. And usually the
5 people who do surveillance tests are not mentally
6 equipped to use the Perfect Gas Law.

7 MR. CLEFTON: That's true. Some of my
8 students aren't equipped to use it.

9 (Laughter.)

10 MEMBER ARMIJO: I'm thinking of something
11 that's a little more qualitative. And you go in there
12 to vent the line, and your expectation, somebody
13 should have an expectation that this thing should vent
14 for no more than five minutes, and that's it. And if
15 it goes on for half an hour, you know you've got a
16 problem.

17 MR. CLEFTON: A burp or belch is
18 questionable, and a void is bad. And if it's 30
19 seconds of venting, then you've got a problem. And I
20 think our operators with their, what would you say,
21 they're skilled craft recognize that, and that's when
22 they would flag it.

23 MEMBER SIEBER: They can do that.

24 MR. CLEFTON: But we've had reports of
25 inspectors who have gone out and questioned, followed

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1 an operator through his watch grounds, and found out
2 that he didn't write down what was there, and he was
3 venting two or three times a day, and it had always
4 been that way, so he figured that was normal. Well,
5 perhaps it was, but maybe that's not acceptable.

6 Our concern as an industry is, we don't
7 know what was operable limits, where we put a warning
8 in that we have to take action with corrective action
9 program, or we put an alarm in that something is going
10 wrong, we have to declare inoperable and have to shut
11 the system down. Those are the categories that
12 challenge us right now. And as you mentioned, it's a
13 Perfect Gas Environment where we've got to do a lot of
14 calculations on each scenario. The question is,
15 what's the most bang for our buck? We've got to stop
16 the problem, and work -

17 MEMBER SIEBER: On a system that's
18 basically isolated, you may accumulate some gas, but
19 you aren't accumulating big volumes.

20 MR. CLEFTON: Right.

21 MEMBER SIEBER: And so if you get more
22 than just a little bit of gas, you probably have a
23 problem that you ought to think about, and look into.

24 MR. CLEFTON: And that's the research
25 project that Duke did a couple of years back.

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1 MEMBER SIEBER: Right.

2 MR. CLEFTON: The water program that Mr.
3 Powers referred to.

4 I guess, in opening, what I'd like to say
5 with the Bs and the Ps, is both organizations have
6 recognized that we have a problem. And in global
7 perspective, we don't think the generic letter should
8 spend or request too much time to go out and research
9 and document how much of a problem we have out there.
10 The same people that would be researching and
11 documenting what was a historic problem are the ones
12 that are going to be fixing the problem right now.
13 And I guess what I'm saying overall is the industry
14 recognizes we have a gas intrusion problem.

15 Now we challenge that there were 60 good
16 examples of gas intrusion, is what we have as a good
17 definition of gas intrusion, because some of those
18 were line-up errors. I mean, if you keep a plant with
19 a leg dry in a system for 22 years, that wasn't gas
20 coming out with liquid in a pipe. That was a liner
21 problem, so I have to challenge that that's a gas
22 intrusion from dynamic or static situations. But it
23 was a void in the flow path of the system, so,
24 therefore, it needs to be under this category and
25 addressed. It's not gas is coming out because we had

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1 cold water going into a hot environment burning up.
2 Every time you have fluid in a pipe, you're going to
3 have a void over at the top unless you have extreme
4 pressure and a pressurizer standing alongside of it,
5 so you don't get bubbles in the pressurizer.

6 MR. BLEY: And that was not a high point
7 problem.

8 MR. CLEFTON: Right. All this concern
9 about transferring the bubble from the pressurizer
10 back to the top of the core, and so we can do that in
11 pipes all along. We can generate it. You could have
12 a vent valve that's leaking, and a negative pressure
13 on it, be sucking valve air back into the system, and
14 hurting ourselves, because valves are mechanical, they
15 can break, their seals go away, and they're typically
16 three-quarter, one inch size valves with small seats
17 that are no easily polishable. You just replace the
18 whole valve types.

19 MEMBER CORRADINI: Just one other thing,
20 so to switch sides a bit, so I didn't know if you said
21 it. Maybe you said it, and I missed it, you're not
22 just interested about static conditions. You're also
23 interested about dynamic conditions that would lead to
24 gas intrusion, like vortexing.

25 MR. CLEFTON: Like vortexing.

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1 MEMBER CORRADINI: Okay. Fine. I just
2 wanted to make sure I didn't miss it.

3 MR. CLEFTON: When you get a pump and you
4 run without an intense amount of suction pressure,
5 you're going to get cavitation. That's bubbles that's
6 coming out that's going to go into -

7 MEMBER CORRADINI: I'm also, though,
8 thinking about any sort of usage of a tank where I can
9 get to the level to the point that it would vortex
10 from a low level.

11 MR. CLEFTON: And that was one of our
12 examples in the generic letter that came out. They
13 ran the tank dry and got air into the pump. Well,
14 that's not gas intrusion, as it is, that was operator
15 error, the low level alarm switch didn't go off and
16 things like that.

17 MEMBER MAYNARD: You also have dynamic
18 situations where you're changing the line-up. I mean,
19 you may switching over to a different suction, or
20 different discharge, and end up with -

21 MR. CLEFTON: And we get into a commercial
22 interest here, not just on the pure safety systems.
23 So you walk through the secondary plant, you've heard
24 air hammer, water hammer when the supports are given
25 inches of movement and stuff like that. I think that

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1 was referenced at one of the TVA plants, that there
2 was a number of water hammers in a plant startup.
3 Well, we've heard that because of the fill process
4 can't get all the bubbles out that you'd like, and
5 when you start the pump, you get an air slight, and
6 you see pipes move three to four inches. It's pretty
7 exciting in the industry to happen in a secondary
8 site. Commercial interest, we don't want to crack or
9 break the pipe, we're out of business. And we're all
10 not there for any particular purpose.

11 MR. BLEY: You said one thing that
12 interests me a little, because I was sitting here
13 thinking all along, I know it's a real operational
14 pain if you get a pump that won't run because of this,
15 and figuring out how to clear it, and use it. So I'm
16 kind of surprised things stay around a long time, but
17 the idea that operationally there are guys out there
18 who know they have a problem informally. They've
19 venting the pipe routinely, and that's not tracked
20 officially, and may get lost in the process. Have you
21 gotten to the point you have a feel of how common that
22 is?

23 MR. CLEFTON: No, I don't have real
24 numbers on that. We encourage it, we encourage
25 management by walking around, we want system engineers

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1 in the field, on safety systems more perusal than what
2 you'd expect. And we find that when you go to talk to
3 the operators when they're actually in the field,
4 because on the watch logs they're not typically
5 writing down that they vented six times.

6 MEMBER SIEBER: On the other hand, walking
7 passed a pump suction, you're not going to know
8 whether it's gas or liquid.

9 MR. CLEFTON: Right.

10 MEMBER SIEBER: You have to do something
11 more than put your hand on it.

12 MR. CLEFTON: So I think what we've
13 collectively agreed is that we have a problem out
14 there. We're working on it. We've got some sites
15 that have been successful at it. Indian Point's got
16 a working system, Duke Energy has a research group
17 that goes after the problems and troubles, the Perry
18 Plant went after high point vents and modified with
19 their system engineers input and stuff like that.

20 A concern we have is that we don't have
21 confidence that we don't have an outlier out there,
22 that we don't have people that are just getting by
23 with operators opening until it's vented. So bringing
24 together the resources of the power plants, we've got
25 the Bs that have, you can see in the slide here. They

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1 funded planning, strategic planning for this year
2 already. They've got a committee working on it. One
3 of their aspects is to respond to the generic letter.
4 The second is to put a solution and resolution
5 together that will apply for creating processes,
6 procedures, and guidelines for the sites that are out
7 there. As we mentioned earlier, the Bs and Ps have
8 separated enough on this issue; recognizing it was
9 just a common one, we're bringing them back together
10 to share some of the solutions. We're doing that
11 through NEI.

12 The Ps, on the other hand, pressurized
13 water reactors, have turned to Westinghouse. They've
14 activated a group that's done a road map for the gas
15 voiding concern. They've got action going out in
16 Rowville right now. Some of the tasks that are listed
17 here on this chart have already been completed.
18 They've got folks working on determining gas voids in
19 different systems.

20 We've had full-size mockups that the
21 industry has used to be able to duplicate systems that
22 were challenging, to figure out where the gas was
23 coming. Sometimes it's an inlet flange, sometimes
24 it's a leaking valve, sometimes it's, as you
25 mentioned, three valves in a row that were a leaking

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1 issue. But we've got activity in both the Ps and the
2 Bs. We're bringing them together at NEI. We've got
3 a steering committee meeting on the 11th of October,
4 next week, an all-day session. We expect to address
5 the 60 items that were in the generic letter. We're
6 going to share the industry experiences, because we've
7 got a number of utility reps that have got successful
8 programs going coming to our meeting. We've got a
9 couple of vendor reps, what you're talking about, the
10 ultrasonic measurement devices, and what limitations,
11 and what capabilities we have with those. We're
12 looking at a path forward. We expect to have a path
13 towards resolution, a time schedule, the resources
14 available, the costs that we'd have to put that
15 together. And then on the following day, on the 12th
16 of October, we expect to share that with NEI for a few
17 hours, with a drop-in visit, if you will. We're just
18 going to share what came out of our meetings quickly
19 as it occurred so that we've got direction. Our hopes
20 are -

21 MEMBER APOSTOLAKIS: NRC, you mean. You
22 want to share it with NRC.

23 MR. CLEFTON: Yes. NEI sharing the
24 industry meeting output with the NRC. Our intent
25 there is that perhaps we can influence the content of

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1 the generic letter, so that we don't spend an immense
2 amount of time just emotionally documenting that we
3 have a problem out there. Let's go back to real root
4 cause solutions that were true gas intrusion problems,
5 and say these are examples. Now that you've seen it,
6 what can you do in the future to recover, and resolve
7 the issue?

8 I don't think, and Warren and I have
9 talked about this, that the six-month period is going
10 to be an appropriate length of time to resolve issues
11 as complicated as what we've discussed this morning.
12 It might be enough time to put a plan together, and to
13 initiate action, and to get some responsible
14 activities identified at each of the licensees, but a
15 six-month period is not going to solve something that
16 we've been working on for 40 to 50 years of problem
17 generation. So we need to be a bit realistic on that.

18 MEMBER SIEBER: Yes, you've got a couple
19 of problems. I don't think there are any two plants
20 that are the same, even plants where you have one unit
21 sitting next to another unit, they're different. And
22 the only kind of drawings that you can get locations
23 of vents, and drains, and fill valves, is isometrics,
24 and they're tough to read, because they're written by
25 room, and you can't -- you have to do a lot of

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1 thinking in order to associate system piping with the
2 components that are in that system. It's not lot a
3 schematic, and a schematic doesn't tell you anything
4 about layout, or vent paths, or chance of
5 accumulation, so this is not a simple job. And I
6 think there is probably, the industry, each plant is
7 going to have to go hand-over-hand over the vulnerable
8 areas in order to be able to make any kind of
9 determination as to where their vulnerabilities are.

10 MR. LYON: If I may make a couple of
11 comments. One, on your drawings, isometrics typically
12 don't indicate slopes in pipes, which are vitally
13 important in some of these aspects. And in my
14 personal experience, they're not always accurate with
15 the as-built plant. And I have found that in side-by-
16 side units where they were right in one plant, and not
17 in the other one, for example.

18 MEMBER SIEBER: That's true.

19 MR. LYON: With respect to some of
20 Gordon's concerns, we share effectively a picture of,
21 we don't want to waste a whole lot of time with
22 unnecessary documentation. We want to get at the
23 problems, and our intent is that the generic letter
24 responses will be correctly focused.

25 With respect to the six months, we fully

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1 realize we're not going to have a complete resolution
2 in place in six months. We're talking typically
3 years, and again, the generic letter would allow the
4 flexibility for that kind of response.

5 MEMBER SIEBER: On the other hand, you
6 don't want to wait until you get tech spec violations,
7 plant incidents, and perhaps an accident to say gee,
8 there's an air pocket there.

9 MR. LYON: And absolutely correct.

10 MEMBER SIEBER: You're better off -

11 MR. LYON: In that case, we would
12 anticipate a feedback that says well, we haven't been
13 able to handle all of these problems, but during the
14 interim, how do we reasonably ensure operability?

15 MEMBER SIEBER: I agree with that.

16 MEMBER ARMIJO: So in the six months
17 period do you expect to come up with some interim
18 guidelines for licensees as to how to address this
19 issue until you complete your research, and come up
20 with a reliable solution that people can follow?

21 MR. CLEFTON: I think, as Warren implied,
22 we're going to have to look at a short term to make
23 sure we don't have an issue that's hurting us right
24 away, so we have guidelines and what to go look for
25 right now, in case you haven't gone out and seen the

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1 vent and drain lines are on the same side of the pipe.
2 And then we have long-term solution of how you ensure
3 that you've done a walk-down when it's available,
4 because we can only get to a lot of these systems and
5 points in certain modes of operation, if you will.

6 MEMBER SIEBER: So you're asking the
7 industry to develop that, as opposed to dictating how
8 they will develop it.

9 MR. CLEFTON: Yes. We'd prefer to develop
10 it ourselves, and come back and give you status
11 reports of the success that we're having, or the
12 hardships, or the barriers, or whatever is in front of
13 us, rather than to be regulatory driven by an
14 artificial schedule that says well, we think it would
15 be good nine months if we have this, and twelve months
16 you have this, because we've got real-life situations.
17 Every pump and every system is going to be different
18 scenario that's going to need to be addressed, and
19 realistically, staff resources, it's going to be a
20 handful of people on each site that can do that, so if
21 he's got eight systems to do, it's going to take eight
22 times whatever -- we'll have a learning curve, but it
23 will still take a duration. So what I propose is that
24 we be asking for a time line of commitment of
25 deliverables from the sites, from the individuals,

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1 perhaps. But we're going to try and work it as an
2 industry with a short-term solution so we don't have
3 a failure that's embarrassing, and a long-term
4 solution that we can feel confident that we've
5 identified what's an operability limit for each of the
6 systems, and that there's a manner of measuring it so
7 that it doesn't occur, and that there's a warning
8 level before that, an alarm level before that, so that
9 we can go into selective leak before failure type
10 arrangement, where we start getting more bubbles than
11 we expected, we've got a belch now, and tomorrow we've
12 got a void, something happened, you need to do a root
13 cause analysis on it. So those are the type of things
14 that -- the brain trust that's coming to this meeting
15 are going to put on the table in a one-day period.

16 The advantage that we have is we're not
17 starting with a blank sheet of paper. We're bringing
18 experience to the table to share which are the best
19 points of each of those.

20 MEMBER CORRADINI: So let me just ask a
21 different question. So why didn't you do this sooner?
22 Was it the threat of the generic letter that got you
23 going? I mean, I -- you seem very resolved to the
24 fact that it's been around, et cetera, so why not 10
25 years ago?

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1 MR. CLEFTON: Well, what I can say in
2 answer to that is it's been done on an individual
3 basis until now, because of the sites that gets
4 violated has to resolve it to get their license back.
5 You're not going to give the keys back unless they fix
6 their -

7 MEMBER CORRADINI: But I'm talking about
8 the NEI's efforts.

9 MR. CLEFTON: NEI's efforts on this now
10 are turning to a collective effort to handle the
11 resources and do a generic solution, if you will, on
12 the guideline. As far as the timing, it just hasn't
13 been high on the radar scope, and the generic letter
14 identified it, but this generic took what, a couple of
15 years to get to that level, too. But we've been
16 documenting and reporting the history, so it's not one
17 that's been ignored on an individual basis. It just
18 hasn't developed to a task force level of importance
19 where we are collectively going -

20 MEMBER MAYNARD: I don't think it's been
21 ignored. I think it's been left up to the individual
22 utilities more, rather than being a coordinated
23 effort. And I think some have done a very good job,
24 some probably haven't done as good a job, and this
25 kind of brings it to a level of consistency that

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1 addresses it for all.

2 MR. CLEFTON: We'd like to raise the bar
3 for everybody.

4 MEMBER SIEBER: People tend to solve the
5 problem at-hand, as opposed to saying this same
6 problem could exist in a lot of other systems.

7 MR. BLEY: Mostly, you think it's the
8 other guy's problem. Until it happens to you, you
9 don't -

10 MEMBER SIEBER: You don't think at all.

11 (Laughter.)

12 MR. BLEY: I have a really different
13 question. It doesn't have to do with what you're
14 focused on, getting the generic letter out, and the
15 response to it. But from both sides, how -- from the
16 NRC side, how is what you're learning here being
17 reflected into the design certification process so we
18 don't have the same thing later? Same thing for the
19 industry, is the industry thinking of doing something
20 to make sure the vendors don't give you plants without
21 hot point vents next time around?

22 MR. BEAULIEU: I'm not aware of any big
23 efforts at this point.

24 MR. BLEY: Is there a mechanism that
25 connects the -

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1 MR. LYON: There is in a sense a mechanism
2 in which our organization, the office that's in charge
3 of all of the new reactors, and our old-timers, so to
4 speak, are communicating back and forth so that we
5 don't run into a piece of one aspect of NRC doesn't
6 know what the other one is doing.

7 MR. BLEY: I ask it because we've been
8 looking at a new design yesterday, and I don't recall
9 seeing any questions, or anything about this issue.

10 MR. LYON: Great point.

11 MEMBER CORRADINI: I'd even go further
12 what Denny is saying, which is all the new systems
13 developed are all dependent upon small delta Ps to
14 move things around. And now I'm almost in the testing
15 mode of the pump, where I can bind things up with a
16 very little amount of gas. So I think that's an
17 incredibly important point, to make sure that at least
18 the industry, or the vendors in their design are
19 thinking about it, and have considered it in how
20 they're doing their detailed design, because I think
21 one of the responses from yesterday for the ESBWR was
22 a lot of this detail design is yet to be done.

23 MEMBER MAYNARD: And I agree, it's an
24 important issue. I think that the regulatory tie, I
25 think for any new design certification, the COL, you

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1 basically do have to go back through all the old
2 existing generic letters, and other items. So I think
3 this will get captured as part of the review. It's
4 not something that is just going to be dropped. Now,
5 as to how well it gets addressed may be a different
6 issue, but it -- once the generic letter comes out,
7 then it will be tied in.

8 MEMBER ARMIJO: It's particularly
9 important because you're talking about gravity-driven
10 systems.

11 MR. CLEFTON: Thermal-driven systems. One
12 of the things in defense of the new designs is that
13 they are -

14 MEMBER ARMIJO: Oh, yes. You know where
15 the high points are.

16 MR. CLEFTON: And we put the systems
17 together back in the 60s, 70s, and -

18 MEMBER CORRADINI: You don't really
19 believe the computers, do you?

20 (Laughter.)

21 (Simultaneous speech.)

22 MR. RILEY: Jim Riley, again. Just a
23 couple of thoughts. It swept beyond where I wanted to
24 make my comment, but I'll take us back for a minute.
25 You had asked about industry getting, and thinking

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1 about what we could do on this, and I agree with what
2 you're saying, that it was done on an individual
3 basis. But we, also, INPO has been doing things on
4 this. INPO did an OER/SER several years ago. They
5 have been following the thing, and as Gordon and I
6 were kind of working this thing up on where we were,
7 it was apparent that INPO was also kind of building
8 this issue up, and we're going to help bring it to
9 everybody's attention, if we didn't trip over it other
10 ways. But there are other things that were ongoing.

11 Regarding the new plants, just a couple of
12 thoughts on that. Because of the fact we have the Ps
13 and the Bs involved in this, I'm hoping here, but you
14 would think there would be more communication, since
15 we got those owners groups involved in the resolution
16 of this, they're feeding us information back to the
17 folks that are designing the plants. We have a new
18 plant working group within NEI that meets regularly
19 and kind of talks about these design certs issues, and
20 infrastructure, and that kind of stuff. And this has
21 got to be something that we also have to do internal
22 to NEI here, to kind of make these kinds of
23 communications over to those guys.

24 Now I'm not telling you whether there's
25 anything going on right now, but this is a good point.

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1 There's things that come up from time to time, and
2 we've just got to make sure that Gordon and I are
3 working on that level of communication with our new
4 plant working group and task forces. Thank you for
5 the comment.

6 MEMBER MAYNARD: I believe that a couple
7 of the more recently identified issues are related to
8 going back looking as a result of some of these INPO
9 and other initiatives, too. Some of these were not
10 self-revealing, you had to go out and look for them.
11 And I think that process has identified some of these,
12 too.

13 MR. LYON: There's one other thing that I
14 consider to be a real important contributor to what's
15 going on. As you can tell from what Gordon is saying,
16 they're off and running on this thing, and we're
17 working together, so the intent here is there aren't
18 going to be any surprises from one side or the other,
19 and we'll be working together to ensure we get to
20 where we need to be. And I'm a little bit excited
21 that this process is ongoing successfully.

22 CHAIRMAN SHACK: That was sort of my
23 question, the requested actions and information in the
24 letter have been changed since the version you saw for
25 public comment. I just wondered if you've seen the

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1 most recent version, and you still have a concern?

2 MR. CLEFTON: No, that's why we haven't
3 addressed those today, because probably the first time
4 I'll see those is on the 12th or so of October. And
5 recognizing that's a document under change, under
6 development, we expect it to have most of what we're
7 looking for. Warren shared with me the contents on
8 the telephone as much as we can. There's been open
9 communication back and forth. We're just concerned
10 that we don't want to be regulatory-driven in a
11 direction that none of us wanted to go, or to ask for
12 something that's impossible to do, that we don't want
13 to keep the pipes all full, by the definition of full.

14 MR. BLEY: One last one from me. I'm
15 sitting here thinking about the guy who's going out
16 crawling around, and he gets to his 43rd vent and
17 opens it, and for the 43rd time he gets no air, start
18 worrying about how thorough it's going to be after
19 that. And I know we lay out plans that everybody will
20 do, and there's no question about that, but I've been
21 there, and after a while you start to worry.

22 The idea of being able to look at the pump
23 response and having some clue sounds attractive in the
24 beginning, but a pump that's been out there for 15
25 years running has a lot of things that will affect its

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1 response. And I'm not sure -- have you thought about
2 how well you can learn anything from that, given a
3 pump with a lot of hours on it?

4 MR. CLEFTON: Well, if you were using that
5 type of qualitative analysis, you'd probably have
6 tracking records on it, so you'd be able to -

7 MR. BLEY: Maybe it will -

8 MR. CLEFTON: Whereas, the venting with a
9 different operator, you have 23 up on the scaffold,
10 and just during startup, and never ever after. That's
11 a difficult one to go for, but the qualitative ones I
12 think we would be able to keep in the calculation
13 realm, if you will, on the engineering -

14 MR. BLEY: At least you could track it
15 into the future.

16 MR. CLEFTON: You could track it. You can
17 see detectible changes in pump performance, and that's
18 why if you had a normal startup and you watched the
19 ramp, the curve of pressure build-up on it, for
20 example, and all of a sudden it was significantly
21 different, the rate came up different than what you
22 expected, that's an alert, call the system engineer
23 and get an analysis going here. But what we can do is
24 raise the awareness, if you will, of the science
25 routes available for the industry, and make that

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1 available. We don't have a lot of vendors out there
2 right now spending time offering services to come out
3 and measure voids. If this becomes a little pocket
4 industry, we might have a whole bunch by this time
5 next year.

6 MEMBER SIEBER: My experience with plants
7 is that operators have a certain amount of
8 professionalism, and that they go and do their job, if
9 they've done it a thousand times before, they'll do it
10 again, or at least the ones that work for me. And I
11 could rely on that.

12 MEMBER MAYNARD: I agree. Rely upon that,
13 not only for venting, but for system lineups, and
14 everything else.

15 MEMBER SIEBER: And if a certain
16 individual fails, it shows up someplace. And you take
17 corrective action.

18 MR. BEAULIEU: One possibility is that if
19 it's impossible to have gas at one point without also
20 seeing it at another point, then you say well, we're
21 only going to open them if we see gas here. That's a
22 way of minimizing the burden, too. You have to
23 properly justify that, but -

24 MEMBER ARMIJO: Well, are there any
25 further questions to either Mr. Beaulieu or Mr.

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1 Clefton?

2 MEMBER MAYNARD: I don't have any
3 questions, but a comment. I'm really encouraged to
4 see the NRC and the industry both in alignment on
5 this. I was pleased to see that the NRC read and
6 seemed to understand, and have attempted to
7 accommodate public comments on the thing, where they
8 were applicable. I think we've talked about a lot of
9 things that this is an important issue, and I don't
10 want my next comments to appear as though I'm saying
11 this is a non-issue. But on the other side of the
12 coin, these systems are very robustly designed. We've
13 had a lot of operating experience. We've had plant
14 transients where things have had to actuate stuff, so
15 while this is an important issue, and we need to
16 attack it, and we need to get on with it, there still
17 is an adequate level of safety out there for
18 protecting the health and safety of the public.

