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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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596TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

OPEN SESSION

+ + + + +

WEDNESDAY

JULY 11, 2012

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ROCKVILLE, MARYLAND

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The Advisory Committee met at the
 Nuclear Regulatory Commission, Two White Flint
 North, Room T2B1, 11545 Rockville Pike, at 8:30
 a.m., J. Sam Armijo, Chairman, presiding.

COMMITTEE MEMBERS:

- J. SAM ARMIJO, Chairman
- JOHN W. STETKAR, Vice Chairman
- HAROLD B. RAY, Member-at-Large
- SANJOY BANERJEE, Member
- CHARLES H. BROWN, JR. Member
- MICHAEL L. CORRADINI, Member
- DANA A. POWERS, Member

1 JOY REMPE, Member
2 MICHAEL T. RYAN, Member
3 WILLIAM J. SHACK, Member
4 JOHN D. SIEBER, Member
5 GORDON R. SKILLMAN, Member
6

7 NRC STAFF PRESENT:

8 ANTONIO DIAS, Designated Federal Official
9 WEIDONG WANG, Designated Federal Official
10 ERIC BOWMAN, NRR
11 RICHARD CORREIA, RES
12 DARRELL DUNN, RES
13 BOB EINZIGER, NMSS
14 MICHELE EVANS, NRR
15 ROBERT FRETZ, JLD
16 MIRELA GAVRILAS, RES
17 CHRIS JACOBS, NMSS
18 TRACY J. ORF, NRR
19 LISA REGNER, JLD
20 JAMES RUBENSTONE, NMSS
21 MARK HENRY SALLEY, RES
22 DAVID STROUP, RES
23 ROBERT TAYLOR, JLD
24
25

1 ALSO PRESENT:

2 DAVE BROWN, FPL

3 RUDY GIL, FPL

4 STEVE HALE, FPL

5 JACK HOFFMAN, FPL

6 JOE JENSEN, FPL

7 FRANCISCO JOGLAR, Hughes Associates

8 JAY KABADI, FPL

9 MARK LEYSE*

10 ROD McCULLUM, NEI

11 KEVIN McGRATTAN, NIST

12 RICK WACHOWIAK, EPRI

13 CHRIS WASIK, FPL

14 JEFF WILLIAMS, US DOE/NE

15

16 *Present via telephone

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

(8:32 a.m.)

CHAIR ARMIJO: Okay, we're now all ready. Good morning. The meeting will now come to order. This is the first day of the 596th meeting of the Advisory Committee on Reactor Safeguards. During today's meeting the Committee will consider the following.

Development of Interim Staff Guidances, ISGs, supporting the Near-Term Task Force Tier 1 orders. Two, NUREG-1934, Nuclear Power Plant Fire Modeling Analysis Guidelines.

Three, Saint Lucie Unit 2 extended power uprate application. Four, technical basis for regulating extended storage and transportation of spent nuclear fuel. And fifth, preparation of ACRS reports.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Antonio Diaz is the designated federal official for this initial portion of the meeting.

Mr. Mark Leyse has provided written comments and requested time to make an oral statement regarding the development of Interim Staff Guidances,

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1 ISGs, supporting the Near-Term Task Force Tier 1
2 orders.

3 There will be a phone bridge line. To
4 preclude interruption of the meeting, the phone will
5 be placed in a listening mode during the presentation
6 and Committee discussion.

7 A transcript of portions of the meeting is
8 being kept. And it is requested that the speakers use
9 one of the microphones, identify themselves, and speak
10 with sufficient clarity and volume so that they can be
11 readily heard.

12 The first topic today addresses the
13 Interim Staff Guidances. And we will receive a
14 briefing and hold discussions with NRC staff on the
15 development of the guidance documents.

16 Dr. Steve Schultz was the subcommittee
17 chairman of the ACRS Fukushima Subcommittee, is in
18 Vienna this week. So I will take the lead in the
19 briefing.

20 The three topics we'll cover are those
21 including the ISG's supporting order EA-12-049, which
22 addresses mitigation strategies for beyond-design-
23 basis external events.

24 Order EA-12-050, which addresses reliable
25 hardened vents for Mark 1 and Mark 2 containments.

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1 And Order EA-12-051, which addresses spent fuel pool
2 instrumentation.

3 The final versions of these ISGs are
4 expected to be released by August 31st of this year.
5 And I'd like to turn the briefing over to Mr. Robert
6 Taylor from the Japan Lessons Learned Directorate, who
7 will open the presentation. Mr. Taylor?

8 MR. TAYLOR: Thank you, Chairman. Good
9 morning, Committee. My name is Rob Taylor and I'm the
10 deputy director of the Japan Lessons Learned Project
11 Directorate. It is a pleasure to meet with the ACRS
12 today to discuss the staff's efforts to finalize the
13 staff guidance for implementation of the Tier 1
14 Fukushima Orders.

15 With me today are Eric Bowman, Bob Fretz,
16 and Lisa Regner, who will make the staff's
17 presentation and answer your questions. They will be
18 supported by staff experts who are in the audience
19 today.

20 Since March of last year the NRC has moved
21 at an exceptional pace to respond to, understand, and
22 implement the lessons learned from Fukushima. That
23 pace has challenged our ability to meet with ACRS as
24 quickly and as frequently as we would've desired.

25 Nevertheless, the ACRS has provided

1 tremendous support and insights that have benefitted
2 the Agency's activities on the lessons learned. We
3 are grateful for your efforts on these important
4 issues.

5 With this past spring's issuance of the
6 Tier 1 Orders and Request for Information, staff now
7 has the ability to reemphasize its normal processes,
8 including frequent interactions with the ACRS.

9 We want to ensure, going forward, that we
10 gain your insights and input as we move forward to
11 implement the lessons learned. We greatly appreciated
12 our recent meetings with the Committee on the Tier 3
13 recommendations.

14 The staff is currently finalizing that
15 paper and is on schedule to provide it to the
16 Commission by the end of the week. Your comments have
17 aided our evaluation of those recommendations.

18 We look forward to your feedback today on
19 the staff guidance documents that we will discuss. We
20 remain committed to issuing those documents by the end
21 of August to support licensees' development of
22 integrated plans by February of next year.

23 Our public comment period on the staff
24 guidance documents closed on July 7. We have received
25 a limited number of submissions of comments from

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1 stakeholders. I attribute that to the staff's efforts
2 to engage stakeholders during the development of the
3 guidance documents, including holding public meetings
4 during the comment period.

5 In fact, to-date, the staff has held over
6 50 public meetings on Fukushima, including those with
7 the ACRS. The insights from those meetings have led
8 to the development of thorough and comprehensive
9 documents that the staff will discuss today. With
10 that, I'd like to turn the presentation over to Eric
11 Bowman, who will start us off.

12 MR. BOWMAN: Thank you, Rob. Good
13 morning. As Rob mentioned, I'm Eric Bowman. I'm the
14 staff lead in the Office of Nuclear Reactor Regulation
15 for the mitigating strategies under Order EA-12-049,
16 as well as the mitigating strategies required by 10
17 CFR 50.54(hh)(2).

18 The things I'll be covering, the guidance
19 that has been proposed by industry for the development
20 and implementation of the mitigating strategies and
21 their document, NEI 12-06.

22 The draft of the Interim Staff Guidance
23 that we published for comment and a little bit of
24 additional information on comments and changes that
25 have been made to NEI 12-06 since we last met. Next

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1 slide?

2 NEI 12-06, the diverse and flexible coping
3 strategies implementation guide, the Revision B1 of
4 NEI 12-06 is the revision that we had based the draft
5 ISG we published in June upon, the document goes
6 through and establishes a methodology and framework
7 for developing the mitigating strategies, laying out
8 initial conditions to be considered.

9 And how to develop the boundary conditions
10 and the baseline coping capability of the individual
11 licensees for the beyond-design-basis external OMATs.

12 It goes further into a assessment of
13 external hazards that would be specific to a site, and
14 implementation of a further guidance and strategies
15 for those sorts of site-specific external hazards.

16 Defines what the site-specific FLEX
17 capability should be and lays out what the
18 programmatic controls for the equipment will be.

19 In addition, the guidance includes the
20 requirements for the Phase 3 of the order, strategies
21 and guidance, which is the maintenance or restoration
22 of spent fuel pool coolant, core cooling, and
23 containment capabilities indefinitely using offsite
24 resources. Next slide?

25 CHAIR ARMIJO: Eric, before you do that,

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1 that chart, from the June subcommittee meetings, there
2 may be some confusion or misunderstanding of the
3 sequence of the activities envisioned in this order.

4 And the concern was raised that the
5 hazards, the definition, the determination of the
6 applicable extreme external hazards was done later in
7 the program, where in the mean time, a number of
8 things were being done which might have to be redone
9 later.

10 And so could you clarify that? Is that
11 really the fact? Is the external hazard really going
12 to be determined after a lot of other stuff has been
13 done that should've been deferred until the hazards
14 were -

15 MR. BOWMAN: There are a couple of
16 different aspects to it that need to be brought to
17 mind. A lot of the information in the guidance
18 document that NEI provided is not sequential.

19 However, the way they've laid out and
20 they've got a flow chart in here to show specifically
21 how they see the process working. There's reasonable
22 protection of the equipment and so forth to the
23 design-basis or slightly beyond it, depending on the
24 design-basis of adjacent sites, in order to establish
25 a baseline coping capability.

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1 The baseline coping capability in the FLEX
2 Guidelines relies on an assumption that offsite power
3 has been lost, onsite sources of power such as
4 emergency diesel generators and alternate AC sources
5 are lost. But keeps availability of the AC
6 distribution system, to the extent that it's provided
7 by station batteries through invertors for a baseline
8 capability.

9 The mitigating strategies include
10 workarounds if that internal power distribution system
11 is not available. For example, restoration of core
12 cooling through the black start of RCIC or a manual
13 start of turbine-driven or diesel-driven AFW, et
14 cetera, or local powering of equipment that survived
15 the casualty by bringing in cables or by other means
16 that doesn't use the internal power distribution
17 system.

18 The evaluation of external hazards in this
19 document is not intended to reset what the design-
20 basis should be. It's intended to provide the
21 licensees with a methodology to look at what are other
22 things that could be hazards that are beyond the
23 design-basis but were not included in the design-basis
24 because of the low probabilities.

25 So that's what the intent is for that. It

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1 doesn't really change the design-basis. It gives them
2 a review -

3 CHAIR ARMIJO: But does it make the FLEX
4 plan less, would a FLEX plan be capable of addressing
5 these newly defined extreme external hazards? That's
6 really the -

7 MR. BOWMAN: Well, we also have the effort
8 that's underway under recommendation 2.1 for
9 reevaluation of the external hazards that may lead to
10 a reset of the design-basis later down the road.

11 MEMBER SHACK: Since it's for beyond-
12 design-basis accidents -

13 MR. BOWMAN: Yes.

14 MEMBER SHACK: -- then clearly it's beyond
15 the current design-basis. But there are a lot of
16 references in it to, you know, you're going to store
17 this stuff in a building that survives the safe
18 shutdown earthquake.

19 MR. BOWMAN: Right.

20 MEMBER SHACK: So that safe shutdown
21 earthquake though, is the current design-basis SSE.

22 MR. BOWMAN: Right.

23 MR. TAYLOR: Eric, if I could? And that's
24 an important point. It's a very good question. And
25 it's one that the staff and the Steering Committee

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1 recognized early on as we were developing the list of
2 Tier 1 activities that we were going to undertake, and
3 attempting to maximize the integration.

4 We recognize that in a perfect world we
5 could integrate them fully and we take one regulatory
6 action. But we realized that the reevaluations that
7 we're talking about for external hazards, seismic,
8 flooding, and other external hazards would take time
9 to be performed.

10 The Steering Committee didn't believe it
11 was prudent to wait to require actions for plants to
12 protect against potential beyond-design-basis events.

13 So recognizing that, we decided it was
14 important to move out with imposing requirements and
15 take the risk that there was a potential that some
16 rework might have to be done. Both the NRC and the
17 industry recognized this and believed it was a prudent
18 first step to take these actions.

19 So when we complete the reevaluations,
20 you'll still have an order in place that requires the
21 protection of that equipment, right? So if rework
22 needs to be done, there's still a regulatory
23 requirement that the licensees adequately protect that
24 equipment.

25 As well as if we pursue a rule make, as we

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1 develop rule making on this, and put the requirements
2 in officially into the regulations, then you'll have
3 that as a regulatory mechanism to require the
4 protection of the equipment that is being put in place
5 in accordance with FLEX.

6 CHAIR ARMIJO: So just to follow-up on
7 Bill's comment and to make sure I get it straight.
8 Let's assume some FLEX equipment is stored in a
9 location that meets the current design-basis hazards.

10 But the evaluation of the extreme external
11 hazards, which is done later, determines that you
12 could have a flood that would flood the storage area
13 for all this FLEX equipment.

14 Then both industry and the staff would say
15 sorry guys, we've got to move that equipment to a
16 different location. Is that the current thinking?

17 MR. BOWMAN: That is the current thinking.
18 The operative words in the order are develop,
19 implement, and maintain. And understanding that your
20 external hazard for the equipment, that you are
21 providing reasonable protection of it, should that
22 change, would impact what would be reasonable
23 protection.

24 In addition, part of it is the use of the
25 offsite resources, which includes other pieces of

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1 equipment that will have standardized connectors and
2 preplanned methodologies for bringing that equipment
3 onsite.

4 For the case of the offsite equipment,
5 protection of it from whatever happens on the site
6 would be provided by the distance from the site
7 essentially.

8 CHAIR ARMIJO: Okay. That's all I had.
9 Thank you.

10 MEMBER SIEBER: Question?

11 CHAIR ARMIJO: Yes.

12 MEMBER SIEBER: In your review of FLEX, I
13 doubt very much that you got an opportunity to include
14 any of the changes that were in Revision C, that I
15 also presume you've seen it, does it make a difference
16 or can you go ahead with your work without
17 incorporating changes from B1 to C?

18 MR. BOWMAN: The changes in Revision C
19 were, for the most part, an effort by industry to
20 address what we had published as exceptions and
21 clarifications in the Interim Staff Guidance.

22 MEMBER SIEBER: Yes -

23 MR. BOWMAN: Our intention is to modify
24 the Interim Staff Guidance to recognize things that
25 have been included in the NEI guidance. And I expect

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1 that we will get a Revision 0 when we come to a final
2 agreement as opposed to, Revision C currently is in a
3 redline markup state to show where the changes are -

4 MEMBER SIEBER: That's what I see.

5 MR. BOWMAN: There are a number of things,
6 like in our Interim Staff Guidance we had included the
7 requirement for reliable backup power to the hydrogen
8 igniters for Mark III and ice condenser containments.

9 It's now been included in Revision C, so
10 we no longer need to take that as an exception to the
11 industry guidance. So we'll be deleting that from the
12 industry, the markups.