19 MEMBER ARMIJO: Thank you. Other comments
20 or questions? Well, thank you, gentlemen.

21 MR. BEAULIEU: Thank you. I turn it back
22 to you, Mr. Chairman.

23 CHAIRMAN SHACK: Again, we're a little bit
24 ahead of schedule. Everybody has been running - I
25 can't believe it.

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1 (Off the record comments.)

2 CHAIRMAN SHACK: We'll break until 1:30
3 today.

4 (Whereupon, the proceedings went off the
5 record at 12:10:15 p.m., and went back on the record
6 at 1:34:11 p.m.)

7 CHAIRMAN SHACK: We can come back into
8 session. Our next topic is the dissimilar metal weld
9 issue. As members will recall, industry had a program
10 to mitigate the similar metal welds on pressurizer
11 nozzles. Then Wolf Creek found some circumferential
12 indications and the staff was concerned that some of
13 the plants would not be able to get their mitigation
14 strategies in place as soon as was desirable. And so
15 there was a question of whether an extension could be
16 granted past December.

17 And the industry undertook a program to
18 more accurately characterize and analyze the behavior
19 of cracks in these kinds of welds. And staff has
20 reviewed that and has granted the extension and we're
21 here today to hear some of the technical work that
22 formed the basis for essentially that decision to
23 consider the extension on the mitigation deadline.

24 MEMBER POWERS: Didn't we go through this
25 once with Davis-Besse?

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1 CHAIRMAN SHACK: One of the reasons is
2 this required an extensive analysis and an assessment
3 and I guess Glenn White, David Steininger will start?

4 MR. STEININGER: Okay, my name is David
5 Steininger. I'm the Senior Program Manager for the
6 MRP and the SGMP. This work was done for the MRP by
7 Dominion Engineering, Glenn White. I want to thank
8 you for the invitation to allow us to provide to you
9 a wrap up of all the work that we've done relative to
10 this advanced finite element analysis to resolve the
11 issue that we've had, as Bill indicated, with these
12 plants that intended to inspect in 2008, first quarter
13 of 2008. So I'll just hand the presentation over to
14 Glenn.

15 MEMBER ARMIJO: Before you do that --

16 MR. STEININGER: Yes, Said.

17 MEMBER ARMIJO: Have you gotten any
18 results from all the inspections that have been done
19 so far? Have there been any other findings or any
20 other indications or have they --

21 MR. STEININGER: Well, we haven't had any
22 new indications domestically, but from what I
23 understand there has been some actual, not linear
24 indications, they've actually done dipenetrant tests
25 on I believe it was a hot leg of Mihama 2. That came

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1 up in the last week or so.

2 If I remember correctly, what I saw were
3 13 linear indications of axial cracks in the --

4 MEMBER ARMIJO: Is this the hot leg --

5 MR. STEININGER: It's the hot leg to the
6 steam generator.

7 MEMBER ARMIJO: Okay.

8 MR. STEININGER: Hot leg to the steam
9 generator. I saw the dipenetrant tests. There were
10 13 indications of cracks. Whether they were called by
11 SCC, I don't know.

12 MEMBER ARMIJO: Yes.

13 MR. STEININGER: I just recently heard
14 that there may -- one of the indications may have some
15 circumferential extent to it. I don't really know
16 what means. UT was performed I think 12 of the
17 cracks. They could not get a depth indication. One
18 of the cracks they did have a depth indication, but I
19 just don't know what that value was. I don't know
20 what the percent through wide -- I don't think it was
21 very large.

22 MEMBER ARMIJO: But as far as the U.S.
23 inspections --

24 MR. STEININGER: About a half inch. They
25 varied.

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1 MEMBER ARMIJO: But as far as U.S.
2 inspections that have been going on, there's been no
3 indications of more circumferential cracks?

4 MEMBER ARMIJO: Not on the pressurizer.

5 MEMBER ARMIJO: Okay.

6 MEMBER SIEBER: Some of these plants went
7 through mitigation, like filled overlays, so you don't
8 know anything about those, right?

9 MR. STEININGER: Well, Farley actually
10 inspected and then mitigated.

11 MEMBER SIEBER: Correct.

12 MR. STEININGER: They didn't pick up
13 anything. They don't have to inspect.

14 MEMBER SIEBER: Right.

15 MR. STEININGER: If they don't want to.
16 They can go directly to mitigation. Farley did.
17 Farley and Southern did inspect and they didn't find
18 anything.

19 MR. SULLIVAN: This is Ted Sullivan. Can
20 I make a comment. We did talk about this a little bit
21 at the last meeting. I'm sorry to contradict you,
22 Dave. Farley actually did --

23 MR. STEININGER: They did find something?

24 MR. SULLIVAN: They did find a circ in an
25 axial. And we talked about that, I believe, at the

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1 last meeting.

2 MEMBER ARMIJO: I forgot about it, that's
3 why I asked again.

4 MR. STEININGER: Was I right on the
5 Mihama?

6 MR. SULLIVAN: Yes, everything we know.
7 You know, one comment is that after they apply the
8 weld overlays, this is not worth a whole lot, but I
9 think it's worth putting on the table that after they
10 do the weld overlays, they do do an inspection. They
11 do into the ordinal weld, at least the top 25 percent.
12 And we haven't heard of any indications found from
13 that inspection.

14 MEMBER SIEBER: Would they be obligated to
15 tell you?

16 MR. SULLIVAN: I believe so. As Tim was
17 saying, the reason that I said I believe so is because
18 starting in I think about a year ago, we insisted with
19 every relief request we granted which is part of the
20 weld overlay process, that licensees tell us about all
21 of the indications they find from their inspections.
22 So we do get that information. We haven't heard of
23 any indications, at least that deep.

24 MEMBER SIEBER: Now one of the things we
25 learned from steam generator tubes or hot bi-metallic

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1 weldments, Alloy 82/182, is that it's temperature
2 sensitive and it appears to have a knee in that curve,
3 is that -- do I have that impression correctly at
4 around 610 or 612 Fahrenheit? It's not linear, right?

5 MR. STEININGER: It is very temperature
6 sensitive, you're correct about that. And most of the
7 experience on steam generators has been on base metal,
8 not weld metal.

9 MEMBER SIEBER: Okay.

10 MR. STEININGER: I would hazard to say
11 that the weld metal, it isn't cracking as we expected
12 it to crack, as fast, for reasons that we don't quite
13 understand.

14 MEMBER SIEBER: But a plant, for example,
15 might want to run at 618 or 620 or 624. T-hot would
16 be more vulnerable than the one that was running at
17 610?

18 MR. STEININGER: The higher the
19 temperature, you're more vulnerable, that's correct.

20 MEMBER SIEBER: And it would be
21 significantly more vulnerable, right?

22 MR. STEININGER: I don't know if I'd say
23 that.

24 MEMBER SIEBER: We don't know what
25 significantly means.

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1 MR. STEININGER: I wouldn't say that.

2 MEMBER SIEBER: But I think there is a
3 knee in the curve?

4 CHAIRMAN SHACK: Crack growth rates grow
5 up pretty fast.

6 MR. STEININGER: But he's talking
7 initiation and initiation is more of a mystery.

8 MEMBER MAYNARD: And the pressurizer,
9 we're operating at higher temperatures than not.

10 MEMBER SIEBER: That always made me
11 scratch my head.

12 MEMBER POWERS: We read in some of the
13 literature that Argonne reported extremely high crack
14 growth rates for the Alloy 600?

15 CHAIRMAN SHACK: It varies. Some of it's
16 good, some of it's bad.

17 MEMBER SIEBER: Actually, the Wolf Creek
18 anomalies that were found are in pressurizer nozzles
19 and surge line, right?

20 MEMBER MAYNARD: The surge line and also
21 the relief safety -- safety relief valves.

22 MEMBER SIEBER: Right.

23 CHAIRMAN SHACK: Glenn, do you want to
24 start?

25 MR. WHITE: So here is our list of topics.

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1 These topics parallel the final report which was
2 released in August, so this is an EPRI report, but
3 it's made available to the public, so it's a copyright
4 only EPRI report that's available for free download on
5 the EPRI website.

6 And Section 1 of the report covers
7 objectives and approach, background. Section 2 covers
8 inputs; 3 helping to find stress. Crack growth
9 modeling is Section 4. Critical crack size
10 calculations is in Section 5. Deep crack modeling in
11 6. And then the main matrix of crack growth results
12 looking at time between detectable leakage and rupture
13 is presented in Section 7 with conclusions in Section
14 8.

15 We're going to concentrate in this talk on
16 the results, so we'll summarize the methodology. We
17 covered that to a large extent in the previous
18 presentation on July 11th.

19 The objective is the same as we've seen
20 before and that's to evaluate detection of leakage
21 from through wall flaws to preclude potential rupture
22 for this group of 51 subject welds. And as Bill
23 mentioned, the NRC has made a decision that there is
24 sufficient confidence in detection if there were large
25 circumferential flaws that they would be detected

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1 through leakage prior to rupture and therefore these
2 plants have resumed their original plants to do either
3 mitigation or PDI inspection in the spring.

4 We saw this slide before on the project
5 team and the support of the expert panel, summed up by
6 EPRI, so I won't go through the names again, but
7 again, this was a team effort involving multiple
8 organizations, plus we had ability in Boulder,
9 Colorado supplied the software and codified their
10 software to allow looking at arbitrary crack shapes.
11 And that was the main advance that allowed these
12 investigations.

13 So this slide summarizes the effect of the
14 -- of looking at arbitrary crack shapes as opposed to
15 semi-elliptical crack shapes.

16 MEMBER CORRADINI: Can you walk us through
17 that?

18 (Laughter.)

19 MEMBER CORRADINI: It's not immediately
20 obviously.

21 MR. WHITE: I am just trying to get the
22 pointer options here.

23 Here we go. You can see my pointer now.
24 So this first look at this red curve here and that is
25 a semi-ellipse. So this is the previous analysis that

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1 was performed by NRC contractor and by Dominion
2 Engineering back in December of last year. The first
3 look at the Wolf Creek experience was to look at well,
4 we start off with a crack that was 26 percent deep and
5 an aspect ratio of about 21 to 1, that was the largest
6 indication seeing that at Wolf Creek. It would have
7 to be in the relief nozzle.

8 Now let's go that flaw, but let's assume
9 that it stays a semi-ellipse where the aspect ratio of
10 that semi-ellipse is allowed to change, but it remains
11 that semi-elliptical shape. So that allows two
12 degrees of freedom, one being the crack growth rate at
13 the deepest point, that's the symmetry point here in
14 the middle of the crack. And at the surface point
15 here. So if we grow that semi-ellipse based on the
16 stress intensity factor at each location, then we can
17 simulate growth in both the depth direction and the
18 circumferential direction.

19 At the point of through-wall penetration,
20 what one gets through that exercise is this red curve
21 here which takes up about 70 percent or so of the
22 cross section of the weld. And when one does crack
23 stability calculations under standard type
24 assumptions, including considering the secondary loads
25 from the thermal expansion piping stresses, giving

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1 them full consideration turns out that this flaw here
2 is not stable, so it becomes unstable, causing rupture
3 before it becomes through wall.

4 MEMBER CORRADINI: Can I say that back to
5 you?

6 So you're doing a series of static
7 evaluations of a crack shape and then with these
8 series of evaluations of the static crack shape,
9 you'll look at it at various positions as it might
10 grow, and then at some point it becomes unstable and
11 goes ripping through the structure?

12 MR. WHITE: Yes.

13 MEMBER CORRADINI: Given the potentially
14 very boundary conditions of temperature, etcetera. Is
15 that approximately right?

16 MR. WHITE: Yes.

17 MEMBER CORRADINI: So then from the first
18 line which is some bloody color at the bottom to the
19 red line, you're going, you're actually watching it
20 under some stress field and temperature field. You're
21 watching it grow?

22 MR. WHITE: We're not -- we're only
23 showing the end points here when it comes through-wall
24 under the semi-elliptical assumption. All the other
25 profiles here are under an arbitrary crack shape

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1 assumption. So we're not longer just allowing two
2 degrees of freedom for the crack growth at the deepest
3 point in the surface --

4 MEMBER CORRADINI: But you described it to
5 begin with as if you started the first analysis was
6 that --

7 CHAIRMAN SHACK: If you did the elliptical
8 analysis, that's what he would have is the series of
9 ellipses that marches out until he get --

10 MEMBER CORRADINI: Right, that's what I
11 was trying to understand.

12 MR. WHITE: Yes.

13 MEMBER CORRADINI: And then at some point
14 it becomes unstable under the stress field and
15 temperature field and away it goes.

16 And now you can go crazy with various
17 shapes other than just elliptical.

18 MR. WHITE: When you look at the semi-
19 elliptical shape, it actually has a negative stress
20 intensity factors along a significant portion of its
21 extent here.

22 MEMBER CORRADINI: Right.

23 MR. WHITE: What that means is there
24 actually is partial crack to closure which is not
25 physically meaningful, so what we've done is we've

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1 created a crack as a larger area than is physically
2 possible and that is because we're growing it based on
3 only two points along the crack profile.

4 MEMBER CORRADINI: To put it in structural
5 language, the energy is not minimized. You've created
6 something that is not possible to occur, right?

7 MR. WHITE: Yes.

8 MEMBER CORRADINI: Okay. Thank you.

9 MR. WHITE: So removing that artificial
10 assumption, this is, in fact, the shape that the crack
11 must take on, given that the crack growth at each
12 point in the crack growth depends on the local loading
13 there, the local stress intensity factor, once the
14 crack begins to grow through the -- into the
15 compressive part of the residual stress distribution,
16 what occurs is that it's only at the top of the pipe
17 where the bending stress is maximum that the crack
18 continues to grow at a high rate. It slows down and
19 approaches a rest along the section here where the
20 bending does not produce enough force to go through-
21 wall.

22 So the profile we end up with is this
23 greenish shade, color here that comes across here.
24 Now the crack does grow farther along in the
25 circumferential direction than semi-ellipse is

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1 predicted to go, but overall the area is much smaller
2 than the semi-elliptical area and this crack is stable
3 under the critical cracks, the crack stability
4 calculations.

5 Once that crack becomes through-wall, we
6 continue the analysis to show how the through-wall
7 portion of that flaw increases in size because that's
8 tied to the leak rate and one has to have not just
9 some leakage occurring, one has to show that we have
10 detectable leakage occurring, in order to catch the
11 cracking through leakage detection.

12 So this slide is intended to show that the
13 motivation behind this project in removing this
14 artificial assumption of the semi-elliptical crack
15 shape which in the past was used for numerical
16 convenience, a calculation of convenience. There's no
17 physical reason for that assumption.

18 MEMBER ABDEL-KHALIK: What's the
19 independent variable that goes from one line to the
20 next? Is it time?

21 MR. WHITE: No, this is space, so this is
22 unwrapping the weld into a flat box there. So we're
23 looking, this is the ID --

24 MEMBER ABDEL-KHALIK: No, no, no, not the
25 axes, but in going through one to the next.

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1 MR. WHITE: Yes, time.

2 MEMBER ABDEL-KHALIK: Time.

3 MR. WHITE: So we're stepping ahead.

4 MEMBER ABDEL-KHALIK: What is time
5 corresponding to the through-wall crack for both
6 analyses?

7 MR. WHITE: In slide 14 we show the actual
8 times that correspond to these steps. We'll just
9 address that exact question. So you can see when we
10 get to the through-wall penetration here, we are 5.7
11 years.

12 MEMBER ARMIJO: Once you have the
13 penetration, how fast does it grow along the surface,
14 opening up that crack?

15 MR. WHITE: It grows relatively rapidly
16 because the -- we're in a high stress zone and the
17 crack is fairly large. So those two things together
18 give a relatively large driving force and you can see
19 from this point here, from this yellow line, initially
20 we have to assume that the -- we can't take credit for
21 the initial thick ligament.

22 A ligament that's less than 10 or 15
23 percent of the wall thickness may not be mechanically
24 stable, so you get local rupture, local collapse,
25 elastic collapse would be expected to be possible. So

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1 we don't take credit for that initial ligament, but we
2 start off with an area here that is at least 15
3 percent of the wall thickness and that's zero days
4 here. And to reach all the way around here is 178
5 days in this example. So whereas the -- to grow a
6 through-wall that process from something was 26
7 percent deep, required 5.7 years; for process of a
8 leak rate increasing is relatively faster, but still
9 allows many opportunities to be detected.

10 MEMBER ARMIJO: But it's six years to get
11 to penetration, but half a year to get to instability.

12 MR. WHITE: Even in some cases more like
13 two months or so.

14 MEMBER ARMIJO: So you can't fool around.

15 MR. WHITE: No, but we are also
16 calculating multiple gallons per minute of leakage
17 often.

18 MEMBER ARMIJO: Should be detectable.

19 MEMBER CORRADINI: So you answered Sam on
20 this plot, but on the one you were -- do you mind just
21 going back to that and just to get an idea of -- so on
22 this one we're through-wall with the green line?

23 MR. WHITE: Yes.

24 MEMBER CORRADINI: And now it's
25 essentially propagating along the surface all the way

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1 through. And just with this unwrapped crack, can you
2 say again what you just said to Sam, so to get to the
3 green line is the matter of months and to --

4 MR. WHITE: No, years.

5 MEMBER ARMIJO: Six years to get to the
6 green line, but to get to the point where it might
7 become unstable and rupture the pipe, that was half a
8 year, more or less.

9 MR. WHITE: Less.

10 MEMBER ARMIJO: Less.

11 MEMBER CORRADINI: And I remember back
12 when you had the subcommittee meeting and the
13 significant leakage was -- I've forgotten.

14 MEMBER ARMIJO: One gpm.

15 MEMBER CORRADINI: Is that what it was?

16 MR. WHITE: There are measures taken to be
17 -- increase the sensitivity of leakage detection.

18 MEMBER CORRADINI: I understand that. But
19 in terms of measurable amounts, my next question was
20 since we're just performing this idealized
21 calculation, where in the idealized calculation as
22 it's opening up is the estimated leakage getting
23 detectable?

24 MR. WHITE: For this example here, again,
25 this is a common set of input assumptions, we call it

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1 the phase one inputs, but the answer is shown in this
2 plot here on the right. The blue line is the
3 increasing leak rate. So for that initial flaw, that
4 initial flaw that this yellow line here -- well, we
5 don't take credit for a surface ligament, the initial
6 flaw is leaking on the order of a .4 gpm. And then
7 you can see that that increases all the way to about
8 8 gpm after 150 days.

9 MEMBER CORRADINI: Thank you.

10 CHAIRMAN SHACK: And your tech spec limit
11 is?

12 MEMBER ARMIJO: One gpm.

13 MEMBER SIEBER: That's pretty close to the
14 detectables.

15 CHAIRMAN SHACK: You put in a compensating
16 -- that was part of your compensation for doing this
17 and that you lowered that to .3, .25?

18 MR. STEININGER: Point 25.

19 MR. RILEY: That was over a baseline, if
20 I remember right and it was .1 increase in a day.

21 CHAIRMAN SHACK: Okay, so in theory,
22 they're going to see that thing as soon as it pops
23 through, that particular crack.

24 MR. WHITE: Now this is typical of the
25 steam space nozzles. The surge nozzle where we

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1 actually had our most limiting results, the leak rates
2 are considerably higher, typically over one gpm when
3 they initially popped through them. Upstream we have
4 the sub-cooled liquid whereas in the steam space we
5 have saturated steam, so the mass, the density,
6 developed the densities is significantly different.
7 And so in terms of leak rates we're more limiting on
8 top of the pressurizer.

9 MEMBER ABDEL-KHALIK: What happens to the
10 thickness of the crack, once it breaks through? The
11 width? Isn't that dependent on a whole lot of things?

12 MR. WHITE: We calculate, based on the
13 crack stability model that a crack on the order of
14 this size, approximately would become unstable. So
15 this ligament would have a fish-mouth rupture that
16 would occur. So there would be ductile overload and
17 tearing that would occur along this region here.

18 MEMBER CORRADINI: I think what Said's
19 asking is how well do you know the third dimension?
20 You're showing us two dimensions. A third dimension
21 --

22 MEMBER ABDEL-KHALIK: Prior to that point,
23 the crack opening.

24 MR. WHITE: Oh, okay. So here's actually,
25 this is a different case, so this is no longer the

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1 Phase 1 case, but it's another case, Case 12. This is
2 actually for a spray nozzle. We're covering all 51
3 subject welds and there's a variety of differences,
4 some slight differences in dimensions and the spray
5 nozzles are smaller than the safety release nozzles
6 and of course, the surge nozzles are considerably
7 larger on the order of 12 inches OD. But here's an
8 example of crack opening displacements for a spray
9 nozzle.

10 First, here on the left is when the leak
11 rate is calculated to get to one gpm and on the right,
12 when the stability margin factor is decreased to 1.2.
13 So that means that this remaining cross section here
14 can support 20 percent more load than is reported for
15 that case.

16 And you can see that the contours show the
17 crack opening displacement. In fact, it's half the
18 displacement because we have a half symmetric model
19 here and you can see that there is a variation in the
20 opening in the through-wall direction and in the
21 circumferential direction. So we considered those
22 factors in our leak rate calculations.

23 CHAIRMAN SHACK: Those are inches, right
24 in the units?

25 MR. WHITE: Yes.

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1 CHAIRMAN SHACK: So it's three mils.

2 MEMBER ARMIJO: You can read those, Bill?

3 MEMBER CORRADINI: He's got his glasses on
4 and he's squinting.

5 MR. WHITE: That plot is three mils, but
6 on the right plot it's six mils.

7 And so for our base calculations we take
8 the crack opening area at the outside diameter and
9 then we plug that into the PICEP model to calculate a
10 leak rate, but we also did sensitivity studies. PICEP
11 also allows you to vary the ratio of the opening area
12 from the ID to the OD and we did that sensitivity
13 check to make sure that the fact that the opening can
14 be somewhat smaller in the middle cross section to
15 make sure that that does not have a significant effect
16 on the results.

17 What tends to compensate that effect is
18 that the crack length is longer as you approach the
19 inside diameter.

20 MEMBER CORRADINI: You used some other
21 software tool to estimate the flow through the crack?

22 MR. WHITE: That's right, so there are
23 well-established codes in the industry. We've also
24 applied the NRC code developed by Batelle called
25 SQUIRT.

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1 MEMBER CORRADINI: SQUIRT.

2 MR. WHITE: We've applied that code also.
3 So this is a well-studied area where there have been
4 experimental work with cracks within IGSEC type
5 morphology, it recreates what's measured and so we can
6 apply that tool, but be careful about how we're
7 dealing with the crack roughness parameters, the
8 tightness of the crack, the tortuosity of the crack,
9 the crack opening area, how that varies through the
10 thickness and the length of the crack.

11 And it turns out that this plot here shows
12 results as the -- this is for an idealized through-
13 wall crack, so these are scoping type calculations.
14 What they show is that as a crack gets longer, one
15 gets higher leak rates, but also as one increases the
16 bending moment, if that bending moment is assumed to
17 line up with the center of the crack, then one gets
18 higher leak rates with higher bending load. That also
19 tends to open the crack in addition to the other
20 loads, the pressure load. And you can see the results
21 here for a steam space type example, nozzle.

22 And what we see is that the SQUIRT code
23 attempts to slightly over protect by 5 to 30 percent
24 the leak rate that's predicted by the PICEP code. In
25 terms of LOCAs, if one thinks about a Loss of Coolant

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1 Accident, a higher leak rate may be a conservative
2 number. For our purposes, it's the lower leak rates
3 that are more conservative. We get a little worried
4 about on-line detection.

5 MEMBER BANERJEE: Do these calculations
6 indicate that there is vaporization and critical flow
7 within the cracks or does sub-cooled water come out?

8 MR. WHITE: No, this is critical flow and
9 so for the surge nozzles you would get a mixture of
10 steam and liquid. In the steam space nozzles, it
11 would be a super-heated steam.

12 But these codes are all non-equilibrium,
13 a two-phase choke flow model that have been calibrated
14 versus some experimental data. So it's non-
15 equilibrium choke flow --

16 MEMBER BANERJEE: When you say it's
17 calibrated versus experimental data through cracks or
18 through what?

19 MR. WHITE: Through cracks, some the
20 inter-granular stress-corrosion cracks.

21 MEMBER CORRADINI: But the very fact it's
22 a tortuous path, the major uncertainty is what the
23 area and the roughness of the pipe is. You
24 essentially have a funny-looking pipe. So whether
25 it's equilibrium or non-equilibrium, in some sense is

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1 immaterial. It's really the ugliness of the crack and
2 the shape that's determining the flow rate.

3 MR. WHITE: There is a range of different
4 morphologies you'd expect. And that's one of the
5 sources of uncertainty. We addressed those
6 uncertainties with a factor of four on the leak rate.