13 MEMBER SIEBER: So all the NEI documents,
14 the FLEX document is a work in progress and you will
15 match to the current version?

16 MR. BOWMAN: We will match to the current
17 version. We will, of course, take into account other
18 stakeholder inputs that we've received. We had six
19 formal comments and one additional comment that hasn't
20 been added formally. I haven't finished -

21 MEMBER SIEBER: Okay.

22 MR. BOWMAN: -- working with the admin
23 staff to determine what are formal comments that need
24 to be addressed.

25 MEMBER SIEBER: Yes, I see things moving

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1 very fast and an opportunity for a jumble.

2 MR. TAYLOR: Of course. And we do, a very
3 important point is our goal and we will meet that
4 goal, is to get the guidance out on August 31st
5 because we believe it's prudent and necessary. So
6 that the industry can move forward with some certainty
7 in developing their integrative plans that they need
8 the time for, between then and February.

9 So we do need to stop the evolution of the
10 document, freeze it. And if it ends up with us still
11 having exceptions, that's okay. We'll issue a final
12 ISG with exceptions that we deem appropriate to the
13 document.

14 MR. BOWMAN: And if it means that we refer
15 to the Revision C of NEI 12-06 in the redline markup
16 state, then so be it. We'll do that. And we can make
17 a Revision 1 to the Interim Staff Guidance at a later
18 point. But we will have the guidance out for the
19 industry to implement the requirements.

20 MEMBER SIEBER: Things are moving fast
21 enough that the opportunity for a jumble is there?

22 MR. BOWMAN: Oh, yes.

23 MEMBER SIEBER: But I'm glad to see that
24 you're on top of it.

25 MR. BOWMAN: Well, thank you.

1 CHAIR ARMIJO: Is it the goal of the staff
2 and the industry to converge and wind up with a
3 minimum number of exceptions to the NEI guidance?

4 MR. TAYLOR: In a perfect world, yes,
5 absolutely.

6 CHAIR ARMIJO: Yes.

7 MR. TAYLOR: I think there's a time
8 constraint that will limit our success, or challenge
9 our success is a better way to put it. If we can get
10 a document whereby we're perfectly aligned, fine. If
11 not, there will be exceptions within our ISG as to
12 what we find acceptable.

13 CHAIR ARMIJO: That's really a timing
14 issue, not a policy issue?

15 MR. TAYLOR: It is. It's a timing issue.

16 CHAIR ARMIJO: Okay.

17 MR. TAYLOR: And if you take more time,
18 you can certainly resolve your differences and reach
19 resolution. But there might be a point where we
20 actually recognize the difference and we're in
21 agreement. We just haven't had time to get a clean
22 version -

23 CHAIR ARMIJO: Right.

24 MR. TAYLOR: -- that everybody agrees to
25 done. So it'll just end up being a version that has

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1 an exception to it.

2 CHAIR ARMIJO: Yes.

3 MR. TAYLOR: Yes, where there's no
4 objection to the exception.

5 CHAIR ARMIJO: Okay. Because that
6 addresses one of the concerns that we had in the
7 subcommittee meeting of this is changing so fast -

8 MR. TAYLOR: Yes.

9 CHAIR ARMIJO: There's a lot of exceptions
10 and comments. And if that's the guidance the industry
11 winds up using it could lead to confusion, and rework,
12 and problems.

13 MR. BOWMAN: In addition, industry is
14 planning on having a series of workshops, led by NEI,
15 on how to meet the guidance. The first one will be
16 the week of September 3rd. And then they have two or
17 three additional ones.

18 CHAIR ARMIJO: Okay.

19 MR. BOWMAN: And we've been discussing
20 with them participating in part in the workshops.

21 CHAIR ARMIJO: Okay. Yes that helps a
22 lot.

23 MR. BOWMAN: So we're working to stay on
24 the same page.

25 CHAIR ARMIJO: Good.

1 MR. BOWMAN: For the definition of site-
2 specific FLEX capabilities, on the slide here are a
3 listing of the types of things that will be in the
4 capabilities.

5 The reasonable protection of the equipment
6 means to deploy the equipment from where it is being
7 stored to the site where it will have to be used.
8 Interfaces with the emergency operating procedures,
9 abnormal operating procedures, and even the severe
10 accident of management guidelines, and so forth.

11 The N+1 sets of equipment are what is, the
12 guidance specifies will be maintained by the licensees
13 onsite and being the number of units on a particular
14 licensed site. The N+1, the intention is to have an
15 extra set with programmatic controls on outage times
16 for the sets of equipment. Next slide?

17 Our Interim Staff Guidances, I mentioned,
18 the draft 1 that was published was a proposed
19 endorsement of Revision B1 of NEI 12-06, with some
20 exceptions and clarifications.

21 In the draft Interim Staff Guidance that
22 we published we included a section on the reporting
23 requirements, to lay out the types of things that we
24 intended to look for in the reports that are, the
25 integrated plans, and the pre-audit reporting, and the

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1 final reporting. That particular section has been
2 incorporated in Revision C in NEI 12-06.

3 The only other things I would add were a
4 lot closer to being in alignment on the programmatic
5 controls running towards consensus standards. NEI has
6 proposed reliance on the INPO document that's listed
7 here. We're looking at it, as well as our
8 relationship with INPO, as to whether it's something
9 that we want to approve.

10 We've also received a -- and it's not on
11 the slide because I just got it this morning --
12 comment from the American Nuclear Society proposing
13 the development of consensus standards, with them
14 leading the effort for the programmatic controls for
15 this equipment.

16 CHAIR ARMIJO: Right.

17 MR. BOWMAN: And that concludes my portion
18 of the briefing. Have you got any further questions
19 for me?

20 CHAIR ARMIJO: Yes, related to the
21 standards, there's a term of rugged design or
22 something that needs to be defined. Let's see, a
23 seismically rugged design. Is there a clear
24 understanding in the staff and industry on what that
25 means? Is that terminology still used in the ISG?

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1 MR. BOWMAN: Was that in the ISG for this
2 order or for the hardened vents order because I -

3 CHAIR ARMIJO: No, it's in the hardened
4 vents. I jumped ahead. I'm just trying to keep
5 track. I'll wait.

6 MR. BOWMAN: I'll leave that for Bob Fretz
7 to address.

8 CHAIR ARMIJO: Yes, right, okay.

9 MEMBER CORRADINI: Just for clarification
10 because I don't remember. I wasn't at the
11 subcommittee meeting. INPO AP-913, that is for
12 equipment qualification for safety-related equipment?

13 MR. BOWMAN: NEI, in the Revision C to NEI
14 12-06, is proposed use of the deadlines of that INPO
15 document for the portable equipment.

16 MEMBER CORRADINI: Right, but I don't
17 remember what INPO, I don't remember. I don't know
18 what INPO AP-913 is. Is it safety-related equipment?

19 MR. BOWMAN: It's not limited to safety-
20 related equipment, per se, it appears. I've glanced
21 at the document. I haven't had an opportunity to read
22 it in depth. And I would defer, of course, to the
23 appropriate technical experts in that particular
24 portion.

25 MEMBER CORRADINI: I'm just trying to

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1 understand if that's where you're pointing, what are
2 the requirements there? That's what I just don't
3 remember.

4 MR. BOWMAN: They have proposed the use of
5 that methodology for the screening and development of
6 the maintenance and testing procedures for the
7 equipment, as well as a development of standard
8 templates.

9 MEMBER CORRADINI: Okay. Thank you.

10 MR. BOWMAN: But we also have the ANS
11 proposal for a difference of standards.

12 MEMBER CORRADINI: Or just simply a review
13 of these.

14 MR. BOWMAN: Could be, right. Could be,
15 yes.

16 MR. TAYLOR: This is a recent development.

17 MEMBER CORRADINI: I just didn't remember
18 what it was, that's all.

19 CHAIR ARMIJO: That was not discussed in
20 the June subcommittee -

21 MR. TAYLOR: No. And I think it is part
22 of an outgrowth of that subcommittee discussion, as we
23 continue to -

24 CHAIR ARMIJO: Yes.

25 MR. TAYLOR: -- look at this issue and how

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1 do we do it. And one of the questions is, it's not
2 typical to staff to endorse INPO guidelines or
3 documents.

4 So the question becomes, how would we do
5 this, how would we? And that's something ongoing
6 within the staff to look at the appropriate use of the
7 standard or to have the standard -

8 CHAIR ARMIJO: Converted into something.

9 MR. TAYLOR: -- converted into something
10 else that we can use.

11 MEMBER SKILLMAN: Yes, throughout the
12 fleet, when the units go through their annual, or
13 their biannual E&A, evaluation and the review -

14 MEMBER CORRADINI: For qualification?

15 MEMBER SKILLMAN: Well, they're every two-
16 year E&A. One of the primary processes is equipment
17 reliability. And the industry is subtle on the AP-913
18 as an acceptable process for equipment. And so it is
19 a consensus standard, all of those, particularly plan
20 engineering design folks at the stations understand
21 this very very well.

22 And since it is recognized as an industry
23 standard, what appears to me is occurring is, industry
24 is saying you know what, we can use 913 for the FLEX
25 equipment because it works for all the other equipment

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1 in the plant.

2 MR. TAYLOR: Okay -

3 MEMBER SKILLMAN: But this is part of the

4 -

5 MR. TAYLOR: That helps, thank you.

6 MEMBER SKILLMAN: -- review by INPO of the
7 licensees on their every two-year E&A.

8 MR. TAYLOR: Okay, thank you. Thanks,
9 Dick.

10 MEMBER SKILLMAN: Yes.

11 MEMBER STETKAR: Eric, on the N+1
12 capability, we had a little bit of discussion about
13 that -

14 MR. BOWMAN: We did.

15 MEMBER STETKAR: -- in the subcommittee
16 meeting. And I noticed that Rev C of NEI 12-06
17 doesn't have any change. The concern that we had is
18 nominally the N+1, if you have a two-unit site, would
19 have a pump for Unit 1, a pump for Unit 2, and a third
20 pump.

21 So that you have essentially redundant
22 capability for failures. But NEI allows you to have
23 a single pump with enough capability to supply both
24 units and one other.

25 So that in the first case if you had two

1 pumps failing, you would need to bring in offsite
2 resources to help one unit. And in that option that's
3 allowed under the NEI guidance, if you had two pumps
4 fail, you now have two units in jeopardy that you need
5 to mobilize equipment for.

6 Does the final ISG address that issue at
7 all? We had some discussion, you said you were going
8 to take it back and think about it.

9 MR. BOWMAN: We haven't come to a
10 conclusion on that yet.

11 MEMBER STETKAR: And I noticed that they
12 didn't change anything in the NEI document with
13 regards to that.

14 MR. BOWMAN: Okay. Thank you. If that's
15 all the questions for me, I'll turn it over to Bob
16 Fretz for the hardened reliable vent system.

17 MR. FRETZ: Good morning. My name is Bob
18 Fretz and I am the project manager for the reliable
19 hardened vents order. And on the screen you'll see
20 some of the topics we'll discuss this morning in our
21 prepared presentation, as well as answer any of the
22 questions you have regarding the Interim Staff
23 Guidance. Go ahead, Lisa, next slide.

24 Now the reliable hardened vent order that
25 was issued in March of this year essentially applies

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1 to the BWR facilities with Mark I and Mark II
2 containment designs.

3 Now the primary focus of the order is to
4 provide a reliable means to protect the containment
5 from overpressure failures, as well as to support
6 strategies associated with the prevention of core
7 damage by assisting in the use of low pressure water
8 sources to ensure that the reactor core remains
9 covered.

10 And again, in a lot of our discussion
11 we've had internally we've been using the words, I
12 guess prevention, to essentially just describe those
13 strategies that were taken prior to core damage.

14 And then we used the word mitigation to
15 describe those strategies that are applied after core
16 damage occurs. So if I mention any of that, that's
17 how I'm using those terms today. Next slide?

18 The reliable hardened venting system shall
19 be able to operate under a prolonged station blackout
20 condition, that is a loss of all AC power, while there
21 is also inadequate containment cooling. So sometimes
22 we refer to this as the TW sequence, sequences
23 regarding these conditions.

24 Now because the order assumes that there
25 is no core damage present, it does not provide any

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1 specific requirements relating to severe accident
2 service, such as being able to withstand the presence
3 of hydrogen, or even requiring licensees to consider
4 a severe accident source term in its assumptions.

5 Now that does not mean we have forgotten
6 those concerns or even those lessons learned from
7 Fukushima. The whole issue of severe accident service
8 is including whether or not to install external
9 filtration or additional filtration on these hardened
10 venting systems will be the subject of an upcoming
11 Commission paper.

12 So it's one of those things that we have
13 not forgotten but essentially the purpose of the order
14 is to really assist in those strategies related to
15 prevention of core damage. Okay, next slide?

16 Now the order includes three basic design
17 objectives. That is licensee shall design the system
18 to minimize the reliance on operator actions. The
19 system shall also be designed to minimize personal
20 exposure to occupational hazards while operating the
21 system.

22 And the system shall be designed to
23 minimize plant personnel exposure to any radiological
24 additions that might be present in responding to the
25 event.

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1 Now the second bullet there, large bullet,
2 is that also the order essentially adopted the venting
3 capacity requirement that was similar to what was
4 recommended in the generic letter 89-16, you know,
5 more than 20 years ago. So we essentially adopted the
6 same thing. We felt that the basis for that was still
7 valid.

8 MEMBER CORRADINI: This is the second
9 bullet?

10 MR. FRETZ: The second bullet, yes, the
11 capacity is.

12 MEMBER CORRADINI: And in referencing
13 that, is there an analysis that's attached to that,
14 that one understands why one percent makes sense from
15 a timing standpoint?

16 MR. FRETZ: Well, we're essentially
17 pulling from the analysis that was done in
18 relationship to generic letter 89-16, in that the
19 suppression pool has the capacity to accept decay heat
20 during, essentially the first three hours of the
21 accident before the pool itself becomes saturated.

22 And further analysis has shown that any
23 kind of decay heat, following that point, is less than
24 one percent. So we have essentially adopted that same
25 analysis.

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1 MEMBER CORRADINI: If I might just ask, so
2 then is that the limiting case, that is with the range
3 of Mark I designs and Mark II designs, it's either
4 that or longer? That is, I don't have a situation.
5 I don't have a potential licensee that just because of
6 the design of a torus, of the wetwell, excuse me, and
7 their power, three is really two. Do you know what
8 I'm asking?

9 I'm asking is the three-hour one percent,
10 which actually are consistent, the minimum for all the
11 population of plants, given some past -- you said 89-
12 16 analysis. You know what I'm asking now?

13 MR. TAYLOR: You're asking is there's a
14 two-hour -

15 MEMBER CORRADINI: Yes, I'm asking is -

16 MR. TAYLOR: Is there a plant out there
17 with a two-hour -

18 MEMBER CORRADINI: I'm asking if there was
19 an outlier.

20 MR. TAYLOR: Yes.

21 MEMBER CORRADINI: That's what I'm asking.

22 MEMBER STETKAR: You can have a different
23 scenario. For example, if ADS doesn't work, for
24 example, and you can't depressurize, you only have the
25 SRVs blowing down. Is there any scenario where you

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1 might want to open a vent to depressurize, which could
2 occur earlier?

3 CHAIR ARMIJO: Sure.

4 MALE PARTICIPANT: At a higher power
5 level.

6 MEMBER CORRADINI: Right, but I guess, but
7 at a higher, as a shutdown power.

8 MEMBER STETKAR: As a shutdown power.

9 MEMBER CORRADINI: In all intensive
10 purposes -- I don't to answer for them.

11 MR. TAYLOR: I think it's a really good
12 question. I think when we looked at this we still
13 felt the basis was valid. But we'll take that back
14 and take a look as we develop the final ISG is, are
15 there any outliers out there --

16 MEMBER CORRADINI: Right.

17 MR. TAYLOR: -- that we need to
18 specifically address relative because we are writing
19 a generic guidance document, as opposed to a plant-
20 specific one. But if there's a potential outlier out
21 there where the guidance wouldn't fit or meet, we
22 would also expect that outlier, that plant, to
23 identify that the guidance isn't applicable to it and
24 recognize it.

25 So we have a responsibility but so does

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1 the licensee. They shouldn't take a guidance
2 threshold and apply it when they know it doesn't fit
3 to their plant.

4 MEMBER CORRADINI: Okay, that's fine. And
5 the outlier I was thinking of besides system design is
6 not different times of putting stuff into the wetwell
7 but an ATWS event. So that I have some sort of full
8 power event which shortens the time, that gives me
9 less margin to saturation. So that's the one that I
10 guess I wanted to ask about.

11 MR. TAYLOR: ATWSes are very difficult
12 events to deal with. They are very challenging events
13 from a pressure. And our Steering Committee
14 considered ATWS events as part of the initial
15 conditions for it and said, you're taking a very
16 extreme event, a very low probability initiating
17 event, an external event that causes something of this
18 nature and then you're adding an ATWS on top of it.

19 MEMBER CORRADINI: That's fine.

20 MR. TAYLOR: You're complicating the
21 probabilities or you're -

22 MEMBER CORRADINI: If there's a risk
23 argument, that's fine. I just wanted to make sure
24 that, what was going through my mind was the
25 consistent connection of time with power and outliers

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1 to that.

2 MR. TAYLOR: It does presume a shutdown of
3 the reactor.

4 MEMBER CORRADINI: Right.

5 MR. FRETZ: That's the assumption, that we
6 would have an ATWS.

7 CHAIR ARMIJO: This came up in the
8 subcommittee and I want to make sure the full
9 committee members hear it.

10 And that is there was an opinion by one or
11 more members that there are a lot of hardened
12 containment vents out there right now, a lot of
13 variety depending on who designed it, who built them.

14 And the feeling was that there must be
15 some that are close to, or actually meeting, the
16 requirements of a reliable hardened containment vent
17 but you won't know that until you get the submittals
18 back from the order.

19 And it was suggested that the staff review
20 those things with enough detail to say hey, there's
21 some best practices out here that we can endorse, or
22 encourage, or something.

23 Is that the staff's plan, to review the
24 submittals and say hey, this is a state of the
25 industry as far as the existing hardened vents and

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1 this is a best practice? This is a good way to do it.
2 Or is it just, you know, what's going to happen with
3 those submittals, I guess?

4 MR. TAYLOR: That's a really good
5 question. The plan right now for all the submittals,
6 when we get the integrated plants, is the staff will
7 complete safety evaluations on those plants. So that
8 there is a clear basis for what we accepted and what
9 we approved, as part of the compliance with each of
10 the orders.

11 It would not be a difficult, or
12 challenging next step, to say that if a plant came in
13 and demonstrated that they had a design that met the
14 intent of the order and we agreed to point to the rest
15 of the industry and say hey, here's a model that you
16 can follow as an acceptable.

17 We haven't heard a plant come forward yet,
18 to my knowledge, Bob, to say hey, based on the draft
19 of the guidance document here's our checklist and we
20 obviously meet it. Now that doesn't mean it doesn't
21 exist. It just means we haven't heard it yet.

22 CHAIR ARMIJO: Okay, right, okay. And the
23 other question that came up was a definition of
24 seismically rugged design.

25 MR. TAYLOR: Sure.

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1 CHAIR ARMIJO: And Bob, maybe you can help
2 us on that?

3 MR. FRETZ: Well, sure, the seismically
4 rugged design, essentially we're defining that as
5 essentially that the system needs to be designed to
6 withstand the design-basis earthquake, or the current
7 seismic requirements of the plant.

8 With that said, we are not requiring that
9 the system meet all the requirements of Appendix B,
10 you know, post or downstream of the second containment
11 isolation valve. So therefore, it doesn't meet any of
12 the, let's say Cat 1 requirements for, we inspected
13 the quality control matters.

14 And so that's why we are trying to use the
15 term seismically rugged design to essentially say,
16 design a system to be able to withstand the earthquake
17 and that it remain functional following the
18 earthquake. But that the system not necessarily meet
19 the safety-related design.

20 And I think you had a question earlier
21 regarding whether or not the industry understands
22 that.

23 I guess I can only answer that by the, I
24 guess the absence of a lot of questions on the
25 definition of that during our public meetings, and our

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1 dialogue we've had with the various stakeholders, at
2 least from the industry stakeholders. They seem to
3 understand what the staff's intent is on that.

4 MEMBER SIEBER: I think that it would be
5 a departure, the Agency's practice to choose a design
6 and say this is superior to these others, that it
7 either meets the requirements or it doesn't.

8 MR. TAYLOR: That's correct.

9 MEMBER SIEBER: On the other hand, you
10 might see somebody in the hall and say this is a
11 pretty good one. And the somebody might be NEI.

12 MR. TAYLOR: Of course, we don't
13 discourage best practices. So you're absolutely
14 correct. We try to promulgate a performance-based
15 requirements and let the licensees propose how to meet
16 those requirements. And then we judge those proposals
17 or we evaluate those proposals.

18 MEMBER SIEBER: Whether they comply or do
19 not?

20 MR. TAYLOR: Yes. That's exactly right.

21 MEMBER SIEBER: As opposed to whether one
22 is better than another?

23 MR. TAYLOR: But the industry is, I give
24 them some credit. They are good at learning lessons
25 from each other. And if they see somebody who's got

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1 a good design and a good way to do it, that has
2 already been found acceptable by the staff, they try
3 not to reinvent the wheel too often.

4 MEMBER SIEBER: Right. And they're
5 getting better at that as time goes on.

6 MR. FRETZ: Yes, right. And then as far
7 as our dialogue with the BWR Owners Group, they are
8 sharing information amongst each other.

9 MEMBER SIEBER: Yes.

10 MR. FRETZ: And as it turns out, one
11 licensee has about one-third of all the, you know,
12 that being Exelon, has about one-third of the plants
13 either needing a new system or existing system. So
14 I'm sure there will be no problem with them sharing
15 information on -

16 MEMBER POWERS: Maybe.

17 MR. FRETZ: And I just made a commonality
18 of designs, you know, we know say even among licensees
19 in that one.

20 MEMBER SIEBER: I do have a question that
21 involves some speculation. But obviously the current
22 designs, and the design requirements for hardened
23 vents, does not include its ability to be able to vent
24 hydrogen.

25 MR. FRETZ: Right.

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1 MEMBER SIEBER: Because that's beyond the
2 design-basis. On the other hand, there have been
3 concerns about hydrogen explosions in the vent systems
4 and examples of where that's happened.

5 And it is not beyond my personal dream of
6 the future that some day somebody is going to say, you
7 ought to do that and make them hard enough to
8 withstand detonation or deflagration.

9 And under those circumstances, the work
10 that's being done now and the requirements that are
11 laid on that, are wasted because current vent systems
12 won't meet the severe accident requirement.

13 Do you see any pathway to resolving that
14 to avoid back pedaling twice? Or what is your vision
15 at how this will all pan out?

16 MR. TAYLOR: I think it's a very good
17 question. Of course, we want to minimize rework,
18 right, the potential for rework. That's why we're
19 moving as expeditiously as possible on the severe
20 accident aspects of the venting system.

21 MEMBER SIEBER: Right.

22 MR. TAYLOR: That activity that we
23 deferred, we do not believe we had enough work done,
24 by the time we had completed the orders in March, to
25 make a recommendation to the Commission on both the

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1 severe accidents and the filtered aspects of what the
2 requirements of the vents should be.

3 So the staff is working very diligently on
4 the analyses and the assessment of those issues so
5 that we can make a comprehensive recommendation to the
6 Commission on those issues.

7 We're hoping to complete that in a
8 sufficient, timely manner so that the industry can
9 factor that into the design of the vents that they're
10 putting in. If they're making upgrades and
11 enhancements to those capabilities, they could include
12 what needs to be done, relative to that, to minimize
13 the work.

14 MEMBER SIEBER: Yes, that will be a
15 challenge because you're changing the regulatory space
16 in which the design must fit. I would hope that it
17 would work out that we could avoid rework and really
18 cover some aspects, some of the more probabilistic
19 aspects of severe accidents. But it's not clear to me
20 that we can do that under the current framework.

21 MR. TAYLOR: We share your concern. We
22 share your interest in that.

23 MEMBER SIEBER: Great.

24 MR. TAYLOR: Absolutely.

25 MEMBER SIEBER: I figured you would. But

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1 I thought I would put it out on the table anyway.

2 MR. TAYLOR: We appreciate it. We do, we
3 appreciate that.

4 MEMBER SKILLMAN: I'd like to go back to
5 Dr. Armijo's comment on seismically rugged. I'm
6 reminded of 30 and 40 years ago when we battled our
7 way through seismic design before we had the
8 regulatory guides that provided guidance, Reg Guides
9 1.26, 1.29, 1.48, 1.51.

10 Words matter and seismically rugged will
11 probably be interpreted by many different people, many
12 different ways. It would seem that it might be
13 helpful for the staff to simply say, design-basis
14 earthquake commercial quality. The industry
15 understands that.

16 MR. TAYLOR: Okay.

17 MEMBER SKILLMAN: And the industry knows
18 how to build strong robust systems independent from
19 Appendix B to 10 CFR 50. They know how to do it.
20 Most of the fire systems are like that.

21 MR. TAYLOR: Okay.

22 MEMBER SKILLMAN: So it might be
23 advantageous to consider what you mean in terms of
24 seismically rugged. And there are probably some words
25 that the bulk of the design engineering teams at the

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1 sites could say, we know how to do that.

2 And we can make it at least as good, or
3 even maybe better, than what would've come with an
4 Appendix B seismic one system using commercial
5 quality.

6 MR. FRETZ: Right.

7 MEMBER SKILLMAN: That might save a whole
8 lot of time and a lot of words.

9 MR. FRETZ: Thank you, okay. And I
10 appreciate that. That was essentially the staff's
11 intent. Sam, is that -

12 CHAIR ARMIJO: Yes, that's really helps.

13 MR. FRETZ: Thank you.

14 MR. TAYLOR: Thank you.

15 MR. FRETZ: Yes, I appreciate that. Okay,
16 just turning to the next slide, I guess on Slide 12 is
17 a listing of some of the other major features of the
18 reliable hardened vent.

19 Again, the order allows remote or manual
20 operation. It does not preclude either. Also,
21 because no core damage is assumed, the order also
22 allows venting from either the drywell or the wetwell
23 currently, as written.

24 So the system must also include design
25 features to prevent the loss of containment integrity

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1 as a result of inadvertent operator action.

2 The system must be designed to minimize
3 cross flow. That's even cross flow between units, as
4 well as amongst themselves, such as a standby gas
5 treatment system.

6 The system must be designed to discharge
7 the effluent at a point above adjacent plant
8 structures. Licensees must be able to monitor that
9 effluent, at least the overall radioactivity of that
10 effluent, that could be released.

11 And again, like we talked about earlier,
12 the system must be capable of functioning following a
13 seismic event. However, it's not safety-related but
14 again, we could clarify that a little bit better and
15 maybe look at the term used.

16 MEMBER SHACK: Yes, I guess -- I'm sorry
17 -- like I said, the last time you looked at this with
18 GL-89-16, and the BWR Containment Performance Program,
19 a drywell event was not one of the suggestions.

20 CHAIR ARMIJO: Yes.

21 MEMBER SHACK: And what did we learn since
22 then that says a drywell vent is a good idea. I know
23 you've now got this strict separation between
24 prevention and mitigation. But what is the real
25 purpose of, as I say, once you start to think about

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1 severe accidents --

2 CHAIR ARMIJO: You don't want it.

3 MEMBER SHACK: Just even if it's in the
4 back of your mind, why not stick with 89-16?

5 MR. FRETZ: Well, the order itself is
6 nonspecific. It does not say either drywell or
7 wetwell. But it does not preclude the use of either
8 the drywell. That said --

9 MEMBER SHACK: The Guidance seems to. I
10 mean it permits both. It certainly doesn't --

11 MR. FRETZ: Right. Like I was saying,
12 we're stating in the negative that the order is
13 essentially is silent on whether or not a drywell or
14 wetwell vent is used.

15 Because we understand that some plants do
16 have, in their existing systems, drywell venting as
17 well as wetwell venting. Usually many of them have
18 both locations. Some have only the wetwell venting.

19 CHAIR ARMIJO: The question is, is that
20 still a good idea to have both? Have we really looked
21 at that whole idea of venting, now that we're thinking
22 in terms of mitigation as well as prevention?

23 MR. FRETZ: Well, under the current
24 framework of the order, the order assumes that no core
25 damage is present. So therefore, there is no, I guess

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1 essential harsh, radiological consequences associated
2 with that. So as of right now, without any kind of
3 severe accident service required under this order, the
4 drywell is satisfactory.

5 MEMBER CORRADINI: But -- Bill was going
6 to ask the same question. Just from an analysis step,
7 can you give me an example where you'd prefer to do it
8 through the drywell? I might be missing something.
9 So can you give me an example? I understand you want
10 to provide flexibility but I'm looking for an example.

11 MALE PARTICIPANT: I'm sure Mr. Stetgar
12 would give you an example.

13 MEMBER STETKAR: No, I don't have an
14 example. But my concern would be the pragmatism of
15 somebody saying well, it's easier for me to meet the
16 requirements for my drywell vent, so this is now my
17 hardened vent to meet these requirements. Because
18 it's easier for me to declare that to be the case.
19 And therefore --

20 MR. FRETZ: You're right.

21 MEMBER STETKAR: -- that is what I'm
22 taking credit for.

23 MR. TAYLOR: And they would meet the
24 requirements of the order. Our order is performance-
25 based in that respect because it's about containment

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1 pressure.