7 MEMBER ABDEL-KHALIK: How realistic are
8 these values for the moment? The full moment is 275
9 --

10 MR. WHITE: There are some nozzles that do
11 have a load reported to be that high. Perhaps they're
12 conservatively high. But they are, in some cases
13 there are some loads reported to be that high. And
14 when we got into this work, it was not clear whether
15 the most conservative case, the limiting case was the
16 highest moment or the lower moment because moment has
17 compensating effects. It tends to open up the cracks
18 more and giving more leakage, but it also decreases
19 the critical crack stability, so they go hand in hand.
20 And what we saw through the matrix of results is that,
21 in fact, the higher loads, the higher bending moment,
22 the fact on crack stability is more important than the
23 benefit on the leak rate.

24 There's also the third effect is that the
25 crack is predicted to grow somewhat faster so there's

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1 less time, because of the higher moment. So there are
2 three factors that tend to balance each other and
3 that's why we were very careful to look at a full
4 range of moments because they can be again design
5 numbers. They can be higher than actual, but there
6 are also -- in fact, there's one plant that had one
7 nozzle that was capped, so there was no pipe attached
8 to that nozzle, so we know the bending moment on that
9 one is zero.

10 And so when the bending moment tends to
11 push the crack through wall in a particular location,
12 so in that sense it also helps getting a crack that's
13 focused in one location that can give you leakage
14 before rupture, but on the low end, what we saw was
15 because the residual stresses under an axisymmetric
16 assumption have to be self-balanced in through-wall,
17 the cracks cannot make it all the way through-wall
18 without a bending moment to assist it.

19 MEMBER BANERJEE: I have a question. Is
20 there any effect of the flow on making the crack grow
21 more rapidly? The critical flow is a very high
22 velocity, very erosive. And what effect does it have
23 on the cracks?

24 MR. WHITE: I think that would be
25 conservative not to take credit for that effect.

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1 MEMBER BANERJEE: No, I'm saying would it
2 make the crack open up faster?

3 MR. WHITE: If it erodes some grains,
4 Davis-Besse work showed that perhaps flow effects tend
5 to open up the crack in the weld at Davis-Besse and in
6 the Sierra-Leone nozzle. So that effect would tend to
7 give a higher leak rate without affecting the crack
8 stability.

9 Now the dynamic forces would both tend to
10 affect the loading on the crack.

11 MEMBER BANERJEE: Then we have jets, for
12 example, coming out and eroding things. This would be
13 like internal erosion problem with very high speed
14 flows. I mean if this is all liquid, the velocities
15 would be about a thousand meters per second. They
16 would be 300 meters per second. So what effect does
17 that have?

18 MR. WHITE: Well --

19 MEMBER BANERJEE: Has any tests been done
20 on that? Are you assuming that it has no effect?

21 MR. WHITE: We are not -- to be sure that
22 they're shear forces, then there shouldn't be a
23 significant effect on pushing the crack open more.
24 What we did do was look at the sensitivity of the
25 crack growth and the crack stability to whether we

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1 apply the full pressure on the crack base. So there
2 is going to be a pressure drop across the crack and
3 there are typical calculations according to PICEP. In
4 SQUIRT, you get about a 50 percent drop on average,
5 almost 50 percent.

6 MEMBER BANERJEE: I'm talking about
7 electro-mechanical polishing effect, due to the flow
8 which is also ionic, I presume. There's going to be
9 a number of things there.

10 MR. WHITE: You mean sort of a steam cone
11 effect to open up the --

12 MEMBER BANERJEE: I don't know. I'm just
13 asking the question.

14 CHAIRMAN SHACK: It is steam cutting
15 basically is what he's asking.

16 MEMBER ARMIJO: The answer would probably
17 be different if you had carbon steels instead of the
18 stainless steels. You might be thinking of flow
19 accelerated corrosion zipping through that crack.

20 CHAIRMAN SHACK: This is a speed well
21 beyond flow accelerated corrosion.

22 MEMBER CORRADINI: But so, if I could just
23 ask the question a little bit differently. So you're
24 saying if anything this, ignoring the fact that you
25 had erosive effects of the fluid are conservative

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1 because you're not taking into account what would give
2 you a higher leak to detect --

3 MR. WHITE: It would be non-conservative
4 if it acts to make the crack bigger faster.

5 MEMBER CORRADINI: I was going to say
6 fast. So let me ask the question about you went back
7 and you said that these things have been tuned to
8 experiments. So where have these experiments been
9 done to tune these flows?

10 MR. WHITE: At Batelle Columbus, but those
11 are leak rates attached and they did not try to grow
12 cracks.

13 MEMBER CORRADINI: I was going to ask more
14 did they do this over long periods of time to see if
15 they actually caused erosion from their own idealized
16 cracks.

17 MEMBER POWERS: The machine slots in
18 pressure, that sort of thing.

19 MEMBER CORRADINI: Well, I don't know how
20 they test, but my thought is if they ran it for
21 extended periods of time.

22 MEMBER BANERJEE: As a follow-on, was it
23 done with real cracks or was it done with simulated
24 cracks?

25 MR. WHITE: They were done with stress

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1 corrosion cracks.

2 MEMBER BANERJEE: Okay.

3 CHAIRMAN SHACK: I don't think they saw
4 much in the way of erosion in those tests, but again,
5 they didn't run them for months on end either. They
6 ran them long enough to get a leak rate and then
7 stopped.

8 We are running a little low on time. I
9 will mention that we do see something in steam
10 generator tubes that, in fact, the jet excites the
11 steam generator tube and you get a fatigue driven
12 crack that can grow extraordinarily rapidly in a steam
13 generator tube. Once you get up to the fact when you
14 have a true liquid jet coming out, but I suspect
15 frequencies of these pipes are quite different.

16 MR. WHITE: We saw some in the VC summer
17 experience which had a couple hundred pounds of boric
18 acid deposits on the floor and there was still just a
19 pinhole. So I think in general, these materials --

20 CHAIRMAN SHACK: But those leak rates are
21 much smaller than the leak rates we're talking about
22 here.

23 MR. WHITE: Well, if we are talking about
24 those higher leak rates, they're going to be detected
25 very quickly in three days at most.

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1 MEMBER BANERJEE: My point of view here is
2 that this may be negligible, but should be an effect
3 that you really have looked at and said it's not
4 important, not just ignore it because it doesn't have
5 an effect otherwise. Flow does make things go faster.

6 MR. WHITE: We have plans to submit a
7 paper to a refereed journal, so that's something that
8 we can address in that paper.

9 MEMBER POWERS: If I look at your pink
10 slide, pink blob slide, I'm going to abandon the
11 assumption this elliptical crack indeed, I've never
12 seen a crack that was elliptical, so that seems like
13 a good thing to abandon. And I'm going to calculate
14 this other kind of crack where I look at the growth at
15 each stability point. And you get another kind of
16 crack and I've never seen a crack that looks like
17 that. Is there between the non-physical ellipse and
18 your calculated curve a crack shape that's
19 particularly obnoxious?

20 MR. WHITE: No. From what we see in the
21 calculation is that we get crack arrest in this area
22 because the crack is growing into the compressive part
23 of the residual stress where there isn't a load to
24 overcome that.

25 MR. STEININGER: You get penetration is

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1 what we have seen in stress corrosion cracking.

2 MR. WHITE: We have the Duane Arnold
3 experience that did show a shape that is not radically
4 different from this.

5 CHAIRMAN SHACK: I mean, in these tough
6 materials, it's basically loss of area that you're
7 worried about, and so a particular shape isn't so
8 important as just how much of the cross section you've
9 chewed away.

10 MEMBER POWERS: In going from the ellipse
11 to this peaked shape, it's a qualitatively different
12 behavior.

13 CHAIRMAN SHACK: The shape is important.

14 MR. WHITE: The critical crack size you'll
15 find you've chewed up just about as much area in
16 either case.

17 You can go through-wall and have a
18 through-wall crack out there, but until you chew up
19 the right amount of area, it's going to sit there,
20 roughly.

21 MEMBER POWERS: It's qualitatively
22 different behavior between the two. I'm asking is
23 there anything between that's particularly obnoxious?

24 MR. WHITE: We did look at the effect of
25 the crack shape on the initial flaw. So we did

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1 explicitly look at flaws that were of more uniform
2 depth to start off, parabola or a semi-ellipse to
3 start off. Different shape. So we verified that that
4 assumption was not important to the results.

5 MEMBER ARMIJO: Did you look at the
6 multiple elliptical initiators that coalesced into a
7 calculation cracking?

8 MR. WHITE: We addressed multiple cracks
9 in a few different ways. This slide shows that we
10 have -- we looked at enveloping initial flaws, 360
11 degree part-depth flaws and then multiple individual
12 flaws and then combining them for crack stability
13 calculations.

14 So for most cases we looked at a 360 -- in
15 many cases looked at a 360 degree flaw, so that would
16 assume initiation in many different points. But in
17 other cases we looked at -- this one on the right, you
18 can grasp it assumed initiation of two flaws or an
19 initial condition of one flaw at the top of the cross
20 section and one at the bottom and it grew, both at the
21 same time. And the one on the top grows much more
22 than the one on the bottom in that time period. So we
23 looked at cases like this and looked at how this
24 presence of this second flaw affects the stability of
25 the cross section.

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1 MEMBER BANERJEE: May I ask a question?
2 How sensitive are these results to the stress
3 intensity factor model that you use?

4 MR. WHITE: Numerically, this is just a
5 math problem to calculate the stress intensity factor.
6 So --

7 MEMBER BANERJEE: What you have, your
8 finite element code, all it does is calculate stresses
9 and stress intensities. Then you have to have a model
10 for cracked growths, right?

11 MR. WHITE: That's right.

12 MEMBER BANERJEE: How sensitive is it to
13 the crack growth model?

14 MR. WHITE: We especially looked at that
15 question. We had several cases where we varied the
16 crack growth rate equation. We changed the slope of
17 that line from --the nominal slope is 1.6 exponent,
18 and we changed it to 1 and 2.2, based on the 95th
19 percentile values from the regression analysis and
20 came up with that sensitivity stress test factor. So
21 we think we look at that and the fact of the crack
22 growth rate equation. There's significant uncertainty
23 there and --

24 MEMBER BANERJEE: What did you find for
25 the more rapid crack growth? How long did it take?

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1 MR. WHITE: There was a modest
2 sensitivity. I can find the results. This is much
3 too busy here, obviously, to -- but it's in Table 7.7
4 in the report and this is actually the NRC's
5 suggestion was to show explicitly all the
6 sensitivities to summarize. So there's two pages of
7 them. And it was cases 44, I'm sorry, 42 through 47,
8 looked at this. So 42 we changed the exponent from
9 1.6 to 1.0. And the time between detectable leakage
10 and rupture with margin change from 41 days to 39
11 days. When we increased the exponent to 2.2, it went
12 from 41 days to 47 days --

13 MEMBER CORRADINI: Ten percent effect.

14 MR. WHITE: Ten percent effect there. A
15 little bit higher effect for some other geometries.
16 Here it went from 35 days to 22 days, so that's more
17 like a third effect, maybe.

18 MEMBER BANERJEE: So there's an exponent
19 and there's a coefficient --

20 MR. WHITE: That's the exponent. So we
21 calculate the 75 percentile magnitude crack growth the
22 same because the exponent, you cannot vary the
23 exponent independently of the coefficient and get
24 sensible results. So we also -- it's simply, you
25 don't need to re-run the analysis to look at the

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1 coefficient itself. That's just a scaling factor on
2 time. And that's discussed --

3 MEMBER BANERJEE: Let me ask a more simple
4 question. Imagine your crack growth model gave you
5 crack growth that was three times as fast. Would this
6 open up three times as fast?

7 MR. WHITE: Yes.

8 CHAIRMAN SHACK: It wouldn't change the
9 crack shape. That's the critical thing. It's just
10 scales and times. So the real thing is instead of
11 five years, it's two years, but it still pops through
12 and you still have a fair amount of growth along the
13 surface. So these things are sensitive to the initial
14 crack shape. They're sensitive to the weld residual
15 stresses. They are in a sense almost independent of
16 the crack growth law because that just scales in time.

17 MEMBER CORRADINI: But once you break
18 through the crack growth law --

19 CHAIRMAN SHACK: Yes, at 2.5 gallons per
20 minute, you're detecting this thing in a day or two.

21 MEMBER CORRADINI: But can I ask Sanjoy's
22 question a little bit differently? So once you break
23 through, then the crack growth effect is minimized
24 because now you are essentially just -- you just have
25 so much load-bearing area which is slowly getting

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1 away. Is that correct? Do I have this right?

2 CHAIRMAN SHACK: Yes, that cuts down that
3 amount of time, but again, your time, you don't need
4 much time.

5 MEMBER BANERJEE: It could be 20 days
6 instead of 60 days.

7 MR. WHITE: If you look at the data from
8 the laboratory, world-wide data that's available, the
9 crack growth rate equation, coefficient we're assuming
10 is not that different from the upper end that's ever
11 been seen in the lab. So there is not a big
12 difference between with the highest rates as seen in
13 the lab, versus our normal function.

14 MEMBER ABDEL-KHALIK: Are any of the nine
15 plants operating currently with an unidentified leak
16 close to the tech spec limit?

17 MR. LUPHOLD: I am Tim Luphold. These
18 facilities can generally detect a leak on the order of
19 .05 gallons per minute, some even less depending on
20 the sophistication of their instrumentation for their
21 mass balances.

22 MEMBER ABDEL-KHALIK: So they're all near
23 the detection limit, all nine plants?

24 MR. LUPHOLD: A lot of times these plants
25 are running around like a .05 gpm to like a .1 gpm

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1 leak rate normally for unidentified leakage.

2 So yes, they can see increases above what
3 their current leak rates are. I think that's what
4 you're asking.

5 MR. RILEY: There may be another way to
6 answer that, if I understood the question right is the
7 -- all these plants are still operating under an
8 enhanced leakage program which is significantly below
9 the tech spec limits as it is.

10 MEMBER ABDEL-KHALIK: But I just want to
11 find out where they are and how close are they to
12 either the tech spec -- the new tech spec limit or the
13 detection limit.

14 MEMBER MAYNARD: And I think the magnitude
15 isn't quite as important as the change for this
16 particular one. Somebody might be operating at .05.
17 Somebody else may be at .2. That's not as important
18 as do they see a change. That's part of the enhanced
19 modeling, I think, for doing it. Do they see any
20 upward trend.

21 MEMBER SIEBER: There's an occasional
22 plant that will have a negative impact.

23 CHAIRMAN SHACK: Glenn, how fast do you
24 think you can get through the rest of this.

25 (Laughter.)

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1 MR. WHITE: These are very similar to July
2 11th. We had a handful of cases we're still finishing
3 up. The final matrix was 119 cases. We call the main
4 matrix of 109 cases. All those results either showed
5 stable rest 60 cases or met our evaluation criteria
6 that we covered last time that contain safety margins.

7 MEMBER BANERJEE: These cases, they
8 included the parametric studies of crack growth model
9 and the crack stability model as well?

10 MR. WHITE: That's correct. All the
11 various sensitivities.

12 MEMBER BANERJEE: So you did sensitivity
13 on the crack stability model as well?

14 MR. WHITE: That's right.

15 MEMBER BANERJEE: And you will tell us
16 something about those?

17 MR. WHITE: Sure. The crack stability
18 model, the big message there is for our main cases we
19 considered 100 percent, we considered no reduction in
20 the secondary load. However, we did detailed work
21 that are explained in the Appendices B and C of our
22 document to look at whether, in fact, there would be
23 reduction in the secondary stresses. And what we
24 conclude, let me step back to that slide. So this is
25 slide 19. This introduces appendices B and C. And

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1 Appendix B we looked at structural integrity
2 associates, looked at two models, one of a
3 Westinghouse surge line and one of a CE surge line and
4 modeled the rotation that's produced if one releases
5 the nodes at the location of the surge nozzle. And
6 made conclusions regarding the degree of relaxation of
7 those loads and that was complimented by the work in
8 Appendix C by Quest Reliability and Ted Anderson who
9 looked at elastic and elastic plastic models with
10 idealized through-wall cracks.

11 And what you see here on the right is the
12 normalized crack length goes from zero to one. So in
13 the middle here we have a 50 percent of the cross
14 section is cracked and this is the moment knock down
15 factor. So if you look at the situation with an
16 imposed rotation versus an applied load, one can look
17 at for the imposed rotation case which is more like a
18 secondary, which is a secondary load situation, one
19 can look at how much the applied moment decreases and
20 you can see you get about a 50 percent reduction in
21 load when the crack becomes 40 percent long of the
22 circumference.

23 And then you can take it and extend that
24 to a J-integral, J theta over J_M , so J is the crack
25 driving force. J integral driving force for the

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1 imposed rotation case versus the applied moment case.
2 And for the same crack length, and you can see that as
3 that crack again approaches .4, 40 percent of the
4 circumference, that driving force decays to a great
5 extent compared to the applied moment, peer reply
6 moment case.

7 So this supports at least a reduction in
8 load of at least 40 to 50 percent or more occurring in
9 the surge nozzles and in our main cases we always did
10 not take credit for that. Slide 31 here looks at our
11 most limiting case which we call S1b where we assumed
12 a 360-degree flaw in the surge nozzle starting off 10
13 percent deep and if one assumes 40 percent or more
14 reduction which is supported by the work in appendices
15 B and C, then that result does satisfy the evaluation
16 criteria. So that's a large source of conservatism
17 and we evaluated that explicitly for our most limiting
18 case.

19 The bottom of slide 30 here, this is the
20 work I'm look at multiple flaws. Other than assuming
21 a 360-degree flaw, we did look at different cases with
22 multiple flaws. We based some of those cases on the
23 Wolf Creek surge nozzle experience where three
24 different indications were reported separated around
25 the circumference. One of those indications was

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1 rather small, but we conservatively applied that
2 experience to some of our cases.

3 The last two slides here, 32 and 33, just
4 summarized the conclusions, so the assumption of the
5 semi-elliptical flaw shape, that's an artificial
6 assumption that shows the result in a large
7 unnecessary over conservatism. And that was shown
8 throughout the work. So preparing the work now from
9 our work back in December with the semi-elliptical
10 shape, there's a large change in the results.

11 We concluded that all 51 subject welds
12 were adequately covered by cases that met our
13 evaluation criteria and those safety factors. A
14 couple other important conclusions that mentioned back
15 in July 11th, but we're re-emphasizing here that
16 circumferential cracks tend to show stable arrests.
17 We saw many cases with stable arrest. If one assumes
18 the axi-symmetric loading, then there has to be self-
19 balancing at each point on the circumference and that
20 means that one needs a large bending moment in order
21 to overcome that compression in the wall's residual
22 stress. And that's consistent with the Wolf Creek
23 experience that all four of these five indications
24 were found all between around 25 percent through-wall
25 which is consistent with where you would expect the

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1 arrest to occur, based on our finite element residual
2 stress calculations.

3 So -- and again, all the experience we've
4 had in the world is that we've had through-wall axial
5 cracks. We haven't seen through-wall circumferential
6 cracks in these PWR configurations.

7 Another conclusion I already mentioned
8 here was if you take credit for the relaxation
9 secondary loads, that is supported by the detailed
10 evaluations. That's a large source of conservatism
11 and we concluded that the work supported the viability
12 of leak detection here and again, just to mention that
13 we are publishing -- putting together a paper for a
14 scientific journal.

15 CHAIRMAN SHACK: I have a question, it's
16 a little -- do you understand why your hoop stresses
17 are lower than Dave Rudland's for the welding residual
18 stresses?

19 MR. WHITE: Yes, we've done detailed
20 comparisons and I think we understand most of the
21 reasons for the differences. There are effects. We
22 found that the fill-in weld is a key part of the surge
23 nozzles. Not all the surge nozzles had fill-in welds,
24 but the way that you simulate that fill-in weld, in a
25 sense it's the ID where the whole process is most

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1 sensitive to the residual stresses near the ID, in
2 that first third of the wall.

3 And that fill-in weld comes last, so how
4 you simulate that fill-in weld, the results are
5 sensitive to that and we took two different approaches
6 to the simulation of the fill-in weld. The second
7 major issue is how one simulates the stainless steel
8 to field pipe rod and what kind of constraint one puts
9 on that pipe. So that's an area of active study that
10 we want to continue to work on.

11 The industry and the MRP plans to
12 participate along with the NRC in work on improving
13 the welding residual stresses and to build mock-ups
14 typical of the PWR configurations. So that is going
15 to be a significant effort to look at these questions.

16 One of the main conclusions here was that
17 the results are sensitive to the welding residual
18 stress, and so understanding them, understanding the
19 uncertainties in these calculations is critical as we
20 move forward and that's why that's the next major
21 effort in this area.

22 CHAIRMAN SHACK: Back on schedule. Are
23 there any additional questions from the Committee?
24 Thank you. Thank you. I enjoyed reading the report.
25 It was an impressive amount of work done under an

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1 extremely demanding time schedule. I'm sure your
2 family missed your summer vacation because you
3 certainly didn't have time to take on.

4 Staff is ready to go, I think?

5 (Pause.)

6 MR. SULLIVAN: Dr. Shack, I wanted to make
7 an offer if you're interested. There is a video of
8 that, an animation, that Al has that shows the
9 corrosion of the crack with this elliptical, semi-
10 elliptical restraint. It would take an extra few
11 minutes to do it.

12 CHAIRMAN SHACK: Yes, I would like to see
13 it.

14 MR. SULLIVAN: I think it's worth doing.

15 MEMBER POWERS: It would be far more
16 valuable to actually see a crack growing than to see
17 these computational fantasies.

18 MEMBER ARMIJO: They have them. They have
19 them. It would be nice if they could shown them.

20 MEMBER POWERS: If they would show them,
21 it would be useful. But right now we're not seeing
22 them. We're seeing the computational fantasies.

23 (Pause.)

24 MEMBER POWERS: My point is is that we're
25 doing computations on a continuum and something that

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1 actually has a grain structure with grain flaw, grain
2 boundaries and unusual things that are just not
3 modeled at all and we're attributing some reality to
4 it that may or may not exist.

5 DR. CSONTOS: Okay, we did not include
6 those different micro-structure features in there.
7 This is an isotropic body. We understand that. We
8 believe that there is actually some work that the
9 industry did in one of the MRP documents that looked
10 at, that promote that that kind of micro-structure
11 promotes through-wall growth and not growth around.
12 So what we're doing is conservative to that issue.

13 That's the part of why we went with this.
14 It's also much more difficult in the time allotted to
15 us to evaluate this.

16 CHAIRMAN SHACK: That's also why this is
17 phenomenological model. We don't know what happens at
18 the crack tip. All we do is describe what controls
19 the deformation in that crack tip. We don't
20 understand those processes at all, so this is all an
21 analogy to something that we can simulate in the
22 laboratory which is a cracked tip, and all we do is to
23 say that the crack tip in the laboratory is subject to
24 the same loads and deformations as the crack tip in
25 the real world. We can't tell you any other way

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1 except experiment what happens to that crack tip. So
2 this is not a first principles model.

3 MEMBER BANERJEE: I have a question on
4 that. Has there been any validation of this approach
5 that you are describing?

6 DR. CSONTOS: This approach is well-rooted
7 in good fracture mechanics.

8 MEMBER BANERJEE: I'm just asking has
9 there been an experiment and a calculation done and
10 they agree with each other?

11 DR. CSONTOS: I don't --

12 CHAIRMAN SHACK: I think you can say that
13 what we see in the real world is quite consistent with
14 what we predict from these kind of finite element
15 predictions of welding residual stresses and
16 laboratory measurements of crack growth. I mean,
17 we've been doing this for 30 years in a variety of
18 circumstances.

19 MEMBER BANERJEE: But has there been a
20 sort of a run-off? Let's say that you did a finite
21 element calculation and then went and did an
22 experiment in the lab and they agreed? Not after the
23 fact, but before the fact.

24 DR. CSONTOS: The experiments in the lab
25 are run with certain types of specimens that you get

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1 a crack growth rate from. From that, we take the
2 finite models. We have a k-relationship with crack
3 growth and we model it in that fashion, per se for the
4 whole entire code and the entire kind of fraction
5 mechanics in terms of validation, we do have some for
6 fatigue cracks, but we do not have them for PWSCC
7 cracks because this is the first time that we have
8 really addressed this type of crack growth modeling in
9 this fashion.

10 We haven't been able to make pipes in the
11 last six months to test these and verify them. We are
12 planning to do something along those lines of
13 validation. Once we get this weld residual stress
14 issue taken care of, what you heard Glenn alluding to
15 at the end. Once we validate the weld residual stress
16 is because that's pretty much one of the bottom lines
17 from my clock is that weld residual stress is really
18 governed how these cracks grow.

19 If we really get a handle on the weld
20 residual stress aspect of it, we will then be able to
21 validate the entire model. Without that, we are just
22 shooting in the dark right now. I have some
23 information here about a preliminary effort to
24 validate, but we have a good sense of how this is
25 going. But in terms of validation space, that's

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1 another maybe year or two off until we get the weld
2 residual stress validation done.

3 MEMBER BANERJEE: So if you took the weld
4 residual stress issue out, has the rest of these
5 procedures ever been validated by some what I call
6 integral tests?