2 CHAIR ARMIJO: But that would put them on
3 the path to put in the filter.

4 MR. TAYLOR: Well, if we go there. If the
5 Commission decides that that's the appropriate thing.
6 So a licensee who takes that risk and goes with a
7 drywell vent and makes it meet the requirements of the
8 order.

9 If we ultimately decide later, that when
10 you conclude the mitigation, it requires you to go to
11 a wetwell vent to meet the requirements of that, then
12 they run a risk. So the licensees have a
13 responsibility to think ahead and plan as well as we
14 move forward with this.

15 MEMBER CORRADINI: Well, I guess I'm
16 asking, maybe I'm just too naive about this.
17 Technically, why would I do a drywell vent when I have
18 a suppression pool sitting there with the ability to
19 condense, remove --

20 CHAIR ARMIJO: Scrub.

21 MEMBER CORRADINI: -- scrub, you pick the
22 verb, I'm just struggling.

23 MR. TAYLOR: Okay. Bob, go ahead.

24 MR. DENNIG: This is Bob Dennig. The
25 staff certainly doesn't prefer it. It's just not

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1 concluded by the requirements. And we can't write
2 something in the guidance --

3 MEMBER SHACK: But you guys set the
4 requirements.

5 MEMBER BROWN: You set the requirements.

6 CHAIR ARMIJO: I suspect.

7 MR. DENNIG: We can't write something into
8 the guidance that's not based on the requirements. As
9 far as the engineering concern, that the drywell vent
10 is a better location for heat removal purposes.

11 MEMBER POWERS: I suspect that as we sort
12 out Fukushima, in severe accident space, and we look
13 at what's going on up at the drywell head, and the
14 thermal and radiological insult that an even sealing
15 material faces up there, there may evolve some
16 interest in drywell venting.

17 CHAIR ARMIJO: Some advantage there?

18 MEMBER POWERS: Well, some interest. I
19 persist in believing it to be misguided but I --

20 MEMBER CORRADINI: I guess I'm with your
21 judgment, that it is misguided. So I guess I want to
22 get back to -- I didn't mean to interrupt you, Dana --
23 but I think you're right, it is misguided. So I
24 wouldn't want to encourage them to think in a
25 misguided fashion.

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1 CHAIR ARMIJO: Well, I think you get the
2 sense of concern from --

3 MEMBER CORRADINI: But I guess I don't
4 understand -- the gentleman that was standing up there
5 disappeared on. The order says, thou shalt go do a
6 hardened vent. So that's the order. It's up to the
7 staff to technically decide what makes sense. And I'm
8 trying to understand, technically, why does a drywell
9 vent makes sense.

10 MR. DENNIG: The original draft of the
11 order contained a wetwell language and that was
12 struck. And we were told to be non-specific about the
13 location of the vent.

14 MEMBER CORRADINI: Told by private
15 guidance from commissions?

16 MR. DENNIG: No.

17 MEMBER BROWN: By whom?

18 MEMBER CORRADINI: By whom?

19 MR. TAYLOR: It was discussed extensively
20 by the Steering Committee, as to whether to be
21 prescriptive in picking the location of the vent and
22 there wasn't a clear basis to prescribe a particular
23 vent location, one over the other. It was to let the
24 licensees make a argument for where they wanted to put
25 the vent for their particular design.

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1 MEMBER CORRADINI: Would the staff welcome
2 some suggestions as to where to put the vent from
3 others?

4 MR. TAYLOR: We would, of course, welcome
5 --

6 MEMBER CORRADINI: I'll stop.

7 CHAIR ARMIJO: Okay. I just had a comment
8 on your chart there about minimizing cross flow
9 between units. Why don't we just say prevent instead
10 of minimize?

11 MR. TAYLOR: Prevent is a hard thing to
12 prove.

13 CHAIR ARMIJO: What?

14 MR. TAYLOR: Prevent is a hard thing to
15 prove.

16 CHAIR ARMIJO: Well, and what, no
17 connection. I'm reminded of Unit 3 and 4 at
18 Fukushima, a common stack. And that's what destroyed
19 Unit 4. And why can't we be more --

20 MEMBER POWERS: And the trouble is you run
21 into the same problem with minimize, minimize with the
22 respect to what. The only minimum that you have
23 specified there is zero.

24 CHAIR ARMIJO: Yes.

25 MR. FRETZ: That's the language of the

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1 order so that's where we -

2 MEMBER CORRADINI: I have a question about
3 your seventh bullet when we're done with your third
4 bullet. I didn't appreciate where that, not required
5 to be safely beyond second isolation valve means.
6 Does that mean inside the reactor building or outside
7 the reactor building?

8 MR. FRETZ: Okay. Essentially, that was
9 my shorthand essentially summarizing the quality
10 requirements. Whereas, the quality requirements, you
11 essentially have to adopt the current design-basis of
12 the plant for, up to, and including the second
13 containment isolation barrier.

14 Then downstream of the second containment
15 isolation barrier, it's not necessarily have to be
16 Category 1 seismic, or the current design-basis.

17 MEMBER CORRADINI: But where does that
18 reside, geometrically? Where would it reside
19 geometrically? Or is that up to the licensee again?

20 I mean, so here's what's going through my
21 mind. I guess I'm thinking outside of the realm of
22 said design-basis. But if I have some sort of event
23 that chops off everything above the second isolation
24 valve, and it's inside the reactor building, that
25 would give me pause.

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1 MEMBER SKILLMAN: Well, this is General
2 Design Criteria at 57. This is why the wording is as
3 it is -

4 MEMBER CORRADINI: Okay.

5 MEMBER SKILLMAN: -- causes the way the
6 Appendix A to 10 CFR 50 -

7 MEMBER CORRADINI: Oh, okay.

8 MEMBER SKILLMAN: The General Design
9 requirements are written. And this is General Design
10 Criteria.

11 MEMBER CORRADINI: Right.

12 MEMBER SKILLMAN: So what it says is,
13 including the second isolation valve is ASME 3103,
14 it's seismic one and all QA and after that second
15 valve it can be something different.

16 MEMBER CORRADINI: Okay.

17 MEMBER SKILLMAN: And that's what their
18 telling us.

19 MEMBER CORRADINI: Okay.

20 MR. FRETZ: Yes, that's what we're trying
21 to communicate there. Any other questions? Thank
22 you. I guess, Lisa, we'll go to the last slide.

23 With respect to the draft Interim Staff
24 Guidance, I guess the order for reliable hardened
25 vents, this Interim Staff Guidance differs from the

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1 other two orders that you'll hear this morning, in
2 that we are not endorsing any industry guidance. The
3 staff, and essentially the draft ISG was prepared by
4 the staff with that in mind.

5 So we've had three public meetings with
6 industry and public stakeholders regarding the draft
7 ISG. And the interaction has been quite helpful. The
8 number of insights we've gained, not only from the
9 industry but as well as public interest groups, has
10 been helpful.

11 We've just received about five comments
12 from members of the public during our public comment
13 period. And a number of them did ask that the
14 suggested language changes to some of the various
15 elements of the ISG.

16 Such as, for example, some wanted us to
17 help clarify what instrumentation was required for
18 monitoring the system status. And so we're going to
19 take a look at that.

20 But again, we feel that the interaction
21 with the stakeholders has been very key in the
22 development of this ISG. And it has been a very
23 helpful process along with it.

24 Now again, although, the order for the
25 mitigating strategies order that we heard earlier,

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1 provides move performance-based approach. The staff
2 believes that there is general idea among the ISGs
3 with respect to the orders.

4 The NEI 12-06 dose of .2, this order in
5 its document, as far as requiring the licensees meet
6 the requirements of this order. The ISG does state
7 though, that the reliable hardened vent should be able
8 to function with permanently installed equipment for
9 the first 24 hours of the event.

10 The staff reasoning is that during the
11 first 24 hours plant operators will be focused on
12 restoring cooling to the reactor core. And the
13 possibility of even installing what many are calling
14 the FLEX equipment at that time, in order to attempt
15 to restore cooling to the core.

16 Therefore, consistent with the order's
17 requirements, to design a reliable hardened venting
18 system that minimized the reliance on operator
19 actions, the staff believes that plant personnel
20 should not have to focus on restoring the containment
21 system during this time.

22 But that their efforts be more aligned
23 with and focused on restoring cooling to the core.
24 That's obviously the most important thing that they
25 have to focus on.

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1 So again, the staff's intent on having the
2 system being able to operate during the first 24
3 hours, relatively free of installing, let's say
4 additional equipment to help it work, was that it
5 would allow plant operators the ability to focus on
6 restoring core cooling, which is really the most
7 important thing that they have to worry about.

8 And then they would not have to worry
9 about the containment venting system having to work
10 during this time while their focus was on these
11 efforts. So again, that was the staff's intent in
12 putting this 24-hour requirement.

13 Again, that said, the ISG does not
14 preclude times less than 24 hours if justified by
15 licensee's analysis. So we do recognize that the FLEX
16 program and the guidance, and so we just want to make
17 sure that licensees, their strategies remain focused
18 on restoring the core cooling.

19 And that they be able to, at least,
20 demonstrate that at any times less than 24 hours, that
21 they would be able to handle both at once. So again,
22 that was the staff's intent.

23 MEMBER SKILLMAN: Let me ask this, please?

24 MR. FRETZ: Sure.

25 MEMBER SKILLMAN: Permanently installed

1 equipment, does that mean station batteries? Or could
2 that mean permanently installed, another set of
3 batteries dedicated to this purpose?

4 What I'm really asking about is the
5 philosophy of your use of those words. Were you
6 really thinking about 125-volt DC safety grade? Or
7 were you thinking, if they permanently installed a
8 dedicated set of batteries for this, that would also
9 be okay?

10 MR. FRETZ: I think if the licensee
11 responded with either one of those, that would satisfy
12 the staff's intent.

13 MEMBER SKILLMAN: So it was not
14 necessarily pointing towards the originally installed
15 equipment -

16 MR. FRETZ: No.

17 MEMBER SKILLMAN: -- or presently -

18 MR. FRETZ: No.

19 MEMBER SKILLMAN: -- installed equipment.

20 MR. FRETZ: Again, much of the thought was
21 essentially dedicated batteries -

22 MEMBER SKILLMAN: Okay, thank you.

23 MR. FRETZ: -- for that, as well as even
24 installed nitrogen bottles at strategic locations to
25 provide the mode of force for, well, most of the time

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1 they use air operated valves in many of these systems.
2 And so that will at least provide the mode of force
3 for that, to operate those valves. So that was the
4 staff's intent.

5 MEMBER SKILLMAN: Thank you.

6 MEMBER STETKAR: Bob? Something that, and
7 I'm trying to skim through, quickly, the ISG here to
8 see and maybe you can help me. And I didn't think
9 about this in the subcommittee meeting.

10 The term manual operation is used an awful
11 lot. And does the guidance indicate that the valves
12 need to have capability for low cold, and I'll call it
13 mechanical operation to avoid this term manually?

14 You talk an awful lot about alternate
15 power supplies, alternate pneumatic supplies,
16 alternate means of moving the thing that is other than
17 a mechanical crank, let me use that term.

18 And if the valves are motor-operated
19 valves, okay, they typically will have some sort of
20 mechanical device to operate the valve. Whether or
21 not you can physically touch the device, given the
22 location of the valve, is a different issue.

23 And often time air-operated valves don't
24 have those devices. So is the intent to also, have
25 local mechanic capability to operate these valves?

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1 MR. FRETZ: Essentially, we would allow
2 local manual operation of valves and maybe --

3 MEMBER STETKAR: That's not what I'm
4 asking. Certainly you would allow it. The question
5 is, do you require it? So for example, I can't hook
6 up the nitrogen bottle to it.

7 MR. FRETZ: Bob, do you want to talk about

8 -

9 MR. DENNIG: Yes. I believe and I don't
10 think we raised during the subcommittee simply because
11 I believe the answer is no, we're not requiring that
12 they have, in addition to some way of operating it
13 standoff to have a manual wheel.

14 MEMBER STETKAR: Okay.

15 MR. TAYLOR: We'll take it back for
16 consideration. Thank you. Any other questions?

17 MS. REGNER: The last Interim Staff
18 Guidance we'll discuss is associated with the spent
19 fuel pool instrumentation order. My name is Lisa
20 Regner. I'm the project manager for this order.

21 I'm going to provide a short overview of
22 the standards required by the order. I'll talk about
23 the key features of the proposed guidance document
24 submitted by the Nuclear Energy Institute.

25 And I'll also cover the exceptions to the

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1 NEI document. And I do want to specify that's
2 Revision B. We have recently received a new revision
3 from NEI submitted as a comment. The staff is still
4 reviewing that revision.

5 But the purpose, as Eric said, is to try
6 to align what the staff wants and NEI guidance as
7 closely as possible. So this Revision 0 was submitted
8 to incorporate the staff's exceptions. But what I
9 will talk about here is Revision B exceptions.

10 So this is a summary of the key
11 performance criteria from the order. The purpose of
12 the order is to require reliable instruments to
13 monitor the level of the spent fuel pool to enable
14 emergency responders to make appropriate event
15 response decisions.

16 Specifically, the order requires one
17 permanent primary level instrument and one backup
18 instrument, that may be permanent, portable, or a
19 combination of permanent and portable.

20 The display may be located in the control
21 room or at another easily accessible and protected
22 location. Indication is to be continuously available
23 but may provide on-demand monitoring.

24 MEMBER BROWN: What does that mean again?

25 MS. REGNER: Basically, it means they can

1 take, for instance, they can take a battery-powered
2 monitoring device, an operator can go locally to a
3 hookup. Hook up the battery power and get a reading,
4 get an instantaneous reading.

5 MEMBER BROWN: Is that as an alternative
6 to a continuous?

7 MS. REGNER: Yes.

8 MEMBER BROWN: Then how come you have the
9 words, "continuously available," but then you can do
10 it noncontinuously?

11 MS. REGNER: It's continuously available
12 in that they can get a reading at any time. They
13 don't have to install the entire instrument but they
14 may have to send, we do allow them to send an operator
15 to obtain a reading.

16 And the whole purpose of that is so that
17 they're not draining a battery. It will allow a
18 battery to last much longer so that they can obtain
19 that. They can monitor for a longer period of time.

20 MEMBER BROWN: If the system is simple
21 enough, and I've already looked at, still retained the
22 second slides, that we had a late discussion on in the
23 subcommittee meeting. And in simple systems, you can
24 have a battery-operated, it will last for months.

25 CHAIR ARMIJO: Yes.

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1 MEMBER BROWN: Okay, as opposed, so you
2 don't have to worry about draining the battery if it's
3 an independent set up to do that.

4 MS. REGNER: Yes.

5 MEMBER BROWN: So go ahead. I'm just
6 trying to make the point that it seems like nothing
7 changed subsequent to the subcommittee meeting.

8 MS. REGNER: Right.

9 MEMBER BROWN: And the continuously
10 available is kind of mushy. If it's continuously
11 available to me, it says I can read it all the time.