7 DR. CSONTOS: In terms of dissimilar metal
8 butt weld?

9 MEMBER ARMIJO: Fatigue or stress
10 corrosion crack.

11 DR. CSONTOS: Yes, in terms of fatigue
12 we've done a bunch of pipe tests back how long ago,
13 Dave? That was in the first LPB program.

14 DR. RUDLAND: The tests were done in the
15 '80s for fatigue and things like that, but in terms of
16 cracks in pipes under SCC or monitoring the growth
17 rates, those kind of tests really haven't been done.
18 We use laboratory based-size specimens to predict the
19 growth and assume --

20 MEMBER BANERJEE: You have to fit at the
21 moment you save and take a crack growth model, take a
22 crack stability model and predict anything --

23 DR. CSONTOS: I think that if you looked
24 at Glenn's work back in July 11, ACRS meeting, he
25 showed how our models predicted, is it Duane Arnold

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1 crack growth and that with this model. That's
2 validation --

3 MEMBER BANERJEE: A post prediction,
4 right?

5 DR. CSONTOS: Yes, that is a post
6 prediction.

7 MEMBER BANERJEE: Has there ever been a
8 pre-prediction of an experiment?

9 DR. CSONTOS: There hasn't been a pre-
10 prediction of a weld residual stress model as well.
11 But that's important, though.

12 MEMBER BANERJEE: I agree.

13 DR. CSONTOS: You can't do the second
14 until you do the first.

15 MEMBER BANERJEE: But let's say taking
16 that uncertainty out, has there been a well-controlled
17 experiment which has been pre-predicted by this
18 procedure and puts them together with a time element
19 model?

20 DR. CSONTOS: In fatigue space yes. In
21 crack growth and PWSCC, which is what we're worried
22 about here, or on just SCC, we do have some for IGSCC,
23 but not for PWSCC.

24 MEMBER ARMIJO: But there were pipe tests
25 done for IGSCC.

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1 DR. CSONTOS: There were IGSCC. But those
2 were support.

3 DR. RUDLAND: There was leak rate, but
4 there wasn't necessarily IGSS crack growth pipe
5 experiments.

6 MEMBER ARMIJO: There were a huge number
7 of experiments that GE did with what they called their
8 pipe test lab, specifically, to test the crack
9 initiation and growth basically tensile-loaded, four-
10 inch diameter pipe tests. I'm sure they shared it
11 with the NRC.

12 DR. RUDLAND: Environmental --

13 CHAIRMAN SHACK: They didn't try to do
14 that as a comparison. I would argue that you have
15 lots of field experience that says the predictions we
16 make are what we see consistent with the field. I
17 mean, we predict that core shrouds will grow to a
18 certain depth and by and large, you know, you look at
19 the kilometers of core shrouds that are cracked and
20 they behave the way that they think they do. We
21 predicted that large pipes and small pipes will behave
22 differently under stress corrosion cracking.

23 Now again, the BWRs have given us lots of
24 experimental evidence so that's a different kind of
25 SCC, but it's still a k-controlled fracture mechanics

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1 phenomenological model that I think is a reasonable
2 model for PWSCC.

3 DR. CSONTOS: If we are talking about
4 stress corrosion cracking and then we're talking about
5 fracture mechanics, this is right now the best that we
6 can do. Validation space --

7 CHAIRMAN SHACK: But he's asking you is it
8 good enough?

9 DR. CSONTOS: And a validation space, we
10 have, we'll have to get to that in the next year or
11 two.

12 DR. RUDLAND: I mean, Bill brought up a
13 good point earlier about the welds aren't cracking the
14 way that the base metals are cracking. And so our
15 experience just with the experimental stuff on the
16 base metals is telling us that the welds should be
17 cracking a lot faster than they really are. So we
18 really don't have a good handle on that because there
19 have been no experiments that have really been done
20 for PWSCC and welds.

21 DR. CSONTOS: I wanted to show you the
22 video here, just to give you an idea. I know we're
23 way behind time. Do we just want to bag this and go
24 on?

25 What Glenn showed you early on was that

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1 one graph that you were looking at, one was looking at
2 semi-elliptical crack and the other ones were looking
3 at an arbitrary crack as it grows through a stress
4 field and all the nodes and full-on to cracked growth
5 to whatever extent it wants. In this case, this is
6 the scoping analysis result that we had where we keep
7 the crack semi-elliptical. It grows at this point and
8 at this point alone. So this is where we determine k.
9 The k grows to the extent that is from the crack
10 growth rate equations, and what you see here is it
11 stays in a semi-ellipse and then right here it pops.

12 This is the rupture that occurs. This is
13 because we, what Glenn showed in that pink area is the
14 ligament that is remaining. When we change that model
15 to this model, which is growing the crack along the
16 entire crack front, along every node, k is calculated
17 along the entire node and then the crack grows to
18 whatever extent. This is showing how the crack is
19 growing with a specific weld residual stress profile.

20 This is the crack in white and you can see
21 that the bending moment that Glenn was talking about
22 is coming out at you and the crack will then start to
23 grow. Once the residual stress k, the driven ks, to
24 grow the crack around, it then grows the crack
25 through-wall. That is the amount of opening right

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1 there for leakage. That's what basically we're
2 calculating. That's just a schematic of how this
3 model is being developed.

4 With the presentation -- I'll just go
5 ahead and use this.

6 MR. HAMMER: You have the wrong one?

7 DR. CSONTOS: I don't know.

8 CHAIRMAN SHACK: It's got the right title.
9 October 4th.

10 (Pause.)

11 DR. CSONTOS: I just wanted to show this
12 up here real quick. This is the scope of the work
13 that we have done since October. What we broke it
14 down through is the scoping, the phase one and phase
15 two analysis. The scoping analysis we talked to.
16 That was keeping the crack semi-elliptical. Phase one
17 and we came back to you in March of 2007 and we gave
18 you the results of the scoping study. We gave you
19 some updates on the work, the advanced FEA proposal by
20 the industry, and we gave you some initial, our
21 initial comments in the regulatory activities.

22 In July, we gave you the phase one
23 results, those videos I just showed you. We gave you
24 two-thirds of the phase two result, and that's what
25 we're going to be talking about mostly today. That is

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1 a sensitivity study and we're going to give you the
2 rest of that.

3 My job in the Office of Research was to
4 confirm the industry, confirm or deny the industry's
5 model. We developed separate independent models based
6 up on the sound scientific basis in fracture mechanics
7 and structural mechanics that have been developed and
8 the crack growth rates that have been developed over
9 the past 20 years or more to develop this program and
10 we both developed separate programs.

11 What you see here are, we broke it down,
12 we had 31 cases that we evaluated. Thirty cases are
13 for the phase two, and what I just showed you in those
14 videos are for phase one results. What we have is 15
15 of those cases were to directly compare to industry
16 cases. The other 15 were to evaluate certain
17 conservatisms and certain other parameters that we
18 were concerned with internally at NRC that were
19 irrespective of what the industry did.

20 Industry could have provided those results
21 if they wanted to, but we were going to evaluate those
22 issues on their own.

23 MEMBER ARMIJO: Both groups used the same
24 crack growth rate?

25 DR. CSONTOS: From MRP 115. Yes, that

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1 crack growth rate, we've evaluated, we have been
2 participating in looking through that report and
3 reviewing the report, not officially but internally,
4 and yes, we agree with those results of the crack
5 growth rate.

6 MEMBER ARMIJO: There's no funny stuff
7 going on that maybe the French have done similar crack
8 growth rates and gotten ten times higher or you know,
9 is there pretty much universal agreement that those
10 rates are reliable?

11 DR. CSONTOS: Yes, there's been a real
12 extensive effort in the past five or six years to go
13 through and wash through all the data from all the
14 crack growth rates.

15 MEMBER ARMIJO: Everybody in the world.

16 DR. CSONTOS: Yes. Everybody in the
17 world. And those are usually test -- pardon?

18 MR. SULLIVAN: Including the Navy.

19 DR. CSONTOS: Including the Navy. And
20 what, you know, they take these samples and they put
21 a k and they drive a sometimes constant k and you can
22 get these relationships that way. And so what we're
23 showing here, I've broken it down between safety
24 relief, the spray nozzles, and the surge nozzles.
25 This is the phase two safety relief results, so I

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1 provided to you all the different parameters that we
2 had in the past that we evaluated.

3 In this case, for these phase two results,
4 for the safety and relief nozzles, we confirmed the
5 industry's results. Between, well, I'll break it down
6 here for you. So we've had here time at first leakage
7 from the initial flow size to leakage, margins at 1
8 gpm leak and then time from 1 gpm leak to 1.2 safety
9 margin. That 1.2 is an arbitrary number at the time
10 to compare directly with the industry's results which
11 you have saw. Glenn was using a DEI and the industry
12 were using a 1.2 safety factor or I should say, what
13 is it called, not a safety factor but assessment
14 factor, margin.

15 Here are the spray line results. The
16 spray line results again, we looked at the cases and
17 we again confirm with the industry's cases. Now you
18 will see here sometimes where we'll get a rest while
19 they get 25 years. That's just the slight difference
20 in the weld residual stress fits that we do as
21 different from what the industry has done and what
22 happens is when you get a k that gets to zero, you get
23 crack arrest, and you don't get the crack to grow
24 anymore because there is no energy to grow that crack
25 any further.

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1 And so the small differences can make a
2 big difference in the final outcome of the prediction.
3 So in the case of a spray line, we have confirmed the
4 industry's results.

5 For the surge line, for the most part we
6 have agreement on the industry and our evaluations.
7 You will see here that we are usually about maybe 10
8 to 12, 10 to 15 percent higher in terms of the time to
9 first leakage. We're a little bit lower in the time
10 of first leakage to the margin at 1 gpm leak and
11 that's because of our assumptions that are different
12 in these two different analyses.

13 MEMBER POWERS: What are the units on
14 margin?

15 DR. CSONTOS: Oh, on, these are just
16 margins.

17 MR. SULLIVAN: It's dimensionless.

18 DR. CSONTOS: Yes, it's dimensionless.
19 One is rupture.

20 MEMBER POWERS: You're going to have to
21 point it for me. I don't understand.

22 DR. CSONTOS: This is a margin between
23 leakage and rupture.

24 MEMBER POWERS: Margin is a difference to
25 me.

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1 DR. CSONTOS: Right, and --

2 MEMBER POWERS: Yes, but it's the
3 difference in units.

4 DR. CSONTOS: It's dimensionless because
5 what we're doing here is we are saying that one is
6 let's say a safety factor of one where you do get
7 rupture.

8 MEMBER POWERS: Safety factor on what?

9 DR. RUDLAND: It's a ratio on the loads or
10 on the time, so in this particular case here the
11 margins are 1 gpm are the ratio on the loads at
12 critical crack size versus the loads at the crack size
13 that equals 1 gpm.

14 MEMBER POWERS: Okay, tell me what the
15 load is for the denominator?

16 MEMBER CORRADINI: I think he is looking
17 for some dimensional numbers like time until
18 something.

19 MEMBER POWERS: I'm just trying to figure
20 out what the number is. I mean, 1.03 looks like a
21 great number --

22 DR. RUDLAND: That is an actual load at
23 that point.

24 MEMBER ARMIJO: That's why the times are
25 zero.

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1 MEMBER POWERS: I asked what the units on
2 margin was. One person told me years, one person told
3 me months. Now you told me they are ratios of loads,
4 have nothing to do with time. Now I'm trying to find
5 the loads on what?

6 DR. CSONTOS: If you look, let me show
7 you, those plots that Glenn showed up earlier where
8 you have the margin, it's a factor on loads.

9 DR. RUDLAND: Yes, it's the load at
10 failure for that particular crack size. It's the load
11 at that particular size divided by the load at
12 critical crack size. It's the ratio of the loads --

13 MEMBER POWERS: Could you give me a table
14 of the loads that were used to compute these ratios?

15 DR. RUDLAND: Yes, we could.

16 MEMBER POWERS: Please.

17 DR. CSONTOS: It is in the documentation
18 that we provided.

19 MEMBER POWERS: What, by the way, is a
20 load ratio titled arrest mean?

21 DR. CSONTOS: Arrest means that the crack
22 will not grow, that the ks will get to a point where
23 it is zero.

24 MEMBER POWERS: That mean that the margin,
25 by your definition, is infinite at that point?

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1 MR. BLEY: You never get to 1 gpm, is that
2 what you're saying?

3 DR. CSONTOS: Yes, you never to get to a
4 1 gpm leak period. The crack stops growing through-
5 wall and okay, and so for that matter, that's when we
6 look at a lot of these flaws and how they grow. You
7 have either a crack arrest or you have cracks coming
8 through-wall and when we have cracks growing through-
9 wall, this is the load margin that's available to us.
10 If it is one, that means we have failure, okay?

11 Do you have something that you can show
12 real quick?

13 DR. RUDLAND: I'm going to use Glenn's
14 report. Here is case one, for instance.

15 MEMBER POWERS: Okay.

16 DR. RUDLAND: The loads that are on that.

17 MEMBER POWERS: 5.7 ksi.

18 DR. RUDLAND: And go back to here. For
19 that particular case at that particular time, here is
20 a supportable load on that particular crack.

21 MEMBER POWERS: 255.

22 DR. RUDLAND: Just so the total is 12.78.
23 So in this particular case, the margin is 2.24.

24 MEMBER POWERS: So now if I total this up,
25 I do not get to a .78.

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1 DR. RUDLAND: If you look at 5.71.

2 MEMBER POWERS: 5.71.

3 DR. RUDLAND: By 12.78 is the total
4 support bending point.

5 DR. CSONTOS: The bottom line for this is
6 that when we have --

7 DR. RUDLAND: The ratio to total loads,
8 applied loads, to the total load collapse for that
9 particular crack size.

10 DR. CSONTOS: It's how much load can that
11 pipe, after the crack grows, after the crack grows
12 through-wall, so you have a crack and it goes through-
13 wall, what is the remaining load that that pipe can
14 withstand, it can hold, ok? When it is a ratio of
15 one, that means that it is going to rupture. That's
16 why we have this margin over here. This time, when
17 this is one, the time from 1 gpm link to 1.2 margin is
18 zero because it's already rupturing.

19 DR. RUDLAND: And so the supportable load
20 equals the applied load.

21 DR. CSONTOS: And so basically whatever
22 ligament is remaining on that pipe is not going to be
23 able to withstand the load. So the margin is one.
24 That's why I was trying to relate it back to safety
25 margin. If your safety margin is one and you get to

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1 that load, you have rupture or you have failure.

2 DR. RUDLAND: If you have a margin of one
3 and a half --

4 MR. SULLIVAN: It's really a ratio.

5 DR. CSONTOS: Does that answer your
6 question?

7 MEMBER POWERS: I heard the explanation.
8 When we looked at the tabled numbers here, we don't
9 come up with those numbers.

10 DR. CSONTOS: We can provide more
11 information. We're just confirming.

12 Basically, we're confirming the industry's
13 work on this, so --

14 MEMBER CORRADINI: So let's just try it
15 one last time with the top one which is easy. DEI and
16 you both get the same number, approximately.

17 DR. CSONTOS: Correct.

18 MEMBER CORRADINI: So that means that the
19 moment you get a through-wall, it starts leaking
20 greater than a gallon per minute.

21 DR. CSONTOS: That's correct. At one gpm
22 it's --

23 MR. SULLIVAN: No, it means the moment it
24 starts to leak. Those are the ratios of the load.
25 The load carrying capability versus the applied load.

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1 Or divided by the applied load.

2 It can carry --

3 MEMBER CORRADINI: That's why I'm going --
4 I'm looking at line one, case 17-1. It says 1.03,
5 1.0. But if I understand, then I go to the next roll
6 over, it says time since the leak is zero. That means
7 that I interpret that to mean the moment it starts
8 breaking it leaks at one gpm.

9 So do I have that right?

10 DR. CSONTOS: Yes.

11 MEMBER CORRADINI: Let's just go with
12 that. So that means that it's leaking, but it doesn't
13 mean that it's ripping open. It just means it is
14 leaking greater than this criteria.

15 DR. CSONTOS: Greater than 1.0 -- yes, 1.0
16 gpm leak.

17 MEMBER CORRADINI: Okay, so that's line
18 17.1. I got that. Now let's go down line 17.11.

19 The numbers are the same once again. You
20 guys agree, let's not worry about what 1.36 means.
21 What is the .43 mean?

22 DR. CSONTOS: That's the number of months.

23 MEMBER CORRADINI: Aha!

24 DR. CSONTOS: Point 432 from a one gpm
25 leak, so you have a crack that's gone through a wall.

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1 It's leaking at one gpm.

2 MEMBER CORRADINI: Right.

3 DR. CSONTOS: And then it goes from that
4 to a critical crack size and it takes .43 months to go
5 from the one gpm leak to the critical leak or the
6 critical crack size.

7 MEMBER CORRADINI: It just rips open.

8 DR. CSONTOS: That's right. And a 1.2
9 margin. That's the safety -- it's an evaluation
10 margin that the industry was using. So we're trying
11 to compare it to that number.

12 Ted will talk about what we use. It's a
13 little different. But --

14 MEMBER CORRADINI: If the loads were 20
15 percent higher than they used in the calculations --

16 DR. CSONTOS: Exactly.

17 MEMBER CORRADINI: Okay, I got it.

18 DR. CSONTOS: So it's 20 percent higher
19 and that basically drops the critical crack size down
20 smaller.

21 MEMBER CORRADINI: Thank you. I get it --

22 MEMBER BANERJEE: Can I ask the question?
23 In these comparisons, the difference between the NRC
24 calculations and the industry calculations was what?

25 DR. CSONTOS: We haven't --

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1 MEMBER BANERJEE: The same residual stress
2 models, do you have the same K models? What was
3 different?

4 DR. CSONTOS: Everything. We did
5 everything independently. We -- the residual stress
6 models were fit differently. And so most of the
7 differences that you see here are -- for example, the
8 arrests where it says 17-8 and 19-1, where the
9 industry gets arrests and we get 6.15 and 9.5 years is
10 a difference in the fit of the weld residual stress
11 models. One.

12 Two, we also have differences, why you see
13 a difference of about -- I don't even know how much
14 percent.

15 MEMBER BANERJEE: That's okay.

16 DR. CSONTOS: But basically, there are
17 certain assumptions. When you get a crack to go
18 through-wall, how much can we allow for that crack or
19 do we know the k? The k gets very high at the very
20 tip of the crack, okay? And so once it goes through-
21 wall, so how much do we allow, how much do we assess?
22 Well, what we did is we conservatively said that it is
23 going to be a certain larger extent rather than, you
24 know, modeling it. That's a hard area to model.

25 We have certain different assumptions, and

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1 that's where the differences between the industry and
2 our analysis lay. These aren't two of the same
3 models. These are two independently developed models
4 with different assumptions.

5 MEMBER BANERJEE: They are the same crack
6 growth model, right?

7 DR. CSONTOS: The same crack growth rate
8 expression that was developed in MRP-115.

9 MEMBER BANERJEE: But was it the same
10 exactly or was it different?

11 DR. CSONTOS: The equation that is used is
12 the same. In terms of the k relationship to crack
13 growth.

14 MEMBER BANERJEE: That's fine. That's
15 what I wanted. Was it also the same with regard to
16 the
17 z-factor in the crack stability model?

18 DR. RUDLAND: Yes, it was.

19 MEMBER BANERJEE: Okay, that's a straight
20 answer. So what was the difference was the residuals
21 stressers, the initial conditions, I take it?

22 DR. CSONTOS: Yes.

23 MEMBER BANERJEE: And the finite element
24 code, was the nodalization the same or different?

25 DR. RUDLAND: That was totally unique, so

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1 those were done separately. The mesh size densities
2 and all that kind of stuff was done independently.

3 MEMBER BANERJEE: And the constant
4 equations were the same or not?

5 DR. RUDLAND: It's all elastic. So, yes.
6 It was the same.

7 MEMBER BANERJEE: It's all elastic?

8 DR. RUDLAND: Yes.

9 MEMBER BANERJEE: All right, growth were
10 all elastic?

11 DR. RUDLAND: Yes.

12 MEMBER BANERJEE: And you used the same
13 constant equation?

14 DR. CSONTOS: Yes.

15 MEMBER BANERJEE: Why do you expect them
16 to be different?

17 DR. CSONTOS: The main difference in the -
18 -

19 MEMBER BANERJEE: It's numerically
20 different.

21 DR. CSONTOS: Again, remember, these are
22 finite elements. So you've got to make some
23 assumptions as the crack breaks through the wall and
24 the behavior after it breaks through the wall and the
25 assumptions that you make.

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1 MEMBER BANERJEE: That's the only
2 difference?

3 DR. CSONTOS: That's the difference. Yes,
4 that's the main difference. And how you incorporate
5 the residual stresses into the finite element model is
6 the other difference. We didn't necessarily use the
7 exact same curve fits, the exact same procedures and
8 how we incorporated the weld residual stress in the
9 finite element models.

10 MEMBER ARMIJO: But you can get some very
11 different conclusions if I'm reading this right. Your
12 case 19-1, the DEI calculates for the time, the month,
13 the right-hand columns. They calculated rest and you
14 calculate instability or rupture in a month. That's
15 a big difference.

16 DR. CSONTOS: That's because you're
17 getting very close to that, when you do a residual
18 stress, the trough and the curve, it depends really on
19 where that trough and that weld residual stress
20 profile ends up. If it's just slightly higher, then
21 you don't get a k of zero and the crack does not
22 arrest. So these are the types of things, that's
23 where actually you're going ahead a couple of slides
24 why we did this validation exercise.

25 MEMBER ARMIJO: That's a huge, one guy

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1 says, it will arrest. The other one says it is going
2 to break.

3 DR. CSONTOS: It's because of the weld
4 residual stresses.

5 DR. RUDLAND: And if you look at the
6 complete, I think there were cases of opposite also
7 where we said that it was going to arrest and they
8 said that it wasn't going to. So it is very sensitive
9 in that region.

10 DR. CSONTOS: And again, one month is
11 quite a long time. That's 1.2--

12 MEMBER ARMIJO: I understand.

13 DR. CSONTOS: I'll just briefly, we
14 generally had good agreement between the NRC and
15 industry. The biggest difference was this weld
16 residual stress issue. We did 30 cases. You can read
17 those cases. Because of this issue of the weld
18 residual stresses, we did a validation exercise. On
19 the weld residual stress to an EU report from a group
20 over there that was doing a lot, a lot of study on the
21 assessment of dissimilar metal weld integrity. Most
22 of them were AREVA folks who were doing this work.

23 We dovetailed our modeling efforts to that
24 actual, physical measure values for weld residual
25 stresses and the dissimilar metal weld. They don't

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1 have a 82/182 dissimilar metal weld. They have a 309
2 L dissimilar stainless steel dissimilar metal weld.
3 So it is a little different, but it's the same kind of
4 concept in terms of fabrication effects. These are
5 the results from including all of the EU participants,
6 which you see there. The non-destructive measurement
7 technique was neutron diffraction that were done to
8 model this, to measure the weld residual stresses
9 here.

10 What you see here is the stresses on the
11 actual stresses as a function from the OD to the ID of
12 a pipe from here is the OD, here is the ID, and you
13 can see that our, most of the modeling is fitting
14 along a trend that is fairly good in agreement. Now
15 these, just to let you know, these results, these
16 measurements as you go through the thickness, the
17 neutrons would have had to go from to to the OD to the
18 ID, so that measurements probably better in this area
19 than they are in this area. So that's just an FYI on
20 that.

21 For the most part, we believe that these
22 are in the --

23 MEMBER CORRADINI: So whenever you show an
24 experiment, I actually get interested again. So the
25 first three points I think I see what you're saying,

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1 so why would the neutron defraction cause essentially
2 it looks like a bump in all the levels of stress up?

3 DR. CSONTOS: That's an interesting -- I
4 met with the neutron defraction person who did the
5 experimental -- who did this work. And there's a lot
6 of issues with this particular study and the
7 particular through thickness. You have an issue with
8 the flux and a number of neutrons you can use to get
9 your experimental values for the measurement.

10 He actually had to cut out holes out of
11 the pipe to place the detectors into it and so when I
12 was talking to him, he said that going down to about
13 an inch is about right which is about 25.4 millimeters
14 right there. After that, the neutron flux, the number
15 of neutrons that they were using to calculate the weld
16 residual stresses started getting pretty low.

17 MEMBER CORRADINI: So you have to count
18 longer?

19 DR. CSONTOS: Yes, you have to count
20 longer and also this is along the butter and there are
21 issues of calibration as you keep on going down
22 because butter is going along here, on this side and
23 he was trying to get -- and this is where the Wolf
24 Creek -- this is -- there are some results that aren't
25 as nice as this and you can see that in our reports.

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1 But along the butter is where the issue,
2 where we were looking at for Wolf Creek in terms of
3 the cracking and so this is the best one that we
4 looked at. Now when you did that, the butter is at an
5 angle and he has to go in there and he has to tweak
6 the specimen over a little bit. But also, as you go
7 deeper in, you have to get a larger sampling area.

8 MEMBER CORRADINI: So he's actually
9 smearing what he's measuring?

10 DR. CSONTOS: Exactly. And so there are
11 all these issues and that's one of the reasons why
12 we're concerned with going to neutron defraction at
13 greater than one inch.

14 MEMBER CORRADINI: Okay, thank you.

15 DR. RUDLAND: Quick comment about that.
16 Also, if you look at the experimental results, the
17 stresses don't quite balance through the wall
18 thickness and all the analyses are done
19 axisymmetrically, assuming that everything is the same
20 all around the circumference. Well, in reality,
21 they're not. So in that particular case, you can see
22 the stresses are a little high which means someplace
23 else around the circumference are probably a little
24 bit lower.

25 MEMBER ARMIJO: So you used a residual

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1 stress profile that looks something like this, but
2 the industry's residual stress profile look a lot
3 different?

4 DR. CSONTOS: Yes, it's in -- if you look
5 at our reports, it's different than this because you
6 have to remember when we're looking at this whole
7 issue here in front of us, there are certain welds in
8 these plants that did this back-chipping. That -- on
9 the ID will not let the crack -- that stress will not
10 go down. It will go pop back up. And so what we see
11 in our analysis is that we start off pencil in the ID.
12 It drops off and then drives back up again on the OD.

13 So it's slightly different, but we use
14 different residual stresses modeling than they did.
15 And of course, the more I look into the measurement
16 issue of residual stresses, the more I get more
17 concerned with that there it's just as much error or
18 associated with that than it is with the modeling
19 itself. So be careful with these results. In fact,
20 I was told to be careful with these results beyond one
21 inch, by the actual experiments.

22 So I'll move on. You can read these.
23 Basically, all I want to say is that our confirmatory
24 research program reviewed the industry's work. Our
25 cases that are tied to theirs, in general, show

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1 generally good agreement.

2 MR. SULLIVAN: Okay, there's a regulatory
3 piece that we wanted to talk about also and basically
4 what I wanted to do is try to answer the question how
5 did we come to our decision based on all this
6 information.

7 And we started out by developing some
8 safety factors. They turned out to be a little
9 different from industry's. We wanted to use the
10 safety factors to address uncertainties in analysis
11 methodology and assumptions, weld residual stress
12 modeling differences and leakage calculations.

13 Our goals, we didn't say they were hard
14 and fast, but our safety factor goals were to
15 demonstrate a 1.5 factor on stability for a minimum of
16 one week and with a leakage safety factor of five
17 being satisfied during that time.

18 So I tried to reword that. I knew this
19 would be a little bit of a tricky area. So I put down
20 a second set of wording and that means that one week
21 after the leakage was five times higher than the
22 actual level of the CALs we wanted to still have the
23 stability margin of 1.5 met. So that was another way
24 of saying it.

25 MEMBER ARMIJO: Now the action level is --

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1 MR. SULLIVAN: It's basically .25 gpm. So
2 the slight difference from industry, they set it at 1
3 gpm which is a safety factor of 4. It's about the
4 same. When you look at these curves, it's hard to
5 tell the difference between one and a quarter gpm
6 anyway.

7 And as I just alluded, we didn't really
8 feel we had to show for every single sensitivity case
9 that the safety factors would be met because some of
10 the sensitivity cases don't really reflect realistic
11 or expected conditions and that is what happened.

12 MEMBER ABDEL-KHALIK: And these leak rate
13 measurements are done in the plant on a daily basis?

14 MR. SULLIVAN: They're done at least daily
15 based on -- I think the CALs required that they be
16 done daily. A lot of plants did them daily anyway.
17 Not all. I think some plants actually do them more
18 often than daily.

19 MEMBER MAYNARD: Some actually have an on-
20 line system that is pretty much real time. But as far
21 as for record, they will do it --

22 MEMBER SIEBER: You got to hold the plant
23 steady for an hour in order to be able to do it the
24 old fashioned way.

25 VICE CHAIR BONACA: So essentially it

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1 would be 1.25 gpm. So one week after leakage was 1.25
2 gpm or more.

3 MR. SULLIVAN: In the analysis time frame.
4 But in terms of the plant and based on the way the
5 CALs were awarded, we would expect a plant to shut
6 down in no more than about five days even at that high
7 leak rate and probably the plant would shut down a lot
8 sooner. That's what we've been seeing. We've been
9 seeing plants shut down that haven't even had through-
10 wall leakage, just to find out what's going on and
11 some of them will shut down within a couple of days if
12 they have this kind of leakage. They're very
13 sensitive.

14 MEMBER MAYNARD: They also have other
15 mechanisms besides just the leak rate and it does
16 depend on the plant, where they have some of their
17 instrumentation. But you have radiation monitors and
18 you have temperature monitors and in some cases you
19 can tell where the leak may or may not be.

20 MEMBER SIEBER: It shows up first as
21 radiation, containment radiation.

22 MR. SULLIVAN: We have talked about this
23 several times before and I think Glenn alluded to the
24 fact that there was a set of base cases that were
25 done. They were based on weld residual stresses

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1 calculated by finite element modeling. These
2 calculations were done with and without the effect of
3 the stainless steel safe into pipe weld. Now, that's
4 not the weld we're talking about. That's the next
5 weld outboard. That weld has an effect of, the same
6 kind of effect as you would have by doing what they
7 call a stress improvement operation that tends to make
8 the ID a little bit more compressive.

9 So a lot of our analysis, we just
10 disregarded that weld even though we knew it was
11 there. I'll talk about this a little bit more in the
12 next slide, but ASME weld residual stresses were also
13 used for smaller nozzles. The base cases reflected a
14 range of nozzle weld safety geometries and fabrication
15 steps. They looked at the range of loads and a range
16 of initial flaw assumptions and all of the base cases
17 resulted in either arrest or hope this wording doesn't
18 cause us problems, but substantial margins satisfying
19 NRC's staff safety goals.

20 Basically what that meant is a long time,
21 you can operate for a long time before you would start
22 to challenge the stability margin and still have
23 fairly high leakage. That's what that expression
24 means. And as I think you know from previous
25 presentations, the base cases were supplemented by a

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1 whole bunch of additional sensitivity studies.

2 So in the interest of time I could skip
3 over the safety and relief and go right to the surge.
4 That's where the most interest is. That will save up
5 a few minutes. This is where things got a lot more
6 interesting.

7 I will just say one thing about the safety
8 and relief and spray nozzles and that is that all
9 those cases where they used the calculated weld
10 residual stress, they just got arrest. So what DEI
11 did was they introduced the ASME weld residual stress,
12 which is a more severe condition just to study the
13 problem further. In those cases, they didn't all get
14 arrest, but they didn't reflect what was calculated.
15 I think we all felt that was a good thing to do rather
16 than show the boring results that they all arrested.

17 It was also an appropriate thing because
18 it reflected the fact that there are uncertainties in
19 weld residual stress modeling. So now I'm going to go
20 to this slide.

21 DR. CSONTOS: Operationally, we see the
22 cracks about the same depth from our modeling. They
23 are 20 by 33 percent through-wall. So that's where
24 this seems to arrest.

25 MR. SULLIVAN: I know that we're getting

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1 nervous about the time here. All of the surge line
2 nozzles were done with finite element modeling. The
3 way we addressed the conservatism that we just talked
4 about from the smaller nozzles was we didn't consider
5 the safe end to pipe weld even though that we knew it
6 was there. As I said, all the base cases turned out
7 with good results. All of the cases that were done,
8 even the sensitivity cases that used single flaws like
9 we saw at Wolf Creek, they turned out to have plenty
10 of margin.

11 So now what I'm going to do is just talk
12 about the limiting cases. In the limiting cases,
13 there was the most unfavorable conditions, of course.
14 The highest plant loading. I'm not going to make any
15 thing out of that. They were the loads that were from
16 a couple of the plants. They weren't artificially
17 boosted up. They were the design loads we got from
18 the plants. They reflected the ID back-chipping and
19 welding, which we've talked about before. That does
20 tend to introduce some tensile residual stresses on
21 the ID. That actually was part of fabrication of five
22 of the nine plants. The next bullet that I just said
23 and the last condition was a 360 degree ten percent
24 initial flaw, a fairly severe initial condition. That
25 was the starting flaw. That resulted in essentially

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1 no margin, which is a case that I think we talked
2 about a few minutes ago.

3 So we wanted to address that, of course,
4 because that wasn't very good result. We looked at
5 it, instead of trying to attack or whatever any of
6 those initial conditions, we thought, well, we'll go
7 to the methodology and just see what conservatisms are
8 there that we think might be reasonable to look at.

9 The first conservatism that we looked at
10 was the one that Glenn talked about having to do with
11 what, I'm not sure he used the term knock-down factor,
12 but I'll use the term knock-down factor to account for
13 the drop in secondary pipe thermal loads with crack
14 face rotation. And then we also used a more neutral
15 assumption in terms of load stress by considering that
16 the flaw is in the middle of the weld. We still think
17 that is conservative because what we've seen is that
18 the flaws tend to be towards the butter.

19 And this turned out leaving acceptable
20 margins, if you will, or satisfied the safety factors
21 that the staff came up with.

22 And then we looked at one more case. We
23 thought if it was appropriate to look at the knock
24 down factors, then we should probably look at limiting
25 thermal loads, so we did that. All of the assumptions

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1 were the same then. We looked at the five plants, the
2 limiting case of the five plants with the back
3 chipping and the rewelding, the weld residual stress.
4 Without that safe bend, to pipe weld, the same 360
5 degree, 10 percent initial flaw, the knock down
6 factor, and the different flow stress. This resulted
7 in a margin close to 1.5. As I say, they were about
8 10 percent lower. We thought that that was okay. It
9 was pretty close to what we were setting as a goal and
10 we do consider that 360, 10 percent initial flaw to be
11 somewhat conservative.

12 So we considered that these results were
13 acceptable and then the last slide is really just a
14 conclusion slide which gets to the point of the whole
15 exercise which was that after we finished reviewing
16 these results, including our own results of course,
17 which I've talked about a lot, and starting to write
18 up the safety evaluation and finished our thought
19 process on it, we thought it was reasonable to allow
20 the nine plants to continue to operate until their
21 outages in the spring which is what industry had
22 requested.

23 VICE CHAIR BONACA: You speak of adequate
24 margins. Yes. Compared to the criteria that you are
25 using at the beginning, the one that --

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1 MR. SULLIVAN: Right, the first slide.

2 VICE CHAIR BONACA: The first slide.
3 Would you comment there on the margin?

4 MR. SULLIVAN: For which case?

5 VICE CHAIR BONACA: Well, I mean that
6 presents for the surge line.

7 MR. SULLIVAN: For the surge line, I
8 basically talked in some detail about two cases and I
9 didn't give any numbers, you're right.

10 VICE CHAIR BONACA: Yes.

11 MR. SULLIVAN: For the surge line case
12 where we looked at the plant with the maximum normal
13 loads which was about three slides in from the end, we
14 got approximately 1.57 when the leakage was just high
15 enough to be about 1.25 leakage. In other words, when
16 the leakage did increase enough to satisfy the safety
17 factor of five that we were looking for, the stability
18 margin was 1.57. Within a week, it had dropped to
19 about 1.5.

20 So we considered that that fully met the
21 margins or the safety factor goals that we were
22 looking for.

23 On the next case that I talked about which
24 had to do with including the limiting thermal loads,
25 the margin when leakage got to 1.25 gpm was about 1.35

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1 which is, like I said, about 10 percent less than 1.5.
2 And within a week, it hadn't changed much. That curve
3 is fairly flat. That -- I could show you that later
4 if you want because I brought over Dave's report.

5 VICE CHAIR BONACA: I just want a sense of
6 the margin that you gave to me.

7 MR. SULLIVAN: Yes.

8 MEMBER ABDEL-KHALIK: let's say that
9 somebody comes to you in the spring of '08 and says
10 well, gee, the analysis shows we have plenty of margin
11 and we're continuing this enhanced leakage detection
12 and for some reason or another I really can't do it
13 this outage. Would you entertain that at all?

14 MR. SULLIVAN: I don't think we could.
15 From a technical point of view, I would have a hard
16 time answering why we sort of open the door on this
17 occasion, but we wouldn't continue to open the door
18 for your hypothetical question.

19 I don't think management is particularly
20 disposed to a favorable answer to the type of question
21 that you're asking. I think in part, it's because
22 these are analyses. There's a lot of work that we've
23 acknowledged, particularly in the technical report
24 that EMC² wrote which is attached that shows a lot of
25 the limitations of the technology. We've talked about

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1 a lot of them today, a lot of work still needs to be
2 done, the validation work. And so we don't really
3 want to try to stretch this any further than we think
4 we already have.

5 MEMBER ABDEL-KHALIK: I appreciate the
6 unambiguous answer.

7 (Laughter.)

8 MR. SULLIVAN: We have talked about this
9 with industry. We talked about some similar questions
10 at our meeting on August 20th. I think that there's
11 an increased awareness that the NRC staff is sensitive
12 to deviations taken from the industry's initiative
13 schedule and I think industry is probably going to be
14 more reluctant to take deviations.

15 I don't know if anybody here can really
16 speak to that because we don't really have utility
17 people, but the sense I've gotten from talking to some
18 of the industry folks is that industry is probably
19 going to be a bit more cautious about taking
20 deviations from the schedules that they've laid out in
21 MRP 139. Maybe I shouldn't go down that path because
22 I'm speaking for industry, but --

23 VICE CHAIR BONACA: I would say that it
24 would be speculative at this point.

25 MR. SULLIVAN: Yes.

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1 VICE CHAIR BONACA: I would rather not --

2 MEMBER ABDEL-KHALIK: I was looking for a
3 clear, unambiguous answer and I got it.

4 MR. SULLIVAN: Maybe Jim Riley may want to
5 add or disagree.

6 MR. RILEY: This is Jim Riley. I wouldn't
7 disagree with you, Ted.

8 I am not sure whether you guys are
9 familiar or at all with the deviation process, but
10 I'll say this going in, obviously, this whole issue is
11 extremely sensitive to the industry. And I think
12 deviating at this point probably would be a surprise
13 to many of us.

14 There's some pretty, we think, good
15 controls over how these deviations occur and how
16 they're approved and how they're reviewed and how
17 they're communicated and all that. In fact, we're
18 going back and looking at that whole process once
19 again for the second time in little over a year to
20 make sure that it is doing what it needs to do and has
21 the controls in it that it needs to have and I'll go
22 into the details then if you want me to.

23 But an answer to Ted's question directly,
24 I don't think there's been anything that's been put
25 out there that says you can't deviate. But there is

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1 certainly a lot of sensitivity to this issue and like
2 I said I would be surprised if anybody tried to
3 deviate you further from your schedules.

4 MEMBER MAYNARD: I think Said's question
5 was pointed to this specific item that we're dealing
6 with here throughout the entire MRP program. I would
7 be surprised if anybody came in and --

8 DR. CSONTOS: It is somewhat hard to --
9 (Simultaneous speakers.)

10 VICE CHAIR BONACA: The other thing is
11 that this would really be management's decision to the
12 point that our discussion here is highly speculative
13 about what path that would take and certainly it is
14 also speculative about what ACRS would suggest I mean
15 based on what we have seen.

16 DR. CSONTOS: I want to just offer myself
17 up here. If you have more questions about this, I am
18 available all day tomorrow if you want to. It's
19 really hard to consolidate six months worth of work
20 into ten minutes of slides. So I can answer some of
21 your questions if you need to.

22 MEMBER MAYNARD: Well, I appreciate all
23 the work that has been done in this area. I think
24 that's good. I don't believe that we should rely
25 totally on this as any justification for how long we

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1 take to do so. There's other defense-in-depth
2 measures and I think that one of the main things we
3 need to feel comfortable with is that even if we were
4 wrong on all of this and something did happen, are we
5 still in an analyzed condition or do we create an
6 analyzed accident or an analyzed situation. I kind of
7 hate to make the whole decision based upon a
8 calculation that says it can't happen or it won't
9 happen. I think we need to go to the next step and
10 say what if it did and does that put us outside of an
11 analyzed --

12 MEMBER SIEBER: We're clearly in an
13 analyzed condition. The problem is the condition
14 that's analyzed, it's pretty severe.

15 MEMBER ARMIJO: Yes, you'd have a LOCA.
16 Medium --

17 VICE CHAIR BONACA: Even if it isn't alive
18 --

19 MEMBER SIEBER: It doesn't represent a
20 risk to the public, but it certainly represents an
21 economic loss to the owner/operator.

22 MEMBER MAYNARD: We need to make sure that
23 it remains that as opposed to --

24 MEMBER SIEBER: You put all these margins
25 and conservatisms and you have leak rate and radiation

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1 detection and all these other factors as the early
2 warning that you've got to do something and that's no
3 different than if you didn't know there was a flaw
4 there.

5 MEMBER MAYNARD: Right.

6 MEMBER SIEBER: You're still relying on
7 the same mechanism.

8 MEMBER MAYNARD: But sometimes you find
9 something that you had never anticipated that you find
10 out may or may not create a situation that wasn't
11 analyzed. I don't think this does that. I think it
12 keeps it within the analyzed.

13 VICE CHAIR BONACA: The fact that I have
14 an analysis for a LOCA doesn't give me any comfort on
15 a LOCA. I mean, I certainly don't want to get there.
16 I mean, I think that's what we're trying to do. I
17 think I actually I get some comfort from the fact
18 that, you know, the early evaluations of the NRC was
19 that there was no margin and you would go from not
20 knowing anything about it to a break.

21 DR. CSONTOS: We have learned a lot in
22 this process.

23 VICE CHAIR BONACA: That's right. I think
24 it's convincing to me that you have learned something
25 in between. I mean, there is some margin. And again,

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1 I am confident with the responsiveness of the units,
2 I'm sure, that if there is a leakage of half a gpm
3 they shut down. So that gives me the comfort --

4 DR. CSONTOS: I mean, we've gone from an
5 unanalyzed situation -- the analyzed situation before
6 this all got started was six to one ratio. What we
7 found at Wolf Creek was 21 to 1. We analyzed it. We
8 analyzed the first time. We got bad answers. We
9 reduced the conservatisms and we reduced the
10 uncertainties, but we kept a lot of conservatisms on
11 this phase two work. We evaluated a lot of parameters
12 to understand sensitivity, understand conservatisms,
13 and you see there the base cases with the most
14 realistic conditions with the 21 to 1 flaw and we use
15 a 360 ten percent flaw. We showed safe margins.

16 VICE CHAIR BONACA: Good, I am going to
17 wrap up now. Any additional questions --

18 MEMBER POWERS: What is the longest time
19 that we're delaying action based on the --

20 MR. SULLIVAN: The longest time is about
21 five months, and that means that the way the
22 confirmatory action letters were written, I'm not sure
23 if this is the answer to your question, but the way
24 the confirmatory action letters were written was that
25 we wanted plants to shut down to the end of 2007. So

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1 with these results and with the allowance that these
2 plants could continue to operate until the spring, the
3 longest time is to something like the end of May with
4 sort of a schedule that falls out probably, you know,
5 some in February, March, April, and May.

6 MEMBER POWERS: And we have no hierarchy
7 of plants? You did not talk about any plant being
8 particularly susceptible to this?

9 MEMBER SIEBER: Don't have the data.

10 MR. SULLIVAN: What industry did in the
11 report is they labeled the plants by letters. So we
12 really didn't get into which plant was which.
13 Certainly that information is considered proprietary
14 by industry, which plant is which because of plant
15 specific information that is in the report, if it were
16 disclosed which plant were which.

17 DR. CSONTOS: And those plants that have
18 the back-shipping process are the plants, there's four
19 of them with the surge nozzle. There are five of
20 them. One of them has already been overlaid. So
21 there are only four plants out of the nine that have
22 that concern of an access of weld residual stress that
23 drives a crack to this kind a of a potential
24 situation. So those are the ones that I think are or
25 the ones that we are the most concerned about.

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1 VICE CHAIR BONACA: Thank you very much.
2 With that, we will take a break until a quarter of
3 four. Please come back at quarter of four so we can
4 start and we can talk about the research report.

5 (Whereupon, at 3:29 p.m., the meeting was
6 concluded.)

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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

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.

Advanced Finite Element Analyses of Pressurizer Nozzle Weld Flaws: NRC Confirmatory Program



Al Csontos, Ph.D
October 4, 2007

| U.S. NRC | | Advanced FEA Project: Chronology | | | | | | | | |
|--------------------------------------|--|---|---|--------|--------|--------|--------|--------|--------|--------|
| NRC Scoping Study | | Phase I Analyses | Phase II Analyses | | | | | | | |
| WC Indications Reported to NRC | NRC Scoping Study Initiated | MRP 2007-003 Submitted to NRC | Public Meeting: Phase I Results | | | | | | | |
| MRP 2006-041 Submitted to NRC | Public Meeting: Implications of WC Indications | Industry Proposes Advanced FEA Project | Public Meeting: Fabrication & WRS | | | | | | | |
| NRC Scoping Study Completed | Public Meeting: NRC Scoping Study | Industry Advanced FEA Project Initiated | Public Meeting: Phase II Proposed Matrix Cases | | | | | | | |
| Industry Evaluates NRC Scoping Study | Public Meeting: NRC Safety Concerns | NRC Advanced FEA Confirmatory Project Initiated | Public Meeting: Resolve Technical Issues & Updates | | | | | | | |
| | | Confirmatory Action Letters Submitted to NRC | Public Meeting: Project Updates & Phase II Results | | | | | | | |
| | | NRC Comments to Industry's Advanced FEA Project | ACRS Meeting on Phase I & II Results | | | | | | | |
| | | ACRS Meeting: NRC Scoping Study & MRP Evaluations | Public Meeting: NRC Initial Comments on Industry Report | | | | | | | |
| | | Public Meeting: Advanced FEA Project Outline | Public Meeting: NRC Final Comments on Industry Report | | | | | | | |
| | | | Public Meeting: Summary of Advanced FEA Projects | | | | | | | |
| Oct-06 | Nov-06 | Dec-06 | Jan-07 | Feb-07 | Mar-07 | Apr-07 | May-07 | Jun-07 | Jul-07 | Aug-07 |

U.S. Nuclear Regulatory Commission



Advanced FEA Project: Phase II Safety/Relief Results

| Case # | DEI Case # | Time at first leakage (yr) | | Margin at 1gpm leak | | Time since 1gpm leak to 1.2 margin (Month) | |
|--------|------------|----------------------------|--------|---------------------|--------|--|--------|
| | | DEI | Emc2 | DEI | Emc2 | DEI | Emc2 |
| 1 | 1c | 17.4 | 20.16 | 2.24 | 2.46 | 3.63 | 2.18 |
| 1-1 | 1b | Arrest | Arrest | Arrest | Arrest | Arrest | Arrest |
| 3 | 3c | 26.3 | 29.40 | 2.40 | 2.55 | 4.17 | 2.42 |
| 6 | 6c | 3.4 | 4.13 | 1.70 | 1.79 | 1.37 | 1.13 |
| 6-4 | 35c | 2.9 | 3.26 | 1.62 | 1.81 | 1.07 | 0.70 |
| 9-1 | 9c | 32.2 | 119.18 | 2.50 | 2.50 | 4.80 | 2.90 |

- In addition to the Phase I relief line results, the Phase II results for the safety/relief lines confirm the industry results that margins exist between leak and rupture

U.S. Nuclear Regulatory Commission

3



Advanced FEA Project: Phase II Spray Line Results

| Case # | DEI Case # | Time at first leakage (yr) | | Margin at 1gpm leak | | Time since 1gpm leak to 1.2 margin (Month) | |
|--------|------------|----------------------------|--------|---------------------|--------|--|--------|
| | | DEI | Emc2 | DEI | Emc2 | DEI | Emc2 |
| 10 | 10c | 21.2 | 51.36 | 2.07 | 2.48 | 2.43 | 1.85 |
| 11-1 | 11c | 25.3 | Arrest | 2.08 | Arrest | 2.43 | Arrest |
| 15 | 15c | Arrest | Arrest | Arrest | Arrest | Arrest | Arrest |

- Phase II results for the spray lines confirm the industry results that margins exist between leak and rupture
- Results also indicate significantly long times for leakage to occur or complete crack arrest

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4



Advanced FEA Project Phase II Surge Line Results

| Case # | DEI Case # | Time at first leakage (yr) | | Margin at 1gpm leak | | Time since 1gpm leak to 1.2 margin (Month) | |
|--------|------------|----------------------------|--------|---------------------|--------|--|--------|
| | | DEI | Emc2 | DEI | Emc2 | DEI | Emc2 |
| 17-1 | S1b | 1.2 | 1.30 | 1.03 | 1.00 | 0.00 | 0.00 |
| 17-2 | 17b | 1.2 | 1.36 | 1.71 | 1.80 | 1.17 | N/A |
| 17-8 | 17a | Arrest | 6.15 | Arrest | 1.58 | Arrest | N/A |
| 19-1 | 19b | Arrest | 9.50 | Arrest | 1.58 | Arrest | 1.18 |
| 20 | 20b | Arrest | Arrest | Arrest | Arrest | Arrest | Arrest |
| 17-11 | 25b | 0.50 | 0.86 | 1.36 | 1.37 | 0.43 | 0.31 |