12 CHAIR ARMIJO: Right.

13 MEMBER BROWN: And it could be normally
14 powered from your normal sources. And then if you
15 lose those sources, you've lost all power, whatever it
16 is. The battery takes over.

17 And if you don't have a complicated,
18 microwave, x-ray, radio controlled, wireless thing
19 that consumes five million megawatts just to get a
20 little signal out of the spent fuel pool, it'll last
21 for months.

22 MS. REGNER: Yes.

23 CHAIR ARMIJO: If it's simple.

24 MEMBER BROWN: And yet we just allow
25 anything to come in, as opposed to forcing it in the

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1 direction where it is number one, simple and reliable.

2 MS. REGNER: Right.

3 MEMBER BROWN: And continuously
4 monitorable.

5 MEMBER CORRADINI: So you want to help
6 them.

7 MEMBER BROWN: I'm trying to help them.
8 But we tried to help them in the subcommittee --

9 MR. TAYLOR: And we understand. We heard
10 all the comments in the subcommittee. We haven't
11 changed anything yet.

12 MEMBER BROWN: I noticed that.

13 MR. TAYLOR: And that's on purpose.

14 Because the comment period was progressing. We didn't
15 want to come in here with a bunch of changes as we get
16 comments from all the stakeholders who are giving us
17 comments. We'll take all of the comments we get and
18 look at what changes should be made to the ISGs
19 collectively.

20 So you're absolutely correct, we haven't
21 changed anything since the subcommittee meeting. But
22 that was on purpose so we could collect all the
23 comments. Because we might get a comment quite to the
24 contrary and we want to be able to make sure we hear
25 what is --

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1 MEMBER BROWN: These are contrary to what
2 we suggested.

3 MR. TAYLOR: Somebody might say this is a
4 perfectly good answer, who heard the subcommittee, and
5 might have provided a comment that said, we disagree
6 with the ACRS on that. But that's a hypothetical. So
7 your point is very valid, very important. And we'll
8 take it back and we'll take a look at it.

9 CHAIR ARMIJO: In this permanent backup
10 instrumentation, is there any kind of requirement or
11 expectation that they're diverse? Or assuming you had
12 an installed instrument, would it be okay to come in
13 with a backup instrument that's exactly the same
14 instrument?

15 MS. REGNER: There's no requirement.

16 CHAIR ARMIJO: Okay, there's no
17 requirement --

18 MS. REGNER: They can have the same exact
19 instrument.

20 CHAIR ARMIJO: It can be the same or they
21 can be different?

22 MS. REGNER: Yes, sir.

23 CHAIR ARMIJO: Okay.

24 MEMBER REMPE: I missed the subcommittee
25 meeting. But during the events at Fukushima, they

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1 relied on an indirect water level indicator. But they
2 also relied on the thermocouples in the cool cleanup
3 system as a method for when you have a bunch of junk
4 in your pool, to understand what's going on, where a
5 water level indicator might not help.

6 If all of the U.S. plants have such
7 thermocouples in their cool cleanup systems, then
8 maybe this isn't an issue. But it was sure nice, the
9 thermal imaging didn't help a whole lot. And so those
10 thermocouples were useful.

11 Other countries are saying let's put a
12 temperature indicator in. And I believe, when it was
13 discussed originally in the Near-Term Task Force, that
14 was going to be included along with the water level
15 indicator. And I just am wondering what the logic was
16 for taking it out.

17 MS. REGNER: The staff did discuss, at
18 length, the recommendation, the three recommendations.
19 For example, the parameters were temperature,
20 radiation, and level.

21 The staff did conclude that level would
22 be, again, we're talking extreme events, low
23 probability events, the staff felt that in keeping
24 with a simple instrumentation, again, performance-
25 based criteria for this order, the staff determined

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1 that level would, in fact, provide the most vital
2 information on condition of the pool.

3 MEMBER REMPE: Did the staff go through
4 and verify that all the U.S. plants have thermocouples
5 in their pool cleanup system as part of that decision
6 process?

7 MS. REGNER: Go ahead, Steve.

8 MR. JONES: This is Steve Jones in the
9 Balance of Plant Branch in NRR. We considered what
10 would be available to operators under beyond-design-
11 basis conditions.

12 For most of the plants the cleanup system
13 requires operation of the cooling system and power
14 that may or may not be from a safety-related source in
15 order to provide that as a valid indication of what's
16 going on in the pool.

17 We also considered that the conditions in
18 the pool, temperature wise, we were only talking of a
19 60 degree or so variation between normal operating
20 temperature and boiling.

21 And it really doesn't, under the high-heat
22 load conditions we're most concerned with, that
23 doesn't take a long time to transit through that.

24 MEMBER REMPE: And when you have a lot of
25 junk in your pool it's just nice having something else

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1 to think about, to give you an insight of what's going
2 on.

3 MEMBER BROWN: Wouldn't you like to know
4 it's boiling?

5 MEMBER REMPE: Or that it's heating up a
6 lot?

7 MEMBER BROWN: Here's another example.
8 Thermocouples, RTDs, whatever, you can sprinkle
9 temperature devices all over the place to a little
10 panel where you take the multi-meter, a 9-volt
11 battery, it will last for months, months.

12 And you can go monitor the temperatures
13 and see what ever they're doing. It's simple. It's
14 wires, blacksmith technology. And it's so easy it
15 just boggles my mind.

16 I'm sorry to be emphatic but that's just
17 part of my personality. It boggles my mind that
18 something can be so simple to do and yet we're making,
19 and allowing, the potential for extreme complexity or
20 rejecting certain things.

21 Well, gee there's only 60 degrees to
22 boiling. Well, I think I'd like to know if the spent
23 fuel pool is boiling. I think. I don't know. Is it
24 kind of important if you know it's boiling? You've
25 got all kinds of crap coming off of it.

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1 CHAIR ARMIJO: You have no cooling. The
2 pool isn't draining down. The level is fine, stays
3 fine, except it's going to boil off. Okay, so it
4 would be nice to know if it was a temperature we see
5 increasing in the pool.

6 MEMBER BROWN: Yes.

7 CHAIR ARMIJO: But again, it doesn't need
8 to be a Taj Mahal. It just has to be a simple
9 thermocouple. I'm surprised they don't exist right
10 now.

11 MR. JONES: Licensees would be free to go
12 ahead and install additional instrumentation. The
13 level provided the minimum set of data that we
14 considered important for the decision making we were
15 looking at in response to a beyond-design-basis
16 external event.

17 CHAIR ARMIJO: But, you know, it would
18 take a long time before you had a temperature
19 indication of a problem compared to a water level
20 indication of a problem. Those are big, deep pools.
21 It takes a long time to heat them.

22 MEMBER REMPE: But you've got junk in your
23 pool.

24 CHAIR ARMIJO: Haven't had a hydrogen
25 explosion yet in this scenario.

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1 MEMBER REMPE: It just would be nice to
2 know, do we have thermocouples in the cleanup system.

3 CHAIR ARMIJO: I think it would be nice to
4 do.

5 MEMBER BROWN: I don't think it's a matter
6 of being nice, is it? I think it's a matter of
7 considering what our lessons learned, our experience
8 to-date, in a fairly severe environment and the lack
9 of information, and the compromise of actions that
10 were taken by operators, or they didn't take, because
11 they didn't know what was going on.

12 MR. TAYLOR: We believe the level
13 indication will give them the information necessary to
14 make those decisions. The Steering Committee heavily
15 discussed this and focused on the level indication.

16 That you're absolutely correct, in an
17 event where loss of cooling of the pool occurs, the
18 pool will heat up and will eventually boil if cooling
19 is not restored.

20 And that will be indicated by a change in
21 the level of the pool. So we will get an indication.
22 And these are spent fuel pool events, like Fukushima
23 demonstrated, that it's a slow progressing event.

24 CHAIR ARMIJO: Sure.

25 MR. TAYLOR: We want to make sure that

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1 the operators have the information so they can
2 understand what's going on. But we don't want them
3 distracted and responding to a spent fuel pool
4 condition if they have an ongoing condition with the
5 reactor core.

6 I think it could be done. We decided it
7 was not necessary at this time to require enhanced
8 temperature indication, doesn't mean we can't require
9 it in the future if we determine it's necessary.

10 MEMBER STETKAR: The only thing I've run
11 into, and I've done some risk assessment work with
12 utilities, spent fuel pool things. Most people who
13 run power plants tell me they're not going to send
14 anybody into the fuel building if the pool is boiling,
15 in terms of dose.

16 So for example, once it starts to boil, if
17 it's a lost cooling event and then you start to lose
18 level. If some of your mitigation functions require
19 people to go take either local level indications in
20 the fuel building, or local makeup to the hoses or
21 something like that, there could be a substantial
22 reluctance to send people in there with the knowledge
23 that the pool as started to boil.

24 MR. JONES: That's something I've run into
25 just in terms of the reluctance of plant owners. They

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1 typically will look at conditions of boiling in terms
2 of guidance to send people to the pool edge, if you
3 will.

4 MR. BOWMAN: Understand the industry
5 guidance for the mitigating strategies orders includes
6 a specification of a permanently installed connection
7 to the spent fuel pool --

8 MEMBER STETKAR: Right.

9 MR. BOWMAN: -- makeup system that diverts
10 flow from the deck to be able -

11 MEMBER STETKAR: Yes, I'm aware of that.

12 MR. BOWMAN: -- to refuel the pool without
13 accessing the deck refill.

14 MEMBER STETKAR: Okay. Thank you.

15 MEMBER POWERS: In the aftermath of
16 Fukushima, there was quite a lot of discussion in the
17 Japanese popular press, not so much here in the United
18 States, about the level of whether the spent fuel pool
19 was, in fact, distorted, or shifted, or something like
20 that.

21 MS. REGNER: The sloshing you mean?

22 MEMBER POWERS: What.

23 MS. REGNER: The sloshing of the pool --

24 MR. TAYLOR: You're talking about the
25 actual building structure?

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1 MEMBER POWERS: Yes, the building
2 structure --

3 MS. REGNER: Oh, okay.

4 MEMBER POWERS: -- distorted away from.
5 Did that enter into your thinking on this
6 instrumentation business at all?

7 MS. REGNER: We did consider say
8 catastrophic failure of the structure --

9 MEMBER POWERS: That would be pretty
10 obvious.

11 MS. REGNER: Yes, right. And then that
12 was exactly, and since that didn't, in fact, that the
13 structure was sound at Fukushima, we decided not to
14 address --

15 MEMBER POWERS: Well, I think --

16 MS. REGNER: The answer is yes. We did
17 consider the structure soundness of the spent fuel
18 pool.

19 MEMBER POWERS: Well, I think what I'm
20 asking about, I think what was being discussed at the
21 time was much more modest than that, shifting and
22 whatnot. And I think people were interested in
23 whether racks has slid and moved against each other or
24 something had changed within the pool.

25 MS. REGNER: Yes.

1 MEMBER POWERS: So I'm just asking. Did
2 that kind of thing get discussed? And what was the
3 nature of that discussion?

4 MS. REGNER: We did not assume severe
5 structural damage such as that for this order.

6 MR. JONES: This is Steve Jones, Balance
7 of Plant Branch again. We're looking at this, I guess
8 in a margins perspective and anticipating that the
9 pool would have relatively large seismic margins often
10 to other components in the plant.

11 And from that regard, recognizing we can't
12 design for every eventuality, the level instrument
13 would provide the best and broadest indication what
14 was going on in the pool for an extended period of
15 time. That was really our decision.

16 MEMBER POWERS: Well, for some reason
17 people were concerned about that. And then maybe it's
18 not the huge margins that you might be willing to
19 exist.

20 What I'm coming from, in raising the
21 issue, is a fundamental lack of faith, that we can
22 anticipate with our instrumentation the questions that
23 will be asked at the next accident we have.

24 Since having gone through several of these
25 now, and everyone of them have been followed by, we

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1 need better instrumentation because the operators need
2 to know what's going on and they didn't have it here.

3 No matter what instrumentation you put in,
4 you're going to have other kinds of questions. And
5 that seems to be one of the questions that come up
6 somewhat periphery.

7 There was no problem at Fukushima. And
8 there probably is no problem at our plant. I just
9 wondered what kind of discussions you had on that.
10 Because presumably you're not designing against severe
11 accidents. But you are designing against design-basis
12 seismic events.

13 And seismic events change things away from
14 absolutely horizontal or vertical. And that may be
15 something that people want to know about in responding
16 to a design-basis accident. Though, quite frankly,
17 the easiest thing to do with a spent fuel pool is to
18 look at it.

19 CHAIR ARMIJO: I think we had one other
20 issue that we did talk about in the subcommittee, and
21 that was a resolution with kind of a strange set of
22 resolutions, one put at the top level --

23 MEMBER BROWN: I told you I'd already read
24 ahead.

25 CHAIR ARMIJO: Oh, you did?

1 MEMBER BROWN: And they didn't -- and then
2 he answered the question, they've done nothing to
3 anything.

4 CHAIR ARMIJO: And that hasn't changed so
5 --

6 MEMBER BROWN: Don't take my emphasis on
7 the nothing.

8 MR. TAYLOR: I understand.

9 MEMBER BROWN: I wasn't trying to --

10 CHAIR ARMIJO: We had a lot of discussion
11 on it.

12 MR. TAYLOR: We will take the comments
13 from the subcommittee meeting, as well as from this
14 meeting --

15 CHAIR ARMIJO: Yes.

16 MR. TAYLOR: -- and consider that.

17 CHAIR ARMIJO: You'll address that.

18 MR. TAYLOR: It's just we haven't made a
19 change yet. We haven't decided to make an explicit
20 change yet. If we do, we'll take it back to our
21 Steering Committee, discuss it with the Steering
22 Committee, make an informed decision.

23 If we need to take an exception to the
24 guidance document that the industry proposed and
25 refine what our expectations are, we will do so. But

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1 we just have not reached the conclusion that we need
2 to make the change yet. And it's not because we don't
3 agree with it. It's because we haven't fully vetted
4 and discussed it internally yet.

5 CHAIR ARMIJO: Okay. All right, please,
6 go on. We're running a little late and we do have
7 some comments from a member of the public that I'd
8 like to get in. So let's --

9 MR. TAYLOR: Okay.

10 CHAIR ARMIJO: -- try and wrap it up.

11 MS. REGNER: Okay. In developing the
12 guidance associated with the order, the staff
13 initially wrote its own guidance to assist and promote
14 discussions during stakeholder interactions. I think
15 this was key in a resulting NEI guidance, that was
16 very very aligned with the staff.

17 They did submit Revision B on May 11th, as
18 I stated earlier. They have since submitted Revision
19 0 on July 5th. And the staff is currently evaluating
20 that.

21 The comment period ended on Monday, this
22 past Monday. We have received six comments. Some of
23 those comments are in-scope, some are out-of-scope.
24 I can discuss those if you'd like. But if not, I'd
25 like to just go on and briefly talk about the

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1 exceptions, if you'd like to hear those in the ISG.