- Surge lines results confirm industry results for cases 17-1/S1b, 17-2/17b, 20/20b, and 17-11/25b
- Some divergence occurred for cases 17-8/17a & 19-1/19b, but, substantial margins exist

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Advanced FEA Project Phase II Results

- Generally good agreement between the NRC and industry advanced FEA benchmarked cases
- Of the 30 cases in the NRC confirmatory program:
 - All 11 safety/relief cases showed either arrest or substantial margin between leakage and rupture
 - 3 out of 4 spray cases showed crack arrest with the final case predicting >50 years to leakage with substantial margins between leakage and rupture
 - 9 out of 15 surge line cases show either arrest or adequate margin between leakage and rupture
 - 6 out of 15 surge line cases show little margin due to multiple conservatisms used in the analysis

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6



Advanced FEA Project WRS Validation

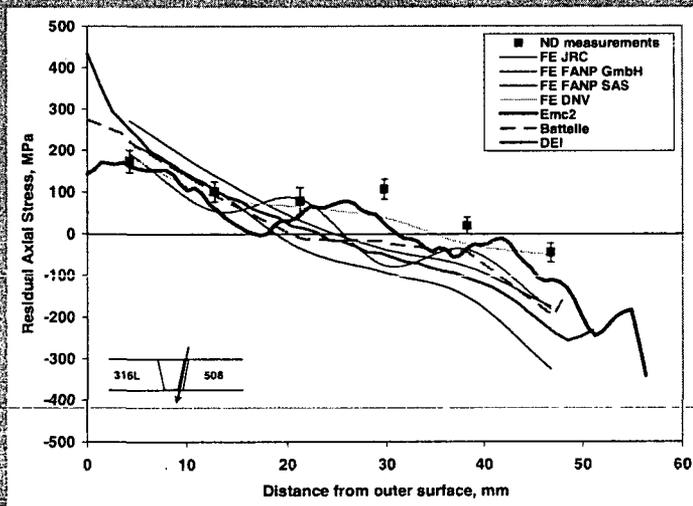
- NRC & industry conducted a weld residual stress (WRS) validation exercise since the Phase II results were most affected by the assumed WRS profiles
- NRC & industry WRS models were validated to the European Union Network for Evaluating Structural Components-III round robin study on the assessment of dissimilar weld integrity
- NRC & industry WRS models were validated to physical measurements of dissimilar metal butt welds
- WRS benchmarking showed generally good agreement between the NRC and industry models

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7



Advanced FEA Project WRS Validation



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8



Confirmatory Project Summary

- NRC confirmatory program developed to benchmark, verify, and evaluate industry's analyses and results
- Unlike the NRC Wolf Creek scoping study, Phase I results predict margins between leak and rupture
- Phase I & II results show good agreement between the industry & NRC advanced FEA model results
- Validation effort provided useful information for understanding the uncertainties in WRS distributions

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9

Advanced FEA Safety Assessment



Ted Sullivan (NRR)

October 4, 2007

- Safety factors (SFs) were used to cover uncertainties in the:
 - Fracture mechanics methodology and analytical assumptions
 - WRS caused by FE modeling differences
 - Leakage calculations
- NRC staff's goal was to satisfy SFs of:
 - 1.5 on stability for a minimum of 1 week and 5 on leakage
 - that is, 1 week after leakage was 5-X higher than action level of CALs, stability margin of 1.5 is to be met
- Staff did not consider it necessary to satisfy these SFs for sensitivity cases with highly conservative assumptions.
 - Not all sensitivity cases reflect realistic or expected conditions

- Base cases reflect:
 - WRSs calculated by finite element modeling for safety/relief and surge nozzles with and without effect of the stainless steel safe end to pipe weld
 - ASME WRS for safety/relief and spray
 - Nozzle, weld, safe end geometries and fabrication steps
 - Range of Loads
 - Range of Initial flaw assumptions
- All base cases either resulted in crack arrest or substantial margin satisfying NRC staff SF goals
- Base cases supplemented by additional sensitivity cases to study additional conditions and assumptions



- All cases with WRS calculated by finite element modeling with or without safe end to pipe weld resulted in crack arrest
- ASME WRS introduced to provide through wall crack results
 - conservatively addresses uncertainties in calculated WRSs
- DEI ran 12 sensitivity cases and Emc² ran 3 cases
 - Results of all cases satisfy staff SF goals except case DEI 42c



- Limiting safety/relief nozzle case 42c:
 - Crack growth rate assumption is highly conservative for majority of crack growth
 - Stability SF falls below 1.5 within a couple of days of leakage SF being satisfied
- All cases with MRP-115 CGRs result in either arrest or satisfying NRC staff SF goals
- Staff concluded that analyses demonstrate reasonable assurance of safety

- WRSs from safety/relief welds used for spray welds
 - Spray nozzle welds have configurations similar to safety/relief
- DEI and Emc² spray nozzle weld cases resulted in either arrest or substantial margin satisfying staff SF goals
- Staff concluded that analyses demonstrate reasonable assurance of safety

- WRSs calculated by finite element modeling
- DEI & Emc² both ran numerous surge nozzle sensitivity cases
 - Majority of cases show either arrest or adequate margin between leakage and rupture
 - All cases with Wolf Creek-like flaws resulted in arrest or adequate margins
- Limiting cases combined most unfavorable conditions
 - Highest plant loading
 - ID back chipping and welding
 - WRS from model without safe end weld even though weld is present – addresses uncertainties in calculated WRSs
 - 360° 10% initial flaw
- Limiting cases with these assumptions resulted in stability SF at first leakage of slightly larger than 1



- Staff approach for assessing this limiting case retained previously stated assumptions but accounted for certain conservatisms in the analysis methodology
- Emc² case 17-10 was run with
 - A knock down factor of 0.6 (based on industry analyses) to account for drop in secondary pipe thermal loads with rotation of the crack and
 - Flow stress based on the more neutral assumption of a crack in the middle of the weld rather than close to the safe end
- Results of this analysis satisfied staff SF goals



- Staff also ran a sensitivity case with limiting thermal loads
 - ID back-chipping and welding
 - WRS of model without safe end weld
 - 360° 10% initial flaw
 - Knock down factor of 0.6 on secondary pipe thermal loads after crack leakage; and
 - Flow stress based on crack in middle of weld
- Results of this case were ~10% lower than SF goals
 - Staff considered results acceptable because of conservative initial flaw assumption
- Staff concluded that analyses demonstrate reasonable assurance of safety



Advanced FEA Project Summary

- Staff's evaluation of all sensitivity cases showed adequate margins between leak and rupture:
 - Majority of cases show either crack arrest or large margins
 - Balance of cases have adequate margins when conservatisms are considered
- Advanced FEA provided reasonable assurance that the 9 plants will continue to safely operate past the 12/31/07 industry imposed deadline to the next refueling outages in Spring 2008



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Pressurizer Nozzle Dissimilar Metal Weld Advanced Finite Element Analyses

ACRS Main Committee
October 4, 2007

Glenn White
Dominion Engineering, Inc.

Topics

- Objective and Approach
- Summary of Methodology
 - Plant Inputs
 - Welding Residual Stress
 - Crack Growth Modeling
 - Critical Crack Size Calculations
 - Leak Rate Modeling
- Analytical Results
- Conclusions

Project Objective

- To evaluate the viability of detection of leakage from a through wall flaw to preclude the potential for rupture of pressurizer nozzle DM welds, given the potential concern about growing circumferential stress corrosion cracks.
- This study is specific to the group of nine PWRs originally scheduled for performance demonstration initiative (PDI) inspection or mitigation during the spring 2008 outage season.
- Commitments were made for these nine PWRs to accelerate refueling outages or take mid-cycle outages. These plants have now resumed plans to perform PDI inspection or mitigation during the spring 2008 outage season given NRC's conclusion regarding its review of the industry evaluations and its confirmatory analyses.

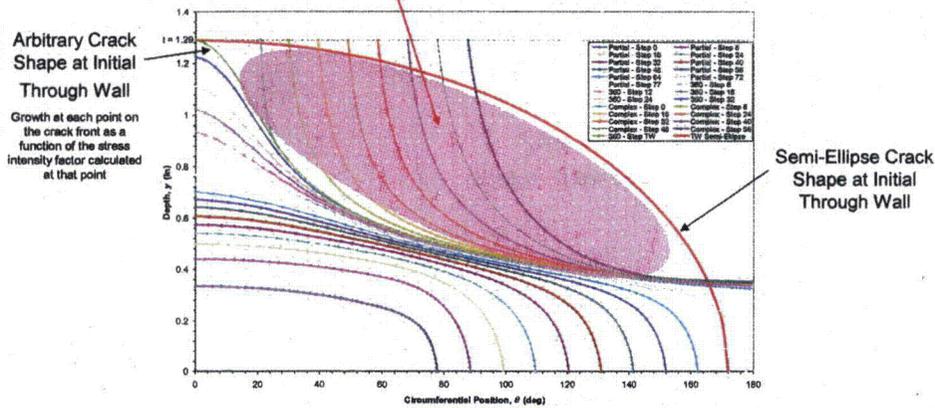
Project Oversight

- Project Team
 - Dominion Engineering (DEI)
 - Quest Reliability – (FEACrack Software Developer)
- Expert Panel
 - Established to provide review, input, and oversight of the technical issues and approaches
 - Members well known in this industry were chosen
 - Ted Anderson, Quest Reliability, LLC
 - Warren Bamford, Westinghouse
 - Doug Killian, AREVA
 - Ken Yoon, AREVA
 - Pete Riccardella, Structural Integrity Associates
 - David Harris, Structural Integrity Associates
 - included specifically for his lack of recent involvement in Alloy 600 fracture mechanics applications to bring a fresh perspective
- Interacted with NRC Counterparts in ~7 NRC public meetings

Project Approach

Artificial Conservatism of Semi-Elliptical Crack Assumption

Semi-ellipse assumption over predicted extent of cracked material in this zone vs. the arbitrary shape methodology for the Wolf Creek nozzle benchmark run



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Project Approach

Key Project Activities

- Software capability development within FEACrack
- Develop and execute an analysis parametric sensitivity case matrix
 - Develop and apply a sensitivity matrix of welding residual stress (WRS) profiles, including weld repairs
 - Crack growth calculations for custom crack shape
- Critical crack size calculations to define the end point for the crack growth calculation
- Leak rate calculations - PICEP and SQUIRT models
- Software verification and benchmarking
- Validation
- Expert panel input and review throughout the project

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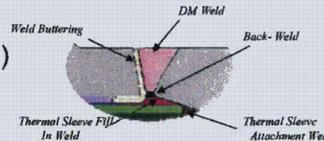
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Plant Inputs

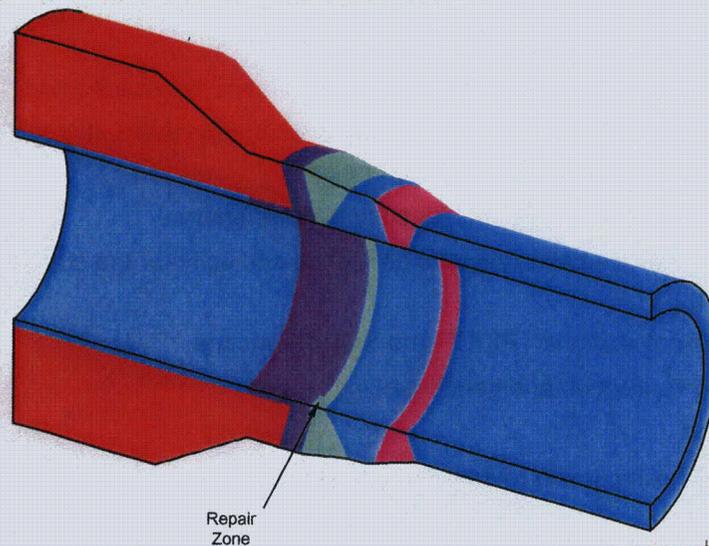
Weld Fabrication → Welding Residual Stresses

- Input obtained from design drawings & shop travelers
- Fabrication Steps affecting weld residual stress (WRS)
 - Fill-In Weld under thermal sleeve (Surge)
 - Fillet Welds (Safety/Relief)
 - Stainless steel field weld to pipe
- Repairs
 - Deep ID Repairs
- Either thermal strain applied to simulate WRS profile or WRS FEA results directly input to crack growth model

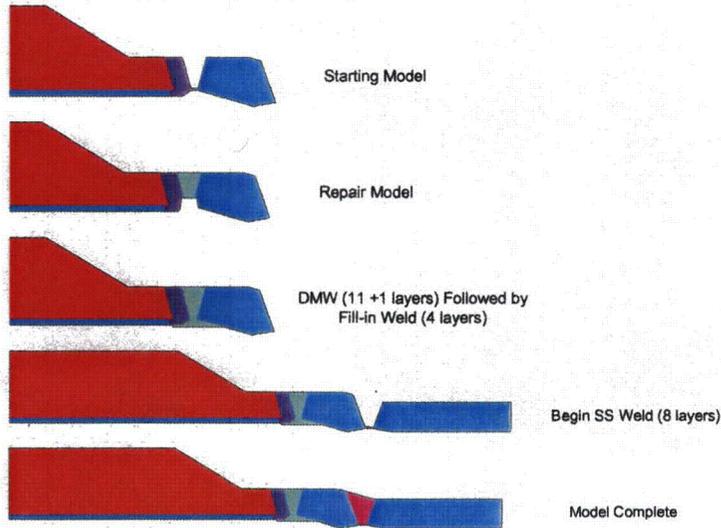


WRS Modeling

Safety/Relief Nozzle 3D Repair Model Geometry



WRS Modeling Type 8 Surge Nozzle Analysis Progression

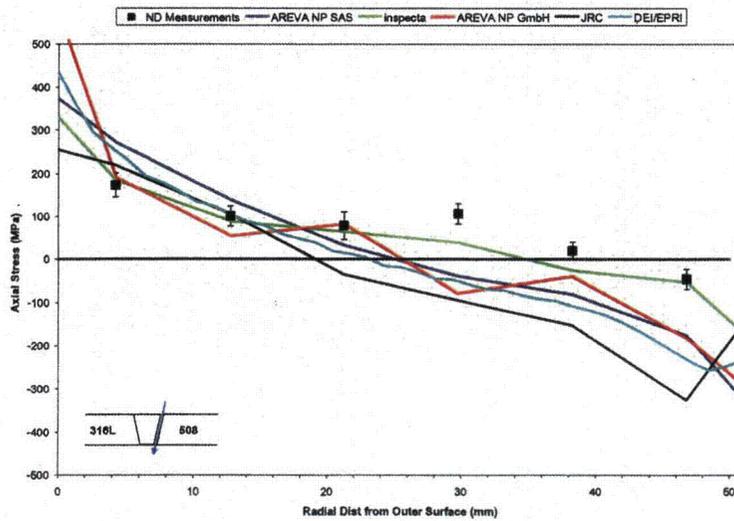


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WRS Validation and Benchmarking EU Mockup—DEI Butter Axial Stress (Through-Wall Section at Butter Layer Center)

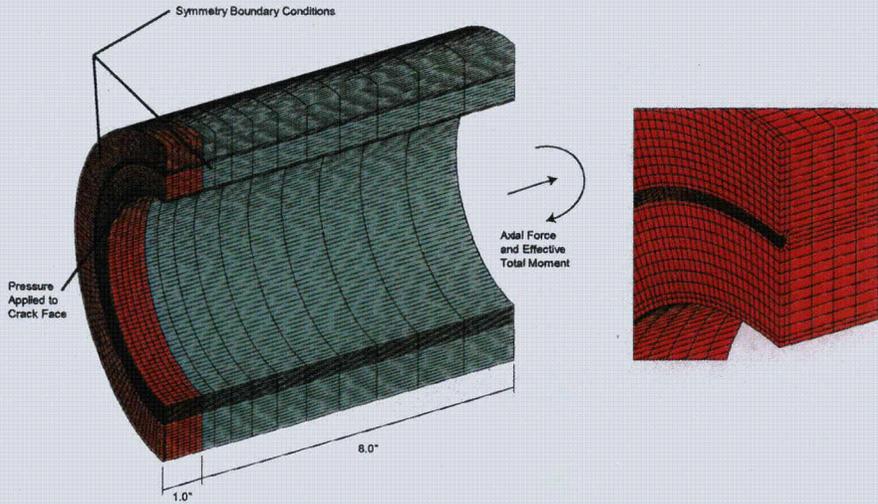


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Crack Growth Modeling Approach Cylindrical Model

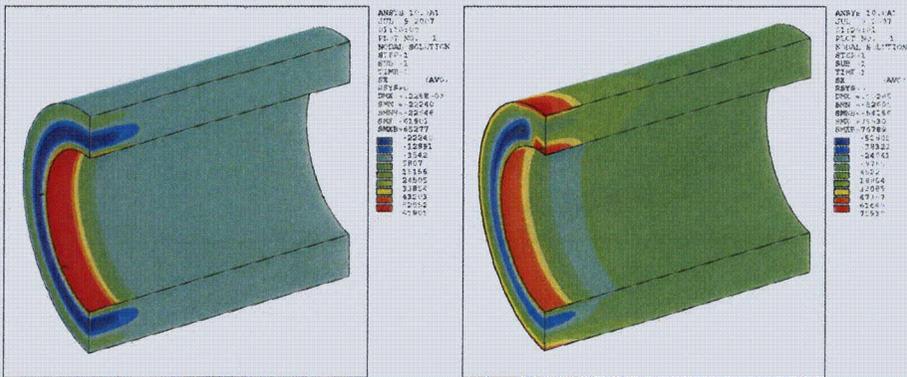


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Crack Growth Modeling Approach Cylindrical Model: Temperature Simulation of WRS



Example of Axisymmetric
WRS Simulation

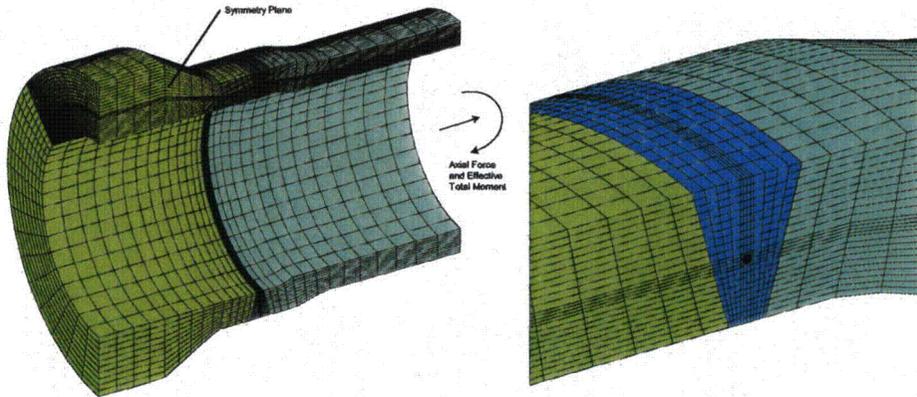
Example of Circumferentially
Varying WRS Simulation

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Crack Growth Modeling Approach Nozzle-to-Safe-End Model (Type 8 Surge Nozzle)

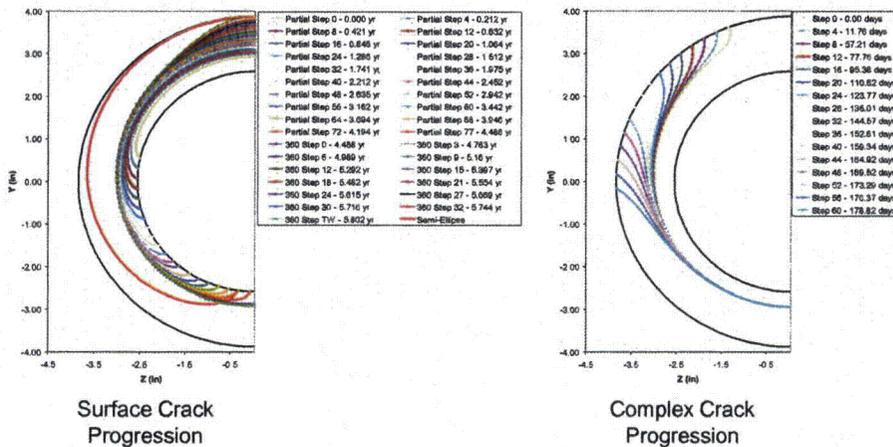


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Phase I Crack Growth Calculations Results for WC Relief Nozzle (December 2006 Inputs)

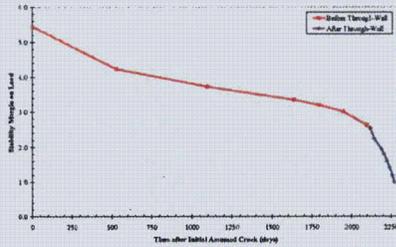


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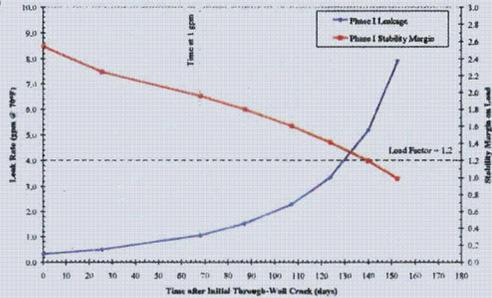
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Phase I Crack Growth Calculations Crack Stability and Leak Rate Results

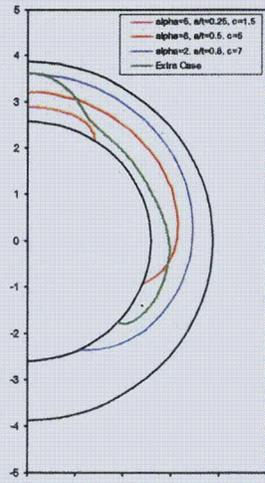


Complete Crack
Stability Development

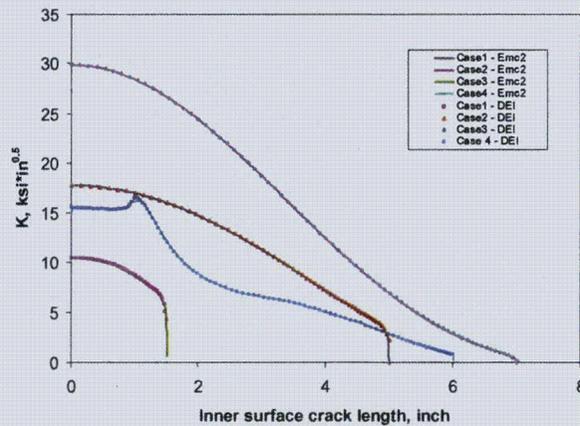
Stability and Leak Rate
Trends for Complex Crack



Stress Intensity Factor Verification Comparison of DEI and EMC2 Results for Analytical Cracks



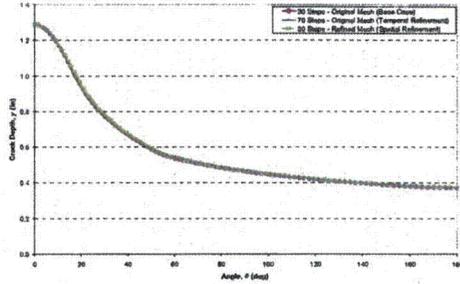
Assumed Nonstandard
Crack Profiles



Comparison of DEI and EMC2
Results Showing Close Agreement
Using Independent Software Models

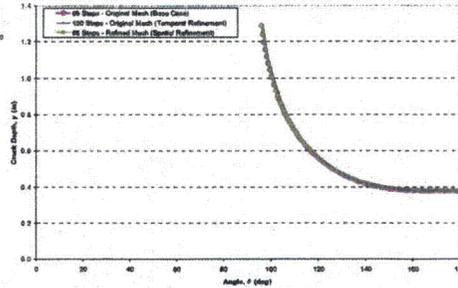
Crack Growth Convergence Checks

Temporal and Spatial Checks Demonstrating Convergence



Surface Crack Growth Progression Starting from Identical Initial Surface Flow (Case 1c)

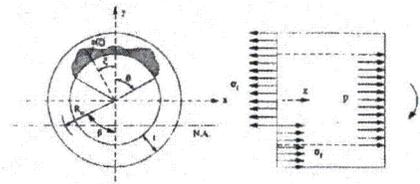
Complex Crack Growth Progression Starting from Identical Initial Complex Flow (Case 1c)



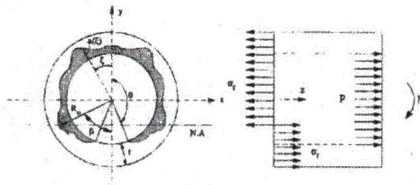
Critical Crack Size Calculations

Force and Moment Equilibrium for Arbitrary Crack

- Rahman and Wilkowski have published the thin-wall solution for axial force and applied moment equilibrium given a circumferential flaw with arbitrary depth profile
- DEI implemented this solution in spreadsheet form
- The solution was applied to crack profiles calculated by the FEACrack software
 - Case 1: Entire crack in tension
 - Case 2a: Part of crack in compression zone with crack taking compression
 - Case 2b: Part of crack in compression zone with crack not taking compression
- Arbitrary Net Section Collapse (ANSC) software by Structural Integrity Associates used to validate spreadsheet calculation
 - ANSC also allows arbitrary moment direction, unlike Rahman and Wilkowski



(a) entire crack in tension (Case 1)



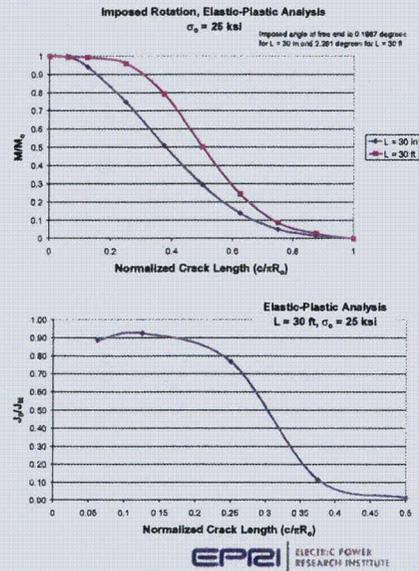
(b) part of crack in compression (Case 2)

S. Rahman and G. Wilkowski, "Net-Section-Collapse Analysis of Circumferentially Cracked Cylinders—Part I: Arbitrary-Shaped Cracks and Generalized Equations," *Engineering Fracture Mechanics*, Vol. 61, pp. 191-211, 1998.