2 CHAIR ARMIJO: Sure.

3 MS. REGNER: They're basically the same as
4 discussed during the subcommittee. Primarily, the
5 staff and these are the staff's disagreements with
6 the, not disagreements but clarifications that the
7 staff would like in the final NEI guidance.

8 MEMBER BROWN: These are things you want
9 put in. In other words, in the present one, just to
10 calibrate me, specify that instruments must be able to
11 resist beyond-design-basis external events. Right now
12 it doesn't say that and you want that thought process
13 in the document?

14 MS. REGNER: Correct.

15 MEMBER BROWN: Okay, all right. I was
16 just trying to get what we mean by exceptions here.

17 MS. REGNER: Right, right.

18 MEMBER BROWN: Thank you.

19 MS. REGNER: And again, this Revision 0,
20 they did attempt to address every one of our
21 exceptions. Okay, the ISG describes acceptable
22 criteria for instrumentation readout indications.

23 The use of sets of instruments. In other
24 words, more than one instrument should read the full
25 range from normal to the top of the fuel racks. And

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1 acceptability of continuous or discreet instrument
2 indications to meet the minimum criteria for
3 resolution and accuracy.

4 The ISG clarifies the personnel-based dose
5 criteria for Level 2, and that the readings are to be
6 available to appropriate plant staff and decision
7 makers promptly when required.

8 The staff also provided a detailed
9 integrated plan template so that licensees will
10 understand the level of detail required by the staff,
11 so that they can write a safety evaluation. Any
12 questions?

13 CHAIR ARMIJO: Okay. Just very quickly
14 comments, questions from the staff. We do have
15 comments submitted by Mr. Mark Leyse and I think I'd
16 like to open it up and have his comments heard.

17 He's on the bridge line and he also
18 submitted some documents which we've distributed. And
19 he asked us to project a couple of slides from his
20 documents, which we're going to do shortly.

21 MR. LEYSE: Yes, this is Mark Leyse, can
22 you hear me?

23 CHAIR ARMIJO: Yes we can, please, go
24 ahead.

25 MR. LEYSE: Oh, okay, great. Yes, my name

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1 is Mark Leyse. I want to thank the ACRS for giving me
2 the opportunity to speak today. I am speaking about
3 a short paper I wrote for NRDC, post-Fukushima
4 hardened vents with high capacity filters for BWR Mark
5 Is and Mark IIs.

6 But I want to clarify that I'm speaking on
7 my own behalf and not for NRDC. May I have the first
8 slide projected, please?

9 CHAIR ARMIJO: It's on the screen. I
10 believe it's a text on total quantity of hydrogen that
11 could be produced in a severe accident.

12 MR. LEYSE: Yes, thank you so much. On
13 this slide is, as you just said, information about the
14 total quantity of hydrogen that could be produced in
15 a severe accident.

16 And it is generally estimated that a total
17 of 500 kilograms of hydrogen was produced in the
18 Three-Mile Island accident. Yet, in a BWR severe
19 accident a total of over 3,000 kilograms of hydrogen
20 could be produced from the oxidation of the zirconium.

21 What we see is a quote from a 1988 Oak
22 Ridge National Laboratory report, that spells that
23 out, that the entire zircaloy inventory of the reactor
24 would eventually oxidize, if there were a complete
25 meltdown.

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1 And then there's another quote from an
2 IAEA paper, which spells out the difference in the
3 quantity that could be produced from a PWR core and
4 also, from a BWR core. And we see that it's
5 significantly greater for a BWR core.

6 In fact, if we factor in the steel and
7 also boron carbide, up to perhaps 4,000 kilograms of
8 hydrogen could be produced in a BWR complete meltdown.

9 Also, in a severe accident if there were
10 a re-flooding of an overheated core, over 300
11 kilograms of hydrogen could be produced in one minute.

12 The NRC's Near-Term Task Force reports on
13 the Fukushima accident does not mention anything about
14 the total quantity of hydrogen that could be produced
15 in a BWR severe accident.

16 Nor does it discuss hydrogen production
17 rates. I think those are two of the key issues if you
18 want to address the hydrogen that is produced in a BWR
19 severe accident and attempt to mitigate it. May I
20 please have the second slide projected?

21 CHAIR ARMIJO: Okay, it's up.

22 MR. LEYSE: Thank you. On this slide is
23 a quote that says, "Filtered venting is less feasible
24 for those sequences resulting in early over-
25 temperature or over-pressure condition. This is

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1 because the relatively early, rapid increase in
2 containment pressure requires large containment
3 penetrations for successful venting."

4 So I hope you keep that in mind because
5 there could be scenarios in which there was re-
6 flooding of an overheated core, which would rapidly
7 produce hydrogen and cause a rapid containment
8 pressure increase.

9 Also, on this slide as Sal Levy stated in
10 a 2011 article, there could be scenarios in which
11 early venting would be necessary.

12 The NRC should also consider that not all
13 severe accidents would be like the Fukushima accident,
14 slow moving, if you will, accidents, station blackout,
15 accident caused by natural disasters.

16 Fast moving accidents could also occur.
17 For example, a large-break loss of coolant accident
18 could rapidly transition into a severe accident. A
19 meltdown could commence within ten minutes after an
20 accident initiated.

21 Early venting might be necessary in a fast
22 moving accident scenario. A high-capacity filter
23 would help protect the surrounding population, who
24 would not have time to evacuate, and prevent becoming
25 exposed to radioactive releases.

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1 This is discussed in more detail in the
2 paper I wrote, along with other safety issues. In the
3 paper I conclude by recommending that a hardened vent
4 be designed so it would perform well in scenarios in
5 which there were rapid containment pressure increases.

6 I state that if such a vent can not be
7 developed, the NRC should perhaps consider, either
8 shutting down or not relicensing BWR Mark Is and Mark
9 IIs. And I also recommend that the NRC require that
10 high capacity filters be installed in addition to
11 hardened vents. Thank you.

12 CHAIR ARMIJO: Okay, thank you, Mr. Leyse.
13 Now I'd like to just quickly ask for comments from the
14 Committee. And if there are none, I'd like to thank
15 the staff for the presentation.

16 I covered a lot of material and we're just
17 a few minutes behind schedule. So I'd like to
18 reconvene, take a break and reconvene at 10:20.

19 (Whereupon, the meeting in the above-
20 entitled matter went off the record at 10:02 a.m. and
21 went back on the record at 10:21 a.m.)

22 CHAIR ARMIJO: Okay, we're back in
23 session. And John Stetkar will lead us through this
24 briefing. We have a quorum.

25 MEMBER STETKAR: Thank you, Mr. Chairman.

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1 We're going to hear this morning from the staff and
2 EPRI on NUREG-1934/EPRI 1023259, about fire models.
3 We had a subcommittee meeting on this topic on March
4 21st.

5 There are, and Mark I'm sure will give us
6 some background on this. But part of the background
7 on this particular new reg is it's developed primarily
8 to provide some practical guidance to fire modeling to
9 people doing fire analysis.

10 And how to use the available modeling
11 capabilities, things to be aware of, kind of good
12 things bad things about particular types of fire
13 models.

14 It was also developed in part in response
15 to a letter that the ACRS wrote back in, I think it
16 was 2008 or 2009, regarding the treatment of
17 uncertainties when people use these fire models, both
18 in terms of addressing modeling uncertainty and
19 uncertainties in the parameters.

20 So this new reg also, in addition to being
21 practical guidance about the use of the fire models
22 themselves, also addresses that issue. And with that
23 I will turn the discussion over to Rick Correia.

24 MR. CORREIA: Thank you. Good morning.
25 Just briefly, we feel we're ready to publish NUREG

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1 1934. We've been through two rounds of public
2 comments and stakeholder interactions.

3 We piloted it during our advance fire
4 modeling training course. We had reviewed a comment
5 by the PRA subcommittee, pretty much in sequence after
6 their review of two major fire reports, the fire HRA
7 and modeling efforts too. So we appreciate that very
8 much. We believe our customers and NRR are satisfied
9 with the project and the NUREG. And we look forward
10 to a letter from the committee. Thank you.

11 MR. SALLEY: I'm Mark Salley from
12 Research. The branch chief of the Fire Research
13 branch. And Rick Wachowiak is here from EPRI. Again,
14 we've worked together on this as a partnership.
15 Slides here.

16 For anybody that's listening on the phone,
17 and I got an ML number. Let me just get that out of
18 the way if they want to download the slides so they
19 can look at it. It's ML12192A143. Again, that's ML
20 12192A143. And those slides are probably available.

21 Again, the purpose of the meeting, and why
22 we've come here today, is we've completed the project.
23 We feel this project is done, it's ready for prime
24 time. We're ready to move on to some other projects.

25 As John said, on the 21st of March we had

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1 an excellent meeting with the PRA subcommittee. And
2 I'd just like to take a second now to the side and re-
3 emphasize what Rick said.

4 We had two major reports that we hit them
5 with, both five year projects. And the one was a Fire
6 HRA project. And the second one was this Fire
7 Modeling. And I think we really, we threw some big
8 projects at the subcommittee.

9 And I just am amazed at the detail and the
10 quality of comments and the discussions, if you go
11 back and look at the transcripts and the exchange. So
12 I really want to thank you, John, and the
13 subcommittee, because it was, I mean, they caught
14 things we missed.

15 And we'd been working on it a while. And
16 it was just an excellent exchange. So thank you for
17 that. Today we're going to have our technical leads
18 give you a quick overview of the project and how it
19 came together.

20 And again, where we're heading in the
21 future with fire modeling. We're not done. This just
22 puts another cornerstone in for us. And we'd like to
23 get a letter from the ACRS endorsing this document.

24 Again continuing on with the purpose of
25 this report. EPRI had a report in 2001 that was

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1 beginning to get a little dated. But it was a fire
2 model users guide. It goes back actually to the FIVE
3 method, if you remember, the IPEEE and Generic Letter
4 88.20 supplement 4.

5 That's kind of the origin of that and
6 where the fire modeling started to pick up. So it
7 clearly needed updated. We saw this as a good
8 opportunity to team up and work under the memorandum
9 of understanding, because both of us could use the
10 document.

11 Also, we had other documents come into
12 play since that original 2001 EPRI report. A big one
13 was the V&V, where we did 1824, and we had a solid
14 V&V, and how does that incorporate in.

15 Another area that we've been looking for
16 is, there's a lot of textbooks on fire dynamics and
17 fire modeling, but none for the nuclear industry. So
18 we wanted something for our people, for our
19 inspectors, and for our licensees that dealt with the
20 unique situations and the unique construction of a
21 nuclear power plant.

22 So we wanted to have a text for them that
23 we've included as our fifth module now in our fire PRA
24 training, which by the way is next week. If anybody's
25 interested, it'll be the first thing. I could throw

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1 a commercial in there, huh?

2 CHAIR ARMIJO: Yes.

3 MR. SALLEY: Commercial spot. And so we
4 wanted to get that textbook. And it serves that
5 purpose. And again it also, as we get more into fire
6 modeling for the reviewers, we wanted a consistent way
7 of doing it.

8 So we hope to present a model consistent
9 way of doing fire modeling type calculations. So that
10 was the purpose of why we did what we did. That
11 probably drove how we assembled the team.

12 MR. WACHOWIAK: Okay. As Mark said, I'm
13 Rick Wachowiak from EPRI. We worked on this project
14 jointly with NRC research. We have a, what we call
15 the memorandum of understanding that allows us to work
16 together on these research projects, share data, share
17 research, and come up with the, essentially the best
18 available information concerning various topics.

19 And on this one we put the team together
20 to address a standard or solid way of addressing use
21 of fire models that are out there, and how to address
22 things like the V&V information that's out there. And
23 also to address uncertainties.

24 So we worked on this as a joint
25 publication. We put a team together that consisted of

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1 NRC experts, industry experts. We drew from the
2 vendors and from the consultants that are doing fire
3 PRAs, and NFPA 805 transitions in using non PRA
4 methods.

5 These teams together -- We got the
6 National Institute of Standards and Technology
7 together, NIST, to work on this with us. And also
8 had, made use of various universities to either help
9 us develop the report, or to do the review.

10 So our review came from places like
11 University of Edinburgh and Cal Poly. Also we used
12 people from University of Maryland to help develop the
13 examples that are listed in the report. So this is
14 the team that we used.

15 And we think that after this collaborative
16 effort we've come up with a substantive document that
17 is very useful to the readers and to the users. Go
18 ahead, Mark.

19 MR. SALLEY: Next slide is just a little
20 time line. I won't get into detail here. This is
21 something you can look at later. But it kind of gives
22 you just a feel for this project.

23 And as we said, the same thing in the HRA,
24 when you look at these big projects like this, and you
25 see that basically this is going on a six year effort,

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1 that you can look at it one way and say, how did it
2 take you so long to develop this report?

3 Or you can look at all the steps and all
4 the pieces and parts that went into it and say, you
5 guys really made good time getting this done in six
6 years. So it's, you know, half full, half empty, you
7 know, the glass is twice the size it needs to be.

8 But there was a lot of steps in this
9 dance. And I think we've done it properly. We've
10 checked all the right blocks. And I think we have a
11 quality document. So this kind of gives you a little
12 overview.

13 MR. WACHOWIAK: So the next thing we're
14 going to do is, we're going to bring up our technical
15 leads to walk you through the various areas of the
16 report. We've got Dave Stroup from the NRC, who
17 pulled most of the report together, and did a lot of
18 good work there.

19 Kevin McGrattan from NIST, and we want to
20 congratulate Kevin, who recently received the Ralph
21 Jensen Award from the Society of Fire Protection
22 Engineers, for his work in influencing the state of
23 the art in fire modeling, and the use of V&V, which is
24 kind of the topic of what we're doing a lot in this
25 report.

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1 And then Francisco from Hughes Associates,
2 who is the technical lead from the industry side.
3 Between Kevin and Francisco they did a lot of the
4 calculational work and things in the report to get
5 these put together. So bring these guys up.

6 MR. STROUP: As Mark said, I'm Dave
7 Stroup. I'm the Senior Fire Protection Engineer in
8 the Office Nuclear Regulatory Research. We have been
9 working on this guide over the last five years. And
10 I think we've developed a nice quality product here.

11 I've put this sort of introductory slide
12 up here about the fire modeling process, that I won't
13 say we came up with it. It's pretty similar to the
14 process that's been presented in numerous different
15 publications with regard to using fire modeling and
16 similar types of analyses in the fire protection
17 performance based design arena throughout the world.

18 As Mark said earlier, we wanted something
19 that was tailored specifically to the nuclear
20 industry. A lot of the information that's currently
21 out there in the mainstream of fire protection, if you
22 will, remains generic in its application. And never
23 gets down to anything very specific.

24 Specifically here, and what we've done
25 with the uncertainty piece, is begun to attach numbers

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1 to the model calculations. In most of fire protection
2 today, you do a model calculation, you get an answer,
3 and it's assumed to be the answer.