Critical Crack Size Calculations

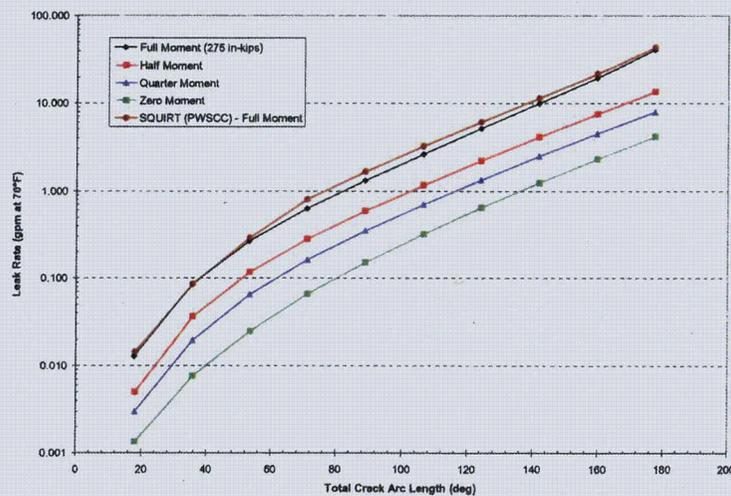
Reduction of Secondary Load with Crack Extension

- Appendix B presents piping models developed for the surge lines of two representative plants to evaluate the maximum capacity of the secondary loads to produce rotation at a cracked surge nozzle, relative to the rotational tolerance of a nozzle weld containing a large complex crack
- Appendix C describes elastic and elastic-plastic finite element analyses of a pipe with an idealized through-thickness crack that were used to determine the effect on bending moment and crack driving force due to an imposed end rotation
 - Because of the finite amount of strain imposed by the rotation, the results (at right) show that the moment knock-down factor and crack driving force relative to the load controlled case decrease significantly as the crack length increases

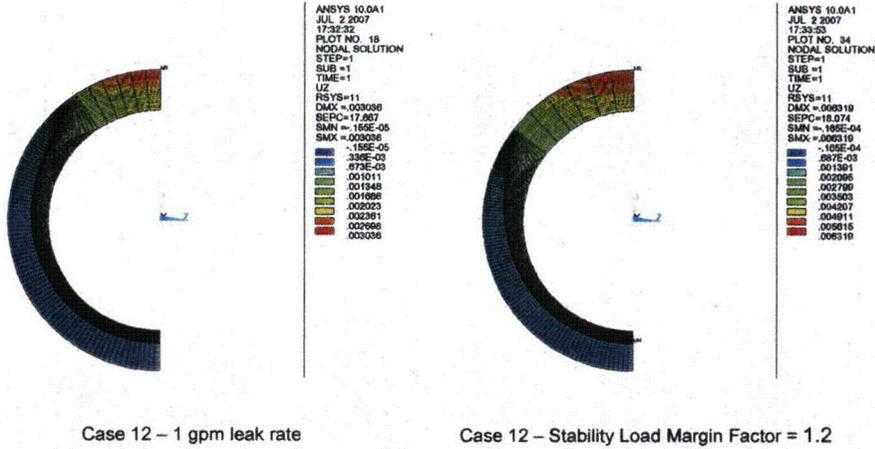


Leak Rate Modeling

Scoping Results Based on WC Relief Nozzle DM Weld Dimensions and COD Calculated by PICEP and SQUIRT



Leak Rate Modeling Example Crack Opening Displacements (Half COD)



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Analysis Case Matrix Evaluation Criteria

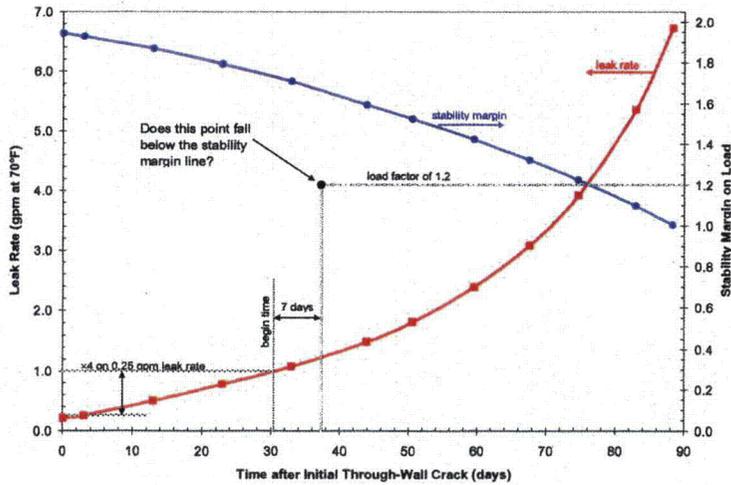


Illustration of Approach for Hypothetical Leakage and Stability Data

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Analysis Case Matrix

Sensitivity Parameters

- Fracture Mechanics Model Type
 - Cylindrical
 - Nozzle-to-Safe-End
- Plant Specific Geometries
- Plant Specific Piping Loads
- Welding Residual Stresses
 - Axisymmetric
 - ID Weld Repair
- Crack Growth Rate Equation
- Initial Flaw Geometry
- Effect of Multiple Crack Initiation Sites

Analysis Case Matrix

Effect of Multiple Crack Initiation Sites

- Sensitivity cases investigate the effect of multiple crack initiation (e.g., Wolf Creek surge nozzle NDE results)
 - Enveloping of multiple initial flaws with one modeled flaw
 - Modeling of a part-depth 360° flaw
 - Growing multiple individual flaws and then combining on a single weld cross section for stability calculation

Analysis Case Matrix

Definition of Case Matrix

- Up to three WRS profiles applied to each case
 - Geometry and load base cases (1-20)
 - Axisymmetric WRS
 - Moment load varied up to maximum reported for specific configuration
 - ID repair base cases (21-26)
 - Non-axisymmetric WRS based on ID repair WRS FEA
 - Further bending moment sensitivity cases (27-30)
 - Sensitivity cases to investigate potential uncertainty in as-built dimensions (31-32)
 - Hypothetical $\pm 10\%$ variation in weld thickness
 - Axial membrane load sensitivity cases (33-34)
 - Relatively narrow range in membrane load for each geometry
 - Effect of length over which thermal strain simulating WRS is applied (35)

Analysis Case Matrix

Definition of Case Matrix (cont'd)

- Simulation of elastic-plastic redistribution of stress at ID (36)
- Effect of initial crack shape and depth (37-41)
- Effect of stress intensity factor dependence of crack growth rate equation (42-47)
 - 5th percentile exponent of 1.0 or 95th percentile exponent of 2.2 assumed
- Effect of pressure drop along leaking crack (48)
 - Other cases assume full primary pressure applies to leaking crack face
- Effect of relaxation of normal operating thermal load (49-51)
 - For through-wall portion of crack growth progression, the normal thermal load has been eliminated for these sensitivity cases (for crack growth, leak rate, and critical crack size calculations)
- Effect of nozzle-to-safe-end crack growth model vs. standard cylindrical crack growth model (52-53)
 - Investigate effect of detailed geometry
- Supplementary cases specific to effect of multiple flaws on limiting surge nozzles (S1-S9)

**Matrix Results
Sensitivity Summary**

| Case # | WRS Location | Para. Name | Qualitative Sensitivity Description | Quantitative Sensitivity Description | Result Comparison | | | | | |
|--------|--------------|------------|---|--|--|--|--|--------|--------|---------------|
| | | | | | Time Interval from 1 ppm to a Stability Margin Factor of 1.2 (hrs) | Stability Margin Factor at 1 ppm (or at initial leak rate if higher) | Calculated Leak Rate (at 70°F) at a Stability Margin Factor of 1.2 (ppm) | | | |
| 2 | c | 1c | Case 1c with intermediate bending moment | Pb from 5.71 ksi to 5.30 ksi | 109 | 118 | 2.24 | 2.40 | 5.81 | 5.89 |
| 3 | c | 1b | Case 1c with low bending moment | Pb from 5.71 ksi to 4.88 ksi | 109 | 125 | 2.24 | 2.40 | 5.81 | 6.23 |
| 5 | c | 4c | Case 4c with low bending moment | Pb from 5.74 ksi to 4.88 ksi | 112 | 137 | 2.18 | 2.35 | 5.22 | 5.81 |
| 7 | c | 8c | Case 8c with low bending moment | Pb from 7.03 ksi to 4.78 ksi | 41 | 71 | 1.70 | 2.01 | 4.04 | 5.44 |
| 9 | c | 8b | Case 8c with low bending moment | Pb from 8.70 ksi to 4.98 ksi | 89 | 144 | 2.14 | 2.50 | 5.56 | 6.58 |
| 11 | c | 10b | Case 10b with low bending moment | Pb from 4.89 ksi to 4.50 ksi | 73 | 73 | 2.07 | 2.08 | 3.81 | 3.70 |
| 13 | c | 12c | Case 12c with low bending moment | Pb from 4.76 ksi to 4.13 ksi | 45 | 64 | 1.80 | 1.94 | 3.54 | 3.43 |
| 16 | c | 15c | Case 15c with low bending moment | Pb from 4.60 ksi to 4.13 ksi | arrest | arrest | arrest | arrest | arrest | arrest |
| 17 | a | 17a | Case 17a with shifted weld residual stress | WRS from w/ SS weld to w/o SS weld | arrest | 35 | arrest | 1.71 | arrest | 69.28 |
| 18 | a | 17a | Case 17a with low bending moment | Pb from 13.67 ksi to 4.85 ksi | arrest | arrest | arrest | arrest | arrest | arrest |
| 18 | b | 17b | Case 17b with low bending moment | Pb from 13.57 ksi to 4.88 ksi | 35 | 43 | 1.71 | 1.79 | 69.28 | 15.76 |
| 20 | b | 19b | Case 19b with low bending moment | Pb from 14.55 ksi to 6.65 ksi | arrest | arrest | arrest | arrest | arrest | arrest |
| 21 | a | 1c | Case 1c with a 20" ID repair (WRS w/o SS weld) | WRS from ASME 3300 fit to 20" ID repair w/o SS weld | 109 | >>21 | 2.24 | 4.42 | 5.81 | 1.28 (note 1) |
| 22 | a | 3c | Case 3c with a 20" ID repair (WRS w/o SS weld) | WRS from ASME 3300 fit to 20" ID repair w/o SS weld | 125 | >>17 | 2.40 | 4.78 | 6.22 | 1.25 (note 1) |
| 23 | a | 8c | Case 8c with a 20" ID repair (WRS w/o SS weld) | WRS from ASME 3300 fit to 20" ID repair w/o SS weld | 41 | >>17 | 1.70 | 3.38 | 4.04 | 1.87 (note 1) |
| 23 | b | 8c | Case 8c with a 20" ID repair (modified ASME WRS) | WRS from ASME 3300 fit to 20" ID repair modified ASME | 41 | 173 | 1.70 | 2.96 | 4.04 | 5.44 |
| 24 | a | 8c | Case 8c with a 20" ID repair (WRS w/o SS weld and multiple repairs) | WRS from ASME 3300 fit to 20" ID repair w/o SS weld; Number of Repairs from 1 to 3 | 41 | >>21 | 1.70 | 2.99 | 4.04 | 1.22 (note 1) |
| 25 | a | 7c | Case 7c with a 20" ID repair (WRS w/o SS weld) | WRS from ASME 3300 fit to 20" ID repair w/o SS weld | 71 | >>21 | 2.51 | 4.24 | 5.44 | 1.31 (note 1) |
| 26 | a | 17a | Case 17a with an ID repair (WRS w/o SS weld) | WRS from w/ SS weld to ID repair w/o SS weld | arrest | 76 | arrest | 2.12 | arrest | 66.51 |
| 26 | b | 17b | Case 17b with an ID repair (WRS w/o SS weld) | WRS from w/o SS weld to ID repair w/o SS weld | 35 | 68 | 1.71 | 2.05 | 69.28 | 61.85 |
| 26 | a | 18a | Case 18a with an ID repair (WRS w/o SS weld) | WRS from w/ SS weld to ID repair w/o SS weld | arrest | >>40 | arrest | 2.83 | arrest | 5.40 (note 1) |
| 27 | b | 17b | Case 17b with intermediate bending moment | Pb from 13.87 ksi to 10.00 ksi | 35 | 38 | 1.71 | 1.74 | 69.28 | 70.43 |
| 28 | b | 17b | Case 17b with low bending moment | Pb from 13.57 ksi to 10.00 ksi | 35 | 27 | 1.71 | 1.87 | 69.28 | 26.75 |
| 29 | b | 18b | Case 18b with high bending moment | Pb from 4.89 ksi to 7.00 ksi | 43 | 11 | 1.70 | 1.38 | 15.79 | 8.49 |
| 30 | b | 18b | Case 18b with low bending moment | Pb from 4.89 ksi to 4.03 ksi | 43 | arrest | 1.70 | arrest | 15.79 | arrest |
| 31 | c | 1a | Case 1c with 10% greater thickness | Thickness from 1.29 in to 1.419 in | 109 | 146 | 2.24 | 2.45 | 5.81 | 6.43 |
| 32 | c | 1c | Case 1c with 10% lesser thickness | Thickness from 1.29 in to 1.161 in | 109 | 74 | 2.24 | 1.90 | 5.81 | 4.80 |
| 33 | c | 4c | Case 4c with low axial membrane stiffness | Pm from 1.90 ksi to 1.84 ksi | 112 | 123 | 2.18 | 2.20 | 6.22 | 5.27 |
| 34 | c | 4c | Case 4c with high axial membrane stiffness | Pm from 1.90 ksi to 2.15 ksi | 112 | 98 | 2.18 | 2.12 | 6.22 | 5.62 |
| 35 | c | 8c | Case 8c with shortened weld length | Weld Length from 1 m to 0.5 m | 41 | 32 | 1.70 | 1.62 | 4.04 | 3.87 |

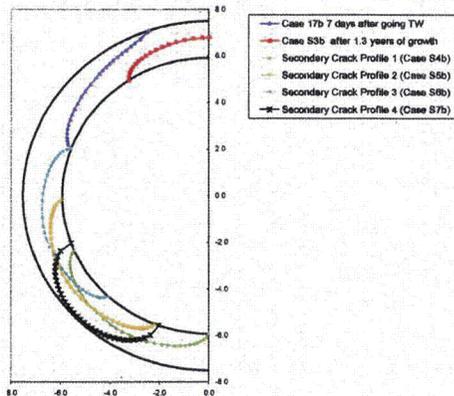
Note 1: Results not specific for a Stability Margin Factor of 1.2; case has Stability Margin Factor >> 1.2 when time > 40 days.

**Matrix Results
Sensitivity Summary (cont'd)**

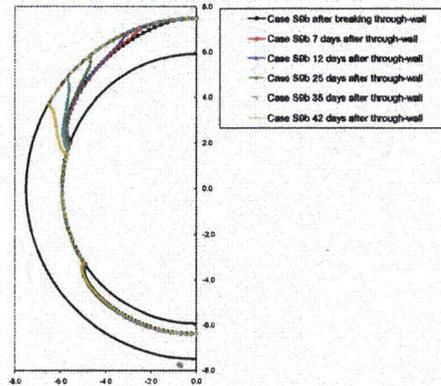
| Case # | WRS Location | Para. Name | Qualitative Sensitivity Description | Quantitative Sensitivity Description | Result Comparison | | | | | |
|--------|--------------|------------|--|---|--|--|--|---------------|--------|----------------|
| | | | | | Time Interval from 1 ppm to a Stability Margin Factor of 1.2 (hrs) | Stability Margin Factor at 1 ppm (or at initial leak rate if higher) | Calculated Leak Rate (at 70°F) at a Stability Margin Factor of 1.2 (ppm) | | | |
| 36 | c | 6c | Case 6c modified with plastic redistribution (modified WRS) | WRS from ASME 3300 fit to plastic redistribution | 41 | 42 | 1.70 | 1.69 | 4.04 | 3.99 |
| 37 | c | 6c | Case 6c with natural shape initial surface flaw | Initial Surface Flaw from Uniform, 10% TW 360° to 2:1, 20% TW, natural shape parallel-arc | 41 | 49 | 1.70 | 1.83 | 4.04 | 4.97 |
| 38 | c | 6c | Case 6c with semi-elliptical initial surface flaw | Initial Surface Flaw from Uniform, 10% TW 360° to 2:1, 20% TW, semi-elliptical parallel-arc | 41 | 49 | 1.70 | 1.83 | 4.04 | 4.97 |
| 39 | c | 6c | Case 6c with constant depth initial surface flaw | Initial Surface Flaw from Uniform, 10% TW 360° to 2:1, 20% TW, constant depth parallel-arc | 41 | 47 | 1.70 | 1.81 | 4.04 | 4.87 |
| 40 | c | 6c | Case 6c with shallow initial surface flaw | Initial Surface Flaw from Uniform, 10% TW 360° to 2:1, 10% TW, natural shape parallel-arc | 41 | 63 | 1.70 | 1.82 | 4.04 | 5.10 |
| 41 | c | 6c | Case 6c with deep initial surface flaw | Initial Surface Flaw from Uniform, 10% TW 360° to 2:1, 40% TW, natural shape parallel-arc | 41 | 44 | 1.70 | 1.77 | 4.04 | 4.70 |
| 42 | c | 8c | Case 8c with low crack growth exponent | CR Exponent from 1.0 to 1.0 | 41 | 39 | 1.70 | 1.87 | 4.04 | 2.97 |
| 43 | c | 8c | Case 8c with high crack growth exponent | CR Exponent from 1.0 to 2.2 | 41 | 47 | 1.70 | 1.84 | 4.04 | 4.84 |
| 44 | c | 12c | Case 12c with low crack growth exponent | CR Exponent from 1.0 to 1.0 | 45 | 37 | 1.88 | 1.69 | 3.64 | 2.64 |
| 45 | c | 12c | Case 12c with high crack growth exponent | CR Exponent from 1.0 to 2.2 | 48 | 40 | 1.88 | 1.81 | 3.64 | 3.95 |
| 46 | b | 17b | Case 17b with low crack growth exponent | CR Exponent from 1.0 to 1.0 | 36 | 73 | 1.71 | 1.71 | 69.28 | 73.58 |
| 47 | b | 17b | Case 17b with high crack growth exponent | CR Exponent from 1.0 to 2.2 | 35 | 22 | 1.71 | 1.70 | 69.28 | 63.34 |
| 48 | b | 17b | Case 17b with reduced crack front pressure | Crack Front Pressure from 2235 psi to 1330 psi | 35 | 39 | 1.71 | 1.73 | 69.28 | 78.05 |
| 49 | c | 9c | Case 9c without thermal loads for TW crack | Pm from 2.34 ksi to 2.40 ksi; Pb from 7.83 ksi to 9.94 ksi | 41 | 145 | 1.70 | 2.85 | 4.04 | 6.57 |
| 50 | b | 17b | Case 17b without thermal loads for TW crack | Pm from 3.72 ksi to 3.71 ksi; Pb from 13.87 ksi to 0.79 ksi | 35 | 293 | 1.71 | 4.33 | 69.28 | 101.43 |
| 51 | b | 19c | Case 19b without thermal loads for TW crack | Pm from 3.45 ksi to 3.30 ksi; Pb from 14.55 ksi to 0.60 ksi | arrest | arrest | arrest | arrest | arrest | arrest |
| 52 | c | 1c | Case 1c with detailed nozzle-to-sleeve end geometry | Geometry from cylinder to detailed nozzle-to-sleeve end | 109 | 94 | 2.24 | 2.26 | 5.81 | 6.61 |
| 52 | b | 19c | Case 19c with detailed nozzle-to-sleeve end geometry and draft FEA WRS interpolation | Geometry from cylinder to detailed nozzle-to-sleeve end; WRS from thermal analysis to draft FEA interpolation | arrest | arrest | arrest | arrest | arrest | arrest |
| 53 | b | 17b | Case 17b with detailed nozzle-to-sleeve end geometry | Geometry from cylinder to detailed nozzle-to-sleeve end | 35 | 49 | 1.71 | 1.69 | 69.28 | 42.36 |
| 51 | a | 17a | Case 17a with 360° initial surface flaw | Initial Surface Flaw from 2:1, 20% TW, natural shape parallel-arc to Uniform, 10% TW 360° | arrest | arrest | arrest | arrest | arrest | arrest |
| 51 | b | 17b | Case 17b with 360° initial surface flaw | Initial Surface Flaw from 2:1, 20% TW, natural shape parallel-arc to Uniform, 10% TW 360° | 35 | not applicable | 1.71 | 1.03 | 69.28 | not applicable |
| 52 | b | 17b | Case 17b with 360° initial surface flaw and low bending moment | Initial Surface Flaw from 2:1, 20% TW, natural shape parallel-arc to Uniform, 10% TW 360° | 35 | 4 | 1.71 | 1.25 | 69.28 | 6.00 |
| 53 | b | 17b | Case 17b with short crack length initial surface flaw | Initial Surface Flaw from 2:1, 20% TW, natural shape parallel-arc to 0.5 ft, 10% TW, natural shape parallel-arc | 35 | 74 | 1.71 | 2.03 | 69.28 | 87.43 |
| 54 | b | 17b | Case 17b with additional crack flow at position 1 | after 7 days of leakage w/ additional 2:1 parallel-arc crack at position 1 (Fig. 7-14) | 35 | not applicable | 1.05 (note 2) | 1.43 (note 2) | 69.28 | not applicable |
| 55 | b | 17b | Case 17b with additional crack flow at position 2 | after 7 days of leakage w/ additional 2:1 parallel-arc crack at position 2 (Fig. 7-14) | 35 | not applicable | 1.05 (note 2) | 1.45 (note 2) | 69.28 | not applicable |
| 56 | b | 17b | Case 17b with additional crack flow at position 3 | after 7 days of leakage w/ additional 2:1 parallel-arc crack at position 3 (Fig. 7-14) | 35 | not applicable | 1.05 (note 2) | 1.29 (note 2) | 69.28 | not applicable |
| 57 | b | 17b | Case 17b with additional limiting crack | after 7 days of leakage w/ additional limiting parallel-arc crack at 80% TW (Fig. 7-14) | 35 | not applicable | 1.05 (note 2) | 1.44 (note 2) | 69.28 | not applicable |
| 54 | b | 19b | Case 19b with 360° initial surface flaw | Initial Surface Flaw from 2:1, 20% TW, natural shape parallel-arc to Uniform, 10% TW 360° | arrest | arrest | arrest | arrest | arrest | arrest |
| 56 | b | 17b | Case 17b with additional crack flow at bottom of weld | Number of initial flaws from single 2:1 parallel-arc crack at top of weld to 2:1 parallel-arc crack at top and bottom of weld (Fig. 7-15) | 35 | 20 | 1.71 | 1.80 | 69.28 | 69.28 |

Note 2: Stability Margin Factor after 7 days of leakage.