4 And it's presumably compared to some
5 hazard criteria. And it's looked at as a pass/fail.
6 Nobody ever takes the next step to say, how accurate
7 is that model? See, we wanted our guide to be
8 application neutral.

9 Fire modeling has a lot of applications in
10 the nuclear industry. NFPA 805 is the obvious one.
11 It also has applications in the significant
12 formulation process, exemption requests, fire hazard
13 analysis, and other areas.

14 So we wanted the guide to focus
15 specifically on fire modeling, and how to actually do
16 the fire modeling piece of the analysis. We went
17 through two rounds of public comments, as well as did
18 a peer review.

19 And as Mark indicated earlier we have
20 pilot tested this document twice for our -- We hold
21 an annual training class together with EPRI on how to
22 do fire PRA. And typically there's two sessions of
23 that class that are offered every year.

24 There's five modules. One new module that
25 we added when we produced the draft of this guide was

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1 the advanced fire modeling module. By pilot testing
2 that document it gave us the opportunity to find out
3 where the holes were.

4 I'll mention a little bit later, but in
5 recent discussions we found that some of the problems
6 that we tried very hard to specify were perhaps not
7 completely specified to the degree we'd like.

8 So we used both the public comments and
9 the pilot testing to identify holes in the document.
10 We'll do one final pilot testing next week to try and
11 make sure we've gotten all the typos.

12 I know I was responding to a question last
13 week from a member of the ACRS and realized that there
14 was a typo in part of that section. So there's a few
15 more. I've read the document so many times now that
16 it's hard to really read it with objectivity anymore.

17 During the first round of public comments,
18 we had over 200 comments on the document. A lot of
19 them dealing with various issues. But most
20 specifically they wanted us to get down to the nitty
21 gritty of how do you actually do these calculations?

22 And in the first draft maybe we were a
23 little bit light on actually getting down to the
24 specificity level that was necessary, and addressing
25 some of the harder questions with regard to

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1 uncertainty, and things like that.

2 As part of the peer review also we had
3 university professors look at it to see if the
4 document was, in fact, a reasonable teaching guide.
5 One of the objectives of this guide obviously is to
6 support our teaching of the advanced fire modeling
7 class, and how do you apply fire modeling for the
8 nuclear industry?

9 I guess part of the measure of success was
10 during the second public comment period we only
11 received one public comment. So hopefully that was an
12 improvement.

13 CHAIR ARMIJO: I think you did well. I
14 was going to say re-write the whole document. But
15 that's okay.

16 MR. STROUP: I hope that's not the case.
17 I mean, I've been -- Part of my background, I came
18 from the NRC. Or I came to the NRC about five years
19 ago from the National Institute of Standards and
20 Technology.

21 And a month or two before I left NIST I
22 actually started working on this particular project
23 with the NRC. So I've been intimately involved with
24 this project for the last five years. And while it's
25 been a worthwhile endeavor, I'd like to move on to

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1 something else.

2 And as we'll talk about a little bit
3 later, towards the end of this discussion, there are
4 new activities that we identified while developing
5 this guide that we need to move into in order to
6 further support the fire modeling initiative.

7 And we had a very rigorous discussion with
8 the subcommittee a couple of months ago. And they
9 identified a number of issues that needed
10 clarification enhancement.

11 One of the biggest ones was use of the
12 models outside the V&V range. When we first did the
13 -- When we first looked at our examples, which we'll
14 hear a little more about later, none of the examples
15 really fit within the V&V ranges of any of the models.

16 So we were faced with the issue of how to
17 address that. So hopefully we've provided some
18 guidance on how to do that now. And there were some
19 other issues about we attempted to bring in some new
20 models into the discussion, THIEF and FLASHCAT, which
21 are a couple of models that have been developed
22 recently based on research by NIST and Sandia National
23 Laboratories.

24 Just recently we had an inquiry from our
25 friends in NRR about a new model that was, or a sub

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1 model of the THIEF model that was developed out at
2 Ohio State. And how or if, or whether it would be
3 worthwhile to incorporate in that model. So we got
4 some guidance in the document about how to incorporate
5 results from new models. Or what to do if you've got
6 a new model.

7 MEMBER STETKAR: Dave, is there a -- Do
8 you have a plan in research to perform a formal V&V
9 for THIEF and FLASHCAT? You know, akin to the 1824
10 type process?

11 MR. STROUP: Well we have recently -- One
12 of the things you'll hear about at the end of this is
13 we have recently initiated a new project with NIST.
14 NIST has continued forward with V&Ving the models that
15 they're responsible for, CFAST and FDS.

16 MEMBER STETKAR: Right.

17 MR. STROUP: But we have also initiated a
18 project. And our friends at EPRI have joined in to
19 continue V&Ving the models that are, the core models
20 that are identified in the user's guide. You look at
21 the information in the V&V guide.

22 Kevin will get into this with Francisco
23 shortly, about the validity range. Well the validity
24 range is not necessarily the range over which the
25 model is valid. It's the range over which we chose to

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1 incorporate test data at that time. NIST has moved on
2 and expanded that range for their models. We want to
3 do that with the FDTs, NUREG-1805, as well as everyone
4 wants to include FIVE and --

5 MEMBER STETKAR: Okay. So for the moment
6 it sounds like the focus is to essentially expand the
7 range of the applicability of the five identified
8 models --

9 MR. STROUP: Yes, and when --

10 MEMBER STETKAR: -- rather than add more
11 to the mix.

12 MR. STROUP: Yes. We've also been talking
13 to NIST. And Kevin actually came up with this idea
14 that if you look at, for example, the FDTs and FIVE,
15 they're really just spreadsheet implementations of a
16 specific correlation algebraic model.

17 So what we proposed to do with this new
18 round of V&V is to focus on the specific physical
19 equation, which would allow us to bring in the THIEF
20 kind of models, the FLASHCAT kind of models.

21 MEMBER STETKAR: Okay.

22 MR. STROUP: And look at those sub models,
23 if you will, outside the broad zone model or CFD type
24 model.

25 MEMBER STETKAR: Okay. Thanks.

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1 MR. STROUP: I think that probably covers
2 most of what I had to say. I'll turn it over to
3 Kevin.

4 MR. MCGRATTAN: Okay. Thanks. My name is
5 Kevin McGrattan. I'm a mathematician at the National
6 Institute of Standards and Technology. And over the
7 course of the last 20 years I've been busy developing
8 fire models.

9 In particular FDS is, Fire Dynamic
10 Simulator, is a model I'm the principle developer of.
11 I want to just take a couple of minutes to discuss two
12 of the issues that were raised in the ACRS letter that
13 was mentioned during the introduction.

14 After we finished the V&V study of the
15 five different fire models, the ACRS had a number of
16 recommendations. And the first recommendation was
17 that the user's guide should provide estimates of the
18 ranges of normalized parameters to be expected in
19 nuclear plant applications.

20 What this really comes down to is that,
21 you know, we did a fire model study. We conducted
22 validation experiments, and so forth. And after that,
23 in talking to people, they said okay, so your models
24 are now validated, right? You say, well yes and no.

25 To say that a model is validated has

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1 different definitions depending on who you talk to.
2 In the validation study we do list a number of -- And
3 you can go to the next slide, please.

4 We listed six non dimensional quantities
5 that describe the scenarios that we looked at. And
6 these have to do with, you know, essentially the size
7 of the room relative to the size of the fire, the
8 ventilation rate, the equivalence ratio, the relative
9 distance from the fire that you might have a target,
10 okay.

11 For any given fire scenario you can take
12 these six parameters and come up with values. And
13 what you see on the chart here, on the right are the
14 range of values that our experiments have. And it's
15 obviously not a complete range.

16 So with the experiments that we had in
17 hand back in 2007, you know, we tested these models,
18 you know, in that range. But there's a considerable
19 amount of area outside of that range that we didn't
20 consider.

21 But it wasn't clear from 1824, the V&V
22 study, how do you actually use this information. So
23 what we've done in the current user's guide is that
24 for each of the eight scenarios that we've looked at,
25 we calculated the six non dimensional quantities.

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1 And the cases where our non dimensional
2 quantity falls inside the validation range, we say
3 we're inside the validation range. We're using the
4 model in a scenario for which it's been validated.

5 However, in many of the cases -- In fact,
6 for every single case that we looked at, these
7 hypothetical scenarios, there were a number of
8 parameters that fell outside of this range.

9 And Francisco is going to talk, in a few
10 more slides, about how we deal with a situation where
11 you're trying to use a model for a fire scenario, for
12 which the model may not have been validated.

13 MEMBER BROWN: Can I ask a simple question
14 about validation?

15 MR. MCGRATTAN: Yes.

16 MEMBER BROWN: Did you ever really set any
17 fires and validate based on actual fires and --

18 MR. MCGRATTAN: Oh, yes.

19 MEMBER BROWN: So you did the real
20 physical stuff? Okay.

21 MR. MCGRATTAN: So the validation study
22 consisted of 26 separate fire experiments.

23 MEMBER BROWN: Okay. Excellent.

24 MR. MCGRATTAN: But of those 26
25 experiments there were only essentially six. These

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1 were six test series. So within one test series you
2 might have multiple experiments. So when you actually
3 calculate these non dimensional quantities you see
4 that our validation study is somewhat limited.

5 And that comes up over and over again when
6 you try to apply these models to the wide range of
7 possible fire scenarios that you could have in a
8 nuclear plant.

9 MEMBER BROWN: Were these volumetrically
10 limited? Such that you had to extrapolate to larger
11 volumes in scenarios based on, you know, trying to use
12 the models? And obviously you don't go burn down
13 seven story buildings.

14 MR. MCGRATTAN: Right, right. So all of
15 these, in all of these experiments the fires were
16 limited in size to, you know, relative to the
17 compartment.

18 But if you look at these non dimensional
19 quantities, I mean, much like a Reynolds number or
20 Froude number, you can extrapolate based on the
21 fundamental physics. And that's what we want to do.

22 We want to quantify, what does it mean
23 when you say I have a big fire in a little
24 compartment, or vice versa? What does it mean to be
25 over ventilated, or under ventilated, oxygen limited,

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1 fuel limited? We wanted to put numbers to that.

2 Because up to now what we're seeing in
3 fire model analyses both inside the nuclear community
4 and outside, is that there's a lot of hand waving that
5 goes on, like yes, my fire scenario's kind of like
6 that stuff that they tested at NIST 20 years ago.

7 But what does it mean, kind of like? We
8 want to really say set forth in this document that
9 we're reviewing today, how do you calculate these
10 quantities and are you or are you not inside this
11 range.

12 And a lot of the five years that Dave
13 talked about was devoted to this issue. Because when
14 we created these six or eight scenarios five years
15 ago, we did it just based on what everybody assumed
16 would be typical fires within plants, based on past
17 experience, and so forth.

18 We didn't say, we didn't think, were these
19 scenarios inside our validation range? And what we
20 found was that most scenarios that you consider don't
21 fall neatly within the range for which you test this.

22 MEMBER STETKAR: So there you go.

23 MR. MCGRATTAN: So there you go. And
24 that's --

25 MEMBER BROWN: Why am I not surprised?

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1 MR. MCGRATTAN: Yes. And a lot of the
2 public comments came back, and rightly so, saying hey,
3 you only tested this model in this range. Looks like
4 you're pushing it. And indeed we were. So we had to
5 come up with ways of justifying use of the model.

6 And in some cases, what we did is, we had
7 to say, you know what, you're right. We can't use
8 this model for this application. It's too much of a
9 stretch. So we ourselves were disciplined in some
10 sense.

11 MEMBER BROWN: Thank you.

12 MR. MCGRATTAN: Just a follow up on what
13 I was saying before. This is a nice schematic diagram
14 that Francisco put together. And it's in the guide.
15 And we use it to discuss what we mean by sort of
16 typical fire scenarios within plants.

17 So here you have, you know, in very
18 simplistic terms, different kinds of compartments. If
19 you're familiar with nuclear plants you could probably
20 readily identify the types of compartments we're
21 looking at.

22 And if you look at those, the L, the H,
23 the L sub f, you know, flame heights, ceiling heights,
24 the dimensions of the room, these are the fundamental
25 quantities that go into these six non dimensional

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1 quantities. So when you're given a new scenario what
2 we ask the user to do is calculate these quantities to
3 determine whether or not you're inside the range.

4 And your choice of model selection is
5 going to be guided by whether or not you're inside
6 this range. So even before you start calculating
7 you've got to go through this exercise, even before
8 you choose the model. Next slide.

9 MEMBER SIEBER: Is it fair to say that the
10 models are more empirical than first principles
11 models?

12 MR. MCGRATTAN: There are three classes of
13 models that we've looked at.

14 MEMBER SIEBER: Okay.

15 MR. MCGRATTAN: Because Dave mentioned
16 they are basically empirical correlations, just one
17 formulas. If I have a heat release rate of a certain
18 value, I can roughly predict the average temperature
19 in this room.

20 MEMBER SIEBER: That's based on
21 experiments?

22 MR. MCGRATTAN: Experiments. Drawing
23 lines through data.

24 MEMBER SIEBER: Okay.

25 MR. MCGRATTAN: Then we move into what are

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1 called the zone models, in which you start to build in
2 more of the fundamental compartment physics, in which
3 you have average hot layer temperatures and average
4 lower layer temperatures. And these are ordinary
5 differential equations that conserve mass and energy.
6 Then you --

7 MEMBER SIEBER: Are there simplifications
8 implied to those in order to make it easy to --

9 MR. MCGRATTAN: Well the major
10 simplification is the assumption that, you know, in a
11 compartment with a fire you just have two
12 temperatures, the hot upper layer and the cold lower
13 layer. That's a big simplification.

14 MEMBER SIEBER: I think so.

15 MR. MCGRATTAN: Okay. So sort of the next
16 class we call the zone model. Then we have the CFD
17 models, computational fluid dynamics --

18 MEMBER SIEBER: Right.

19 MR. MCGRATTAN: -- in which we're
20 calculating in much greater detail the movement of the
21 hot gases and the detail related to heat transfer and
22 all of that.

23 MEMBER SIEBER: Which avoids the two zone
24 --

25 MR. MCGRATTAN: Which avoids the two zone.

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1 MEMBER SIEBER: -- issue.

2 MR. MCGRATTAN: Downside of that these
3 calculations can take days or weeks to run. And what
4 we found in watching the licensees is that you
5 typically start your analysis with the empirical
6 correlations. It's to kind of get your hands around
7 things.

8 Often times that's referred to as a sort
9 of screening process. If in that screening process
10 you find that, you know, a particular fire source
11 doesn't present the hazard to this compartment,
12 however you define that, you may stop there.

13 But then you move systematically up
14 through the levels of complexity if the problem is
15 warranted. So often times the CFD is not used, is
16 used rarely for situations for which the other models
17 don't apply.