Analysis Matrix Results Multiple Crack Cases



Profiles of Pairs of Additional Cracks Applied in Stability Calculations for Cases S4b through S7b Based on Case 17b



Case S9b Growth Progression Based on Individual Growth of Initial 21:1 Aspect Ratio 26% through-wall Flaws Placed at Top and Bottom of Weld Cross Section

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Analysis Matrix Results Summary

- All 109 completed cases in the main sensitivity matrix showed either
 - stable crack arrest (60 cases), or
 - crack leakage and crack stability results satisfying the evaluation criteria (49 cases)
 - generally considerable margins beyond evaluation criteria
- 10 supplemental cases further investigated the effect of multiple flaws on limiting surge nozzle cases
 - Conservative application of the three Wolf Creek surge nozzle indications with limiting surge nozzles (fill-in weld and relatively high moment load) gives results meeting the evaluation criteria with additional margin
 - A case with two long initial partial-arc flaws covering 46% of the ID circumference as opposed to a single initial flaw covering half this circumferential extent (and centered at the location of maximum axial bending stress) has only a modest effect on crack stability
 - On this basis, it is concluded that the concern for multiple flaws in the limiting surge nozzles is adequately addressed by cases that satisfy the evaluation criteria with additional margin

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Analysis Matrix Results

Summary (cont'd)

- Relaxation of secondary loads with crack extension is a significant source of conservatism in the most limiting matrix results
 - A reduction in the secondary load of 40% or more results in the most limiting case (S1b) satisfying the evaluation criteria, even given the assumption of an initial 360° 10%tw flaw
 - This degree of secondary load reduction is supported by the detailed secondary load studies performed (Appendices B and C)
 - Case S1b addresses the most limiting surge nozzles (relatively high secondary moment load and presence of thermal sleeve fill-in weld) and assumes an initial 360° 10%tw flaw (37 inches long)
- Other sources of conservatism for Case S1b:
 - Welding residual stresses (WRS) modeled as axisymmetric
 - WRS does not credit benefit of stainless steel field weld
 - Flow stress in crack stability model based on stainless steel safe end material even though worst case WRS is in the butter area

Conclusions

- Assumption of semi-elliptical flaw shape shown to result in large unnecessary overconservatism
- All 51 subject welds are adequately covered by crack growth sensitivity cases that satisfy the evaluation criteria
- Results show tendency of circumferential surface cracks to show stable arrest
 - Axisymmetric welding residual stress profile must self-balance
 - Consistent with Wolf Creek experience given unlikelihood that four indications found in narrow depth band were growing rapidly at that time
- Sensitivity cases indicate a large beneficial effect of relaxation of secondary loads upon through-wall penetration
 - Detailed evaluations tend to support such a relaxation effect
 - Not fully credited in main cases

Conclusions (cont'd)

- In summary, this study demonstrates the viability of leak detection to preclude the potential for rupture for the pressurizer nozzle DM welds in the group of subject PWRs
- DEI, Quest Reliability, and EPRI plan to submit a paper to a refereed scientific journal on this topic

Managing Gas Intrusion

Gordon Clefton

Nuclear Energy Institute

October 04, 2007

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Managing Gas Intrusion

- **Operational Challenges**
- **BWROG Activities**
- **PWROG Activities**
- **Industry Activities**

Operational Challenges

- **Implementing Technical Specifications**
 - Words say 'full'
 - Basis says normally expect gas intrusion
- **Accessing vent locations**
- **Tracking/trending of vent discharges**
- **Maintaining appropriate surveillance intervals**

BWROG Activities

- **BWROG General Meeting**
 - **Agenda item presentation on ECCS Gas Intrusion**
 - **Support / interest from Prime Representatives**
- **BWROG Chairman**
 - **Presented topic to BWROG Executive Officers**
 - **Recognized problem**
 - **Funded strategic planning in 2007**
 - **Staffed a Committee**
 - **ECCS Gas Intrusion Committee**
 - **Coordinating with BWROG & NEI**
 - **Prepared to respond to GL-xxxx action items**

PWROG Activities

- **PWROG using Westinghouse**
 - **Working Group**
 - **Monroeville PA**
 - **Staff and industry experts**
- **Draft road map for gas voiding concern**
 - **1. Provide acceptance criteria**
 - **a. Acceptance criteria in piping (suction piping)**
 - **i. Amount of gas transport**
 - **ii. Pump Tolerance to gas void**
 - **iii. Issues of gas intrusion from tanks during accident**
 - **iv. Temperature effects on gas transport**
 - **b. Source and rate of gas intrusion**
 - **c. Criteria to characterize discharge piping pressure pulsations in systems with gas voids**
 - **d. Best practices to reduce gas in systems**
 - **e. Gas void detection**
 - **2. Provide Technical Specifications revisions**

Industry Activities

- **NSSSOG**

- Agenda item at quarterly meeting
- Resolution progress reported

- **NEI**

- First steering committee meeting
 - On 11oct07 at NEI
 - Industry experts, BWROG, and PWROG
- NEI-NRC 'drop-in' meeting
 - On 12Oct07 at NEI
 - Strategic information sharing

Managing Gas Intrusion

- **Questions?**
- **Comments?**
- **Concerns?**



**ACRS Meeting on Draft Generic Letter on Managing Gas
Intrusion in Emergency Core Cooling, Decay Heat Removal,
and Containment Spray Systems**

October 4, 2007

**David P. Beaulieu
Generic Communications and Power Uprate Branch
Office of Nuclear Reactor Regulation**

**Warren C. Lyon,
Reactor Systems Branch
Division of Safety Systems**

OUTLINE

- **Background**
- **Purpose of Generic Letter**
- **Desired Outcome of Generic Letter**
- **Principal Concerns And Applicable Regulations**
- **Requested Actions and Information**
- **Public Comments**
- **Recommendation**

Purpose of Generic Letter

- **Request that licensees submit information that demonstrates that NRC regulations are being applied to ECCS, DHR, and containment spray system regarding licensing basis, design, testing, operability, and corrective actions to assure that gas intrusion is maintained less than the amount that challenges operability of these systems, and that appropriate action is taken when conditions adverse to quality are identified.**

BACKGROUND

- **Gas intrusion events have occurred since the beginning of commercial nuclear power operation**
 - **Subject of many NRC generic communications**
 - **Following 1997 Oconee Unit 3 common-mode failure of high pressure injection, no NRC generic action taken based on industry actions**
 - **More than 60 gas intrusion events reported since the 1997 Oconee Unit 3 event**
 - **The number of identified gas intrusion problems and their significance at some facilities raise concerns about whether similar unrecognized design, configuration, and operability problems exist at other facilities.**

DESIRED OUTCOME OF GENERIC LETTER

- **Periodic testing of the subject systems which includes:**
 - **measuring and recording the volume of gas voids at each high point in the subject systems that could impact operability**
 - **venting/removing identified gas voids of any volume to restore the subject systems to a filled condition which may necessitate installation of additional vent valves**
 - **if the location-dependent acceptance criteria for gas void volume exceeded, initiate corrective actions that provides reasonable assurance of operability until the next test**
 - **accelerated test frequency**
 - **identify and correct source of gas**

PRINCIPAL CONCERNS AND APPLICABLE REGULATIONS

- **Licensing Basis**

- **FSAR – specifies that systems are filled with water**
- **TS – surveillance to verify filled**
 - **May cover only portion of system**
 - **Operability not assessed**
 - **Some verifying some sections not possible/practical**

- **Design**

- **10 CFR 50, App B, Criterion III, Design Control**
- **Inadequate provisions (e.g., vent valves) to satisfy design basis filled condition**

PRINCIPAL CONCERNS AND APPLICABLE REGULATIONS - 2

- **Testing**
 - **10 CFR 50, App B, Criterion V, Instructions, Procedures, and Drawings**
 - **Instances of written test procedures do not incorporate the requirements and acceptance limits**
 - **10 CFR 50, App B, Criterion XI, Test Control**
 - **Instances of not testing all segments to confirm acceptance limits and operability (excluded segments justified)**
 - **Required testing includes, but is not limited to, TS surveillances. TS Task Force to address TS later.**
 - **10 CFR 50, App B, Criterion XVII, Quality Assurance Records**
 - **Instances of not recording test results (gas void volume), the acceptability, and the action taken for deficiencies**

PRINCIPAL CONCERNS AND APPLICABLE REGULATIONS - 3

- **Operability**
 - **Technical Specifications**
 - **Instances of not maintaining operable due to gas intrusion**
- **Corrective Actions**
 - **10 CFR 50, App B, Criterion XVI, Corrective Actions**
 - **Gas treated as expected condition rather than a nonconforming condition**
 - **Substantial gas quantities not documented**
 - **Based on the as-found volume and location of gas, corrective actions beyond simply refilling a system may be necessary to provide reasonable assurance that the affected system will remain operable until the next surveillance.**

REQUESTED ACTIONS

- **Evaluate their ECCS, DHR system, and containment spray system licensing basis, design, testing, operability, and corrective actions to assure that gas intrusion is maintained less than the amount that challenges operability of these systems, and that appropriate action is taken when conditions adverse to quality are identified.**

REQUESTED INFORMATION

- **Results of the evaluations done pursuant to the REQUESTED ACTIONS**
- **Information to demonstrate compliance**
 - **10 CFR 50, Appendix B, Criteria III, V, XI, XVI, and XVII**
 - **Licensing basis**
 - **Operating license (Tech Specs)**

PUBLIC COMMENTS - 1

- **Studies will have to be completed**
 - **In order to develop realistic criteria to determine the amount of gas that could impact operability**
 - **Gas detection techniques and the associated accuracies.**
 - **The GL provides technical considerations but leaves it to the industry to address these issues**

PUBLIC COMMENTS – 2

- **The draft Generic Letter does not consider ALARA, personnel safety, or accessibility**
 - **Testing of all segments of piping and components in the subject systems is necessary to confirm acceptance limits and operability unless it has been acceptability established that some items may be excluded.**

PUBLIC COMMENTS - 3

- **For BWRs, proposed GL does not demonstrate that a generic problem of high safety significance exists to justify costs**
 - **staff reviews have clearly established the susceptibility of all plant designs**
 - **Potential to render redundant trains of one or more systems inoperable**
- **Does venting that is preventive in nature need to be documented and quantified?**
 - **Existence of gas is contrary to TS and the FSAR. The affect of this non-conforming condition on operability must be understood.**

PUBLIC COMMENTS - 4

- **Systems are typically presumed operable when a surveillance is current and acceptance criteria are met and documented.**
 - **Based on the as found volume and location of gas, corrective actions beyond simply refilling a system may be necessary to provide reasonable assurance that the affected system will remain operable until the next surveillance.**

RECOMMENDATION

- **ACRS endorse issuance of draft generic letter**



Presentation to the ACRS on Digital Instrumentation and Control (I&C)

October 4, 2007

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Digital I&C Task Working Group Director

Steven Arndt

Senior Technical Advisor for Digital I&C
NRR/DE

Agenda

- Digital I&C Project Plan
- Interim Staff Guidance
 - Cyber Security
 - Diversity and Defense-in-Depth (D3)
 - Highly-Integrated Control Rooms: Communications Issues
 - Highly-Integrated Control Rooms - Human Factors
- ACRS Recommendations Follow Up
 - Evaluation of Operating Experience
 - Inventory and Classification System
- Summary

Digital I&C Project

- **Near-Term Activities**
 - Develop interim staff guidance
- **Long-Term Activities**
 - Revise regulatory documents (RGs, SRP)
 - Continue interactions with industry to have ISG incorporated into industry standards
- **Long-Term Focus of Project Plan**
 - Risk Informed
 - Fuel Cycle Facilities
 - Remaining Human Factors Issues
 - Continue to refine and enhanced guidance as necessary

3

Interim Staff Guidance

- **Status**

| | |
|--|----------|
| – Diversity and Defense in Depth (D3) | 9/28/07 |
| – Highly Integrated Control Rooms – Communication | 9/28/07 |
| – Highly Integrated Control Rooms – Human Factors | 9/28/07 |
| – Cyber Security | 10/31/07 |
| – Licensing Process | 11/30/07 |
| – Risk Informed | 03/31/08 |

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ACRS Interactions

- ACRS provided recommendations to the NRC staff in the area of digital I&C
 - June 22, 2007 SRM – directed the staff to develop an inventory and classification of Digital I&C systems and to evaluate Operating Experience with Digital I&C failures
 - September 13, 2007 – ACRS Subcommittee on I&C
 - October 4, 2007 - ACRS Full Committee Meeting
 - Periodic updates to ACRS Subcommittee on I&C
 - December 31, 2007 - Complete assessment of operating experience and inventory and classification (ACRS Recommendations on D3)

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Cyber Security

- Clarify the NRC staff's guidance with regard to implementation of cyber security requirements for nuclear power plant safety systems
- Interim Staff Guidance
 - Documents regulatory guidance in this area including a cross-correlation table that maps Regulatory Positions 2.1-2.9 from RG 1.152 Rev2 to draft NEI 04-04 Rev2.

6

Diversity and Defense-in-Depth (D3)

- In the Diversity and Defense-in-Depth area there are seven problem statements
 - Adequate Diversity
 - Manual Operator Actions
 - BTP-19 Position 4 Challenges
 - Effects of CCF
 - CCF Applicability
 - Echelons of Defense
 - Single Failure

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Diversity and Defense-in-Depth (D3)

- Adequate Diversity
 - *Additional clarity is desired on what constitutes adequate D3. Determine how much D3 is enough.*
- Manual Operator Actions
 - *Clarification is desired on the use of operator action as a defensive measure and corresponding acceptable operator action times.*
- Interim Staff Guidance
 - There is no distinction in D3 guidance for digital Reactor Protection System (RPS) designs for new/future nuclear power plants and current operating plants.
 - While CCFs in digital systems are beyond design basis, the digital RPS should be protected against CCFs.
 - A D3 analysis should be performed to demonstrate that vulnerabilities to CCFs have been adequately addressed.

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Diversity and Defense-in-Depth (D3)

- **Interim Staff Guidance (cont.)**
 - Where the protective action that should have been automatically performed by the system subject to CCF is required in less than 30 minutes to meet the BTP-19 acceptance criteria, an independent and diverse automated backup, achieving the same or equivalent function, should be provided.
 - This automated backup guidance does not apply to follow-on actions that are handled in a manual fashion.
 - In addition, a set of displays and controls (safety or non-safety) should be provided in the main control room for manual actuation and control of safety equipment to manage plant critical safety functions.
- **Bases for 30-minute Operator Action Time**
 - Minimizing operator burden under the conditions of a digital system CCF
 - Past regulatory decisions
 - Regulatory practices applied in the international community
 - Engineering judgment

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Diversity and Defense-in-Depth (D3)

- **Effects of CCF**
 - *BTP-19 guidance recommends consideration of CCFs that "disable a safety function." Additional clarity is required regarding the effects that should be considered (e.g., fails to actuate and/or spurious actuation)*
 - *Industry also requested that the staff determine whether spurious actuations should be considered when evaluating software CCF*
- **Interim Staff Guidance**
 - In general, spurious trips and actuations are of lesser safety concern than failures to trip or actuate.
 - There may be plant and safety system challenges and stresses; however, these challenges are not as significant as failure to respond to a Chapter 15 event.
 - Software CCFs resulting in a spurious trip or actuation of a safety-related digital protection system do not need to be considered in the single failure analysis.

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Diversity and Defense- in-Depth (D3)

- CCF Applicability
 - *Clarification is required on identification of design attributes that are sufficient to eliminate consideration of CCFs (e.g., degree of simplicity)*
- Interim Staff Guidance
 - Diversity: If sufficient diversity exists in the reactor protection system such that CCFs within the channels are considered to be fully addressed, then no additional diversity would be required in the safety system.
 - Testability: If a system is sufficiently simple such that it is fully tested and found to produce only correct responses, then no additional diversity would be needed in the safety system.

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Diversity and Defense- in-Depth (D3)

- For Further Consideration
 - Work with industry to have ISG refined
 - Adequate diversity strategies
 - Staff assessment of ACRS recommendations on operating experience and inventory/classification
 - Revise the Standard Review Plan

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Highly-Integrated Control Rooms: Communications Issues

- **Interdivisional Communications**
 - *Communications among different safety divisions or between any safety division and any system or equipment that is not safety-related*

- **Interim Staff Guidance**
 - Acceptable *provided* the safety function processor is not encumbered by the communication process.
 - Separate processor & shared memory for communications
 - Limited to support of safety function
 - Communication failures & failures outside a division must not inhibit division's safety function
 - Division must not need input from other divisions to complete its safety function (other than voting logic)

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Highly-Integrated Control Rooms: Communications Issues

- **Command Prioritization**
 - *The process of selecting a particular command to forward to plant equipment when multiple commands exist*

- **Interim Staff Guidance**
 - Safety command from safety system always has priority
 - Hardware-based: physical device with inputs from safety and non-safety sources via hard wire and/or data link
 - Suitable for D3
 - May utilize software external to safety function processor
 - Software-based: safety-grade code executed by safety function processor
 - Not suitable for D3

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Highly-Integrated Control Rooms: Communications Issues

- **Multidivisional Control and Display Stations**
 - *Non-safety control station that can send commands to and/or receive information from equipment in multiple safety and non-safety divisions*

- **Interim Staff Guidance**
 - Must be supplemented by safety-grade stations for safety-related components & functions
 - Safety functions must be carried out using safety controls & indications (per IEEE603)
 - Cannot interfere with safety functions
 - No override except by priority module
 - No bypass initiation or removal except as explicitly permitted by safety system
 - Communications & prioritization should be as described on previous slides

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Highly-Integrated Control Rooms: Communications Issues

- **For Further Consideration**
 - Plant safety analyses must be consistent with possible failure modes
 - Spurious actuations could affect initial conditions
 - Spurious stoppages could affect event progress
 - Spurious events may be initiated by multidivisional stations, or may be initiated by failures in control processors
 - Safety analyses must accommodate what might happen, regardless of the source of the event

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Highly Integrated Control Room –Human Factors

- Minimum Inventory
 - Better describe the process for developing the actual minimum inventory of alarms, controls, and displays needed to implement the emergency operating procedures, bring the plant to a safe condition, and to carry out those operator actions shown to be important by the applicant's PRA, both in the main control room and at the remote shutdown facility.
- Interim Staff Guidance
 - Applicable only to new reactors
 - Identifies
 - Selection criteria
 - Process development considerations
 - Verification
 - Two step process consistent with the design acceptance criteria concept

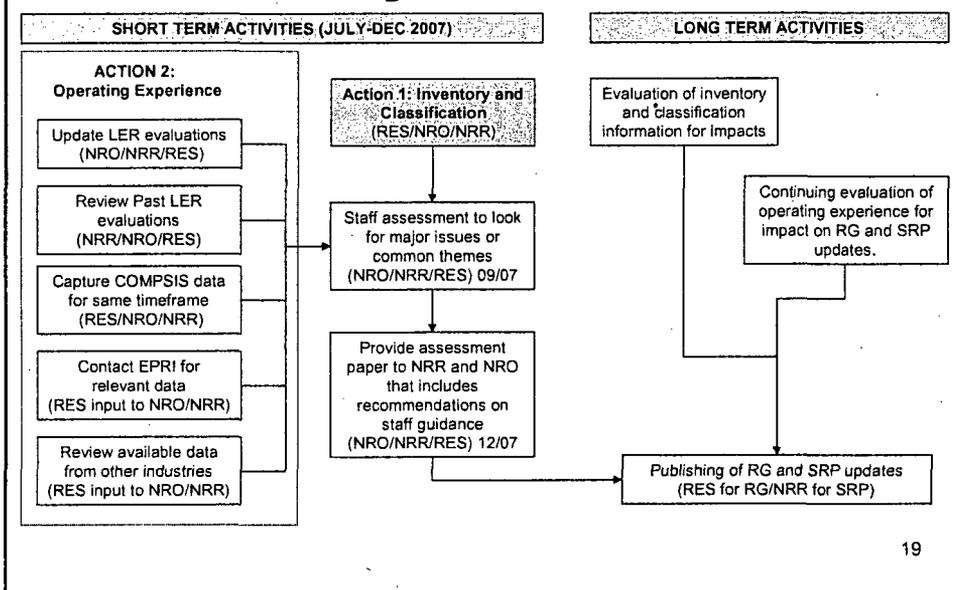
17

Highly Integrated Control Room –Human Factors

- Computer-Based Procedures
 - Develop review guidance and acceptance criteria that are sufficiently detailed to adequately review computerized procedures and associated soft controls, to determine their effect on safety.
- Interim Staff Guidance
 - The content of paper and computer-based procedures can be essentially the same
 - Computer-based procedures should not limit the control or situation awareness of the procedure user
 - Computer-based procedures can incorporate different levels of automation:
 - None (manual)
 - Advisory – Prompts for an action e.g. Start pump "A"
 - Shared – Monitor a process but be unable to access all necessary information about the system due to lack of instrumentation.
 - Automated – Performs the procedure step automatically

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Operating Experience and Inventory/Classification



Operating Experience and Inventory/Classification

- Assessment of operating experience in nuclear and other industries:
 - Internal assessment of operating experience and LER failure data ('87-'06)
 - I&C digital system failures in nuclear power plants ('94-'99)
 - COMPSIS database
 - Contacted EPRI and NEI for similar operating experience failure data
 - *Survey of Digital I&C Failures* (ORNL)
 - *Risk Informed Safety Assurance and PRA of Mission-Critical Software-Intensive Systems* (NASA)

Operating Experience and Inventory/Classification

- Preliminary findings of review of operational experience
 - Availability of quality data is limited
 - Exact causal data is particularly difficult to locate
 - CCFs are credible
 - Other industries use diverse systems to mitigate the effects of CCFs
 - Ongoing NRC programs (e.g., operating experience program) are valuable in that they collect, analyze and distribute information providing lessons learned to staff, applicants, vendors, and licensees.

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Operating Experience and Inventory/Classification

- The inventory and classification research will provide
 - A framework for collecting operational data
 - Guidance for evaluating operational data
 - A process for translating operational data into D3 regulatory guidance
- Regulatory-based Classification systems
- Design-based Classification systems
- Operational-based Classification systems

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Operating Experience and Inventory/Classification

- NRC reviews of operational data have revealed that nuclear system failure classes are similar to failure classes in systems studied by Rashly, Perrow, and NASA
- A proposed failure-type classification expands on the work done by Rashly, Perrow, Aldemir, and NASA
- The proposed classification consists of three attributes
 - Complexity (including hardware and software complexity and testability of the system)
 - Interactions/inter-conductivity (including inter-system communications and the importance of timing and feedback with other systems)
 - Importance (including risk importance, how important the system is for maintaining defense-in-depth and the consequence of system failures)

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Operating Experience and Inventory/Classification

- Preliminary Conclusion
 - On the basis of an assessment of existing classification systems and operating experience data,
 - *No changes to the proposed D3 ISGs are required.*
- Future Plans
 - September 28, 2007
 - Complete short-term staff assessment
 - December 31, 2007
 - Provide white paper that details potential impact upon staff guidance
 - Capture assessment results of inventory/classification and operating experience
 - 2008 and beyond
 - Provide inputs for proposed long-term activities to refine guidance
 - Continue ongoing operating experience program reviews

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Overall Summary

- Steering committee is functioning effectively
- Project plan is in place
- Interim Staff Guidance is being developed
- Continuing interactions with ACRS Subcommittee on I&C
- Strong industry support
- Staff is on-schedule to complete near-term deliverables

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Digital Instrumentation & Control (I&C)

October 4, 2007



Diversity and Defense-in-Depth (D3)

- **Seven Problem Statements:**
 - When is diversity needed?
 - How diverse is diverse enough?
- **Remaining Challenges:**
 - Credit for manual operator actions
 - Use of risk insights
 - Common cause failure applicability
 - Adequate diversity



Diversity and Defense-in-Depth

- **Path Forward:**
 - **Develop methodology for operator response time assumptions**
 - **Develop process for considering risk**
 - **Review operating experience data**
 - **Complete research on adequate diversity**
 - **Further refine interim guidance (ISG)**
 - **Revise BTP-19**



3

Operating Experience

- **Obtain insights on failure modes**
- **Review and characterize 300+ events (NRC and INPO databases)**
- **Share information with NRC**
- **Document findings**



4

Communications

- **Problem Statement:**
 - **Need better guidance for inter-divisional independence and data communication**
- **Remaining Challenge:**
 - **Implementation of interim guidance (ISG)**
- **Path Forward:**
 - **Further refine ISG, if appropriate**
 - **Revise IEEE 7-4.3.2 and RG 1.152**

NEI

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Human Factors

- **Problem Statements:**
 - **Minimum Inventory**
 - **Computer-based Procedures**
 - **Graded Approach to Human Factors**
 - **Safety Parameter Display System**
- **Remaining Challenges:**
 - **Implementation of interim guidance (ISG)**
 - **Completing longer-term actions**

NEI

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Human Factors

- **Path Forward:**
 - Further refine ISG, if appropriate
 - NRC endorse industry reports
 - Minimum Inventory
 - Computer-based Procedures
 - Graded Approach
 - Develop or modify other guidance, as appropriate

NEI

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Cyber Security

- **Problem Statement:**
 - NEI 04-04 and RG 1.152 have different guidance
- **NEI 04-04, Rev. 1**
 - Endorsed by NRC in December 2005
 - Contains programmatic guidance
- **Regulatory Guide 1.152, Rev. 2**
 - Issued in January 2006
 - Contains design guidance

NEI

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Cyber Security

- **Desired Outcome:**
 - Allow either RG 1.152 or NEI 04-04
- **Path Forward:**
 - Perform gap analysis
 - Modify NEI 04-04, if appropriate
 - Develop interim guidance (ISG)
 - Revise IEEE 7-4.3.2, RG 1.152, and SRP