18 MEMBER SIEBER: Yes. How do you make the
19 decision as to what level you should be at? What's
20 the judgement call?

21 MR. MCGRATTAN: Yes. And a lot of what
22 you see in the guide in these examples is exactly
23 that. We usually start the analysis with the hand
24 calculations. What we call the hand calculations, the
25 empirical correlations.

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1 MEMBER SIEBER: Right.

2 MR. MCGRATTAN: If we see that these
3 critical values, say the temperature of a cable,
4 sprinkler activating or so forth. If we see that
5 something --

6 The simple models are suggesting that
7 we're approaching temperatures that might, you know,
8 damage a cable, then we often go and use the next
9 level of complexity, say the zone model, to get a
10 second opinion. And finally we move to the CFD.

11 Often times the decision is that if the
12 empirical models are based on certain strict
13 assumptions. And in a lot of realistic fire scenarios
14 these assumptions no longer hold. Like the fact that
15 in most plants you don't have nice flat ceilings.

16 You don't have a ceiling jet that spreads
17 nicely from a center point. And in which case you
18 might use a hand, or an empirical correlation to see
19 if you're in the ball park of failing a cable.

20 But if you're not comfortable with some of
21 the assumptions in that hand, in the empirical
22 correlation, you tend to move on to the next level of
23 complexity.

24 MEMBER SIEBER: Okay. Now my picture of
25 this is that these models give you a mathematical

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1 numerical description of what's going on at a given
2 point in time.

3 MR. MCGRATTAN: Yes.

4 MEMBER SIEBER: That the fire obviously is
5 progressing.

6 MR. MCGRATTAN: That's correct.

7 MEMBER SIEBER: It's either using up the
8 combustible material --

9 MR. MCGRATTAN: Right.

10 MEMBER SIEBER: -- or new sources of
11 oxygen are available, or what have you.

12 MR. MCGRATTAN: Right.

13 MEMBER SIEBER: How do you move from time
14 zero to time one to time two to time three --

15 MR. MCGRATTAN: Okay.

16 MEMBER SIEBER: -- to show that
17 progression?

18 MR. MCGRATTAN: Well the zone model is an
19 ordinary differential equation in time. So we're just
20 simply solving these equations. And then we have a
21 time history of the temperature in the upper layer and
22 the lower layer.

23 MEMBER SIEBER: Okay.

24 MR. MCGRATTAN: The CFD model, that's a
25 partial differential equation in which every little

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1 grid cell that covers the room we have a time history
2 of --

3 MEMBER SIEBER: Yes. Provided nothing
4 changes.

5 MR. MCGRATTAN: Provided that, if we
6 assume a door is open or a door is closed.

7 MEMBER SIEBER: That's different.

8 MR. MCGRATTAN: Right.

9 MEMBER SIEBER: The door, if the door
10 burns down somewhere in the middle --

11 MR. MCGRATTAN: Right.

12 MEMBER SIEBER: -- then the CFD
13 constraints change.

14 MR. MCGRATTAN: Right. But we do include
15 in our calculations -- And you can do it with the
16 zone models and the CFD --

17 MEMBER SIEBER: Can you do it step by
18 step?

19 MR. MCGRATTAN: You can do it step by
20 step. For example, there's always the assumption that
21 the fire brigade arrives at a certain time. And you
22 can actually build that into your model. So when the
23 firefighter opens the door oxygen is going to come
24 into the room.

25 MEMBER SIEBER: Right.

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1 MR. MCGRATTAN: So we do include this kind
2 of time dependence into the calculation.

3 MEMBER SIEBER: Okay. This sounds very
4 complicated.

5 MR. MCGRATTAN: Well it can be. That's
6 why it took us five years.

7 MR. JOGLAR: Well in most of our
8 applications time is the output. What happens at this
9 point in time is what we need to know.

10 MEMBER SIEBER: Right. When does the
11 cable fail?

12 MR. JOGLAR: Yes. When I have to leave
13 the control room. When is the cable fail? And then
14 I compare it with my ability --

15 MEMBER SIEBER: When the sprinklers go
16 off.

17 MR. JOGLAR: Yes, to suppress.

18 MEMBER SIEBER: Yes.

19 MR. JOGLAR: So often we run these
20 calculations up to the point in time where we need to,
21 we need an answer for. And we can do that very well.
22 And what happens is that a number sensitivity cases
23 get run next to it to account for the kind of changes
24 you're mentioning, like opening doors or stuff, to
25 make sure that our answer all the time doesn't change

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1 if other things happen. And if they do, then we have
2 to address them.

3 MEMBER SIEBER: Now hopefully I will limit
4 the number of questions that I ask. But say you have
5 a fire in a room and a sprinkler goes off. Is there
6 -- Sprinklers from a fire protection engineers
7 viewpoint are not installed by calculation. They're
8 installed by the standard for the code that you're
9 using at a given time. So many feet apart in such and
10 such a grid.

11 MR. MCGRATTAN: Right. Correct.

12 MEMBER SIEBER: As opposed to where the
13 real fire hazard is compared to the rest of the room.

14 MR. MCGRATTAN: Right.

15 MEMBER SIEBER: And therefore you have to
16 calculate from a spatial point which of the sprinklers
17 go off.

18 MR. MCGRATTAN: Right.

19 MEMBER SIEBER: When does this actuate?
20 When does that actuate?

21 MR. MCGRATTAN: Right.

22 MEMBER SIEBER: And that's similar to when
23 does the fire brigade show up and open the door. And
24 all of a sudden --

25 MR. MCGRATTAN: Right. But one can

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1 calculate when a sprinkler will activate. I mean,
2 there are known parameters of thermal inertia for a
3 given sprinkler.

4 And even the correlations, there is
5 something known as a ceiling jet correlation that will
6 give you the temperature as a function of distance
7 from the center point.

8 MEMBER SIEBER: Right. I'm familiar with
9 that.

10 MR. MCGRATTAN: And you can calculate the
11 activation time of a sprinkler.

12 MEMBER SIEBER: Okay.

13 MR. MCGRATTAN: What happens after the
14 sprinkler activates is still beyond the capability of
15 these models.

16 MEMBER SIEBER: Oh, it is?

17 MR. MCGRATTAN: Yes.

18 MEMBER SIEBER: Oh.

19 MR. MCGRATTAN: As in terms of, will the
20 fire be suppressed or not? That is still a very
21 difficult thing to predict.

22 MEMBER SIEBER: Or would it cease to be,
23 or not be suppressed to the extent that it would
24 activate other sprinklers.

25 MR. MCGRATTAN: Exactly. Yes.

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1 MEMBER SIEBER: So that's a weakness.

2 MR. MCGRATTAN: Yes. And these are the
3 kinds of limitations in the models that we point out
4 in this guide. That yes you can predict when the
5 sprinkler will activate. But, you know, beyond that
6 you may not want to use a model.

7 MEMBER SIEBER: Well I guess if you look
8 at it retrospectively we're better off than when we
9 were when it was all, you know, the 1905 National
10 Park.

11 MR. MCGRATTAN: And outside of the nuclear
12 industry, in my experience within the commercial
13 sector, often times the authority having jurisdiction
14 just wants to know, is that sprinkler going to
15 activate?>

16 MEMBER SIEBER: Right.

17 MR. MCGRATTAN: Is something blocking it
18 and so forth.

19 MEMBER SIEBER: They're hard to test.

20 MR. MCGRATTAN: Yes.

21 MEMBER SIEBER: Because when you test it
22 the sprinkler no longer exists.

23 MR. MCGRATTAN: Yes.

24 MEMBER SIEBER: You can't test and then
25 put it in service.

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1 MEMBER STETKAR: I think also, I mean, you
2 know, we're talking about fire models here in nuclear
3 plant applications, especially the kind of risk
4 informed applications.

5 These are part of the larger model of the
6 fire scenario. And in many cases that larger model
7 either will explicitly evaluate a probability or
8 successful -- Maybe not extinguishing, but at least
9 control of additional spread of the fire scenario,
10 within the context of that larger probabilistic model.

11 So, you know, it's not a perfect world in
12 terms of a dynamic simulation tool. But those types
13 of issues, in terms of effectiveness of the sprinkler,
14 at least in terms of preventing further growth of the
15 fire, not necessarily extinguishing the fire, are
16 handled within the context of some of the models.

17 MR. MCGRATTAN: And you'd think that --
18 I mean, in essence that might be what you call a sub
19 model. And that is, sprinkler activates water, hits
20 the fire source, and the heat release rate levels off.
21 Or decays at a certain --

22 MEMBER STETKAR: Yes. It at least doesn't
23 increase any further.

24 MR. MCGRATTAN: That's right. That is --

25 MEMBER STETKAR: And in many cases that's

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1 all you need in the context --

2 MR. MCGRATTAN: That's an empirical sub
3 model.

4 MEMBER STETKAR: That's right, yes.

5 MEMBER SIEBER: Well that's consistent
6 with the NFPA codes of the old says. Because it never
7 assumed that your fixed suppression equipment put
8 fires out.

9 MR. MCGRATTAN: Right.

10 MEMBER SIEBER: The idea was to control --

11 MR. MCGRATTAN: Contain --

12 MEMBER SIEBER: Control the fire until
13 your fire brigade got there and put the fire out.

14 MR. MCGRATTAN: Right.

15 MEMBER SIEBER: Or you ran out of stuff to
16 burn.

17 MEMBER SKILLMAN: Kevin, you've described
18 your effort to put together these models. And I've
19 got a question, a curiosity question. With a
20 sprinkler system you normally get a fine mist, or
21 something more than a fine mist, a good spray.

22 And if you have a pair of compartments
23 that are communicating, and you end up with hot gas on
24 the ceiling, a lot of hot gas. And say it's a 20 foot
25 high ceiling, and you've got an eight to ten foot, two

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1 meters, three meters of very hot --

2 MR. MCGRATTAN: Yes.

3 MEMBER SKILLMAN: -- gas. You end up
4 creating steam. How do your models address what is
5 now not smoke? It's a heat layer --

6 MR. MCGRATTAN: Right.

7 MEMBER SKILLMAN: -- that you're now
8 generating another material --

9 MR. MCGRATTAN: Right.

10 MEMBER SKILLMAN: -- which is steam?

11 MR. MCGRATTAN: Right. Well the empirical
12 correlations don't address it all. Because they're
13 simply not designed for something so complex. The
14 zone models also don't because they just assume you
15 have an average upper layer temperature composition.
16 The CFD models, however, have the capability.

17 So the model that I've developed, fire
18 dynamic simulator, we do track the water droplets. We
19 evaporate the water droplets. We mix the water vapor
20 in with the CO2 and the other fire products. Okay?

21 However, we haven't validated the model
22 for these complex scenarios yet. It's one thing to
23 write down equations and solve them. We can do that.
24 But that's a very complicated fire scenario to test
25 experimentally.

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1 And for one, all of your fire experiments
2 are typically monitored by thermocouples. And once
3 you set off a sprinkler, thermocouples are gone. So
4 we don't have a lot of good validation data on that
5 kind of scenario, which is why I say that once a
6 sprinkler has activated, except for the very
7 simplistic assumption that the fire's not going to
8 grow anymore, the fire models are pretty much --

9 At least the current state of the art is
10 that they are limited in how they can predict what's
11 going to happen after that. Again, the physics are in
12 the complex models. But these physics mechanisms have
13 not been tested yet.

14 MR. JOGLAR: A quick clarification what
15 Kevin said. One of the zone models we have here has
16 that type of ability. The room that you -- It absorb
17 heat as the evaporation process happens. So that is
18 in the physics. But it's very crude.

19 MR. MCGRATTAN: Yes.

20 MR. JOGLAR: It's fairly crude. And they
21 have crude assumptions like, well the fire's going to
22 stop growing after water starts, which is not even a
23 calculation. So yes, they try to calculate the
24 temperature given now you're adding water into the
25 environment.

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1 And you're evaporating, and some of that
2 heat is going to evaporation instead of heating stuff.
3 But the application of that process in practical
4 result is very crude. It's very crude. And of
5 course, it's not validated.

6 MR. MCGRATTAN: Yes.

7 MEMBER SKILLMAN: Thank you, thank you.

8 MEMBER SIEBER: Well the value of this,
9 compared to the old deterministic methods is that you
10 can arrive at some sort of a estimate of a probability
11 that other events will occur, like failed wires,
12 failed controllers --

13 MR. MCGRATTAN: Right.

14 MEMBER SIEBER: -- equipment that ceases
15 to function, and so forth. And to me that's the
16 difference. That's the motivation to pursue this
17 path.

18 MR. MCGRATTAN: Right. And what I often
19 see is that, you know, for a given fire scenario
20 that's under analysis, the empirical correlation, you
21 know, might be all you need. But what I see is often
22 times the more complicated models are run just to see
23 if there's anything more to the scenario that you
24 might not think about.

25 MEMBER SIEBER: Right.

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1 MR. MCGRATTAN: And I've had people show
2 me interesting phenomena in --

3 MEMBER SIEBER: Oh, really?

4 MR. MCGRATTAN: -- CFD. You know, I
5 didn't think the smoke would, you know, billow down to
6 the floor over here, you know. I mean, that's the
7 kind of thing that they might --

8 A little bit of insight that they get by
9 running the more complicated models. Even if again,
10 the empirical correlation, you know, does what you
11 need, it just provides more insight.

12 MEMBER SIEBER: Okay. Thank you.

13 MR. MCGRATTAN: Okay. I'll continue with
14 the next comment that was made. Can we go back one
15 level? Yes. So following the V&V study we had to
16 come up with a way of essentially boiling down all our
17 results.

18 And you can imagine that we made thousands
19 of point to point comparisons between model and
20 experiment. We had 13 quantities that we were looking
21 at. We had five different models. And we developed
22 the system that's shown on the slide here of, for any
23 given model shown on the top of the chart, and any
24 different quantity.

25 And we looked at all of the comparisons

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1 between model and experiment. And we sort of
2 qualitatively assigned a color. Green being that the
3 model agreed well. And I'll say that in quotations.
4 The model agreed well with the experimental
5 measurements.

6 Yellow, you know, not perfect, but not bad
7 either. And we also had a red, even though we never
8 actually assigned it. What you see in white are
9 situations where the model simply doesn't predict that
10 particular quantity, which some might say is red, and
11 we put it as white.

12 Regardless of that the -- Go to the next
13 slide. The committee didn't like it, to put it
14 bluntly. The color designations provide no
15 quantitative estimations of the intrinsic uncertainty.
16 And that's, it was a very good comment.

17 Because what we say was that people were
18 misinterpreting these colors. In particular yellow.
19 What does yellow mean? Well if you think about a road
20 signal, yellow either means slow down or speed up,
21 depending on how you drive.

22 You know, what we saw was that, you know,
23 people were saying, well for this quantity this model
24 gets a green. I can use it carte blanche, regardless,
25 right? It's always right. It's always good.

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1 And yellow, some people were saying, well
2 we'll use it cautiously. And some people were saying,
3 well don't use it at all. So we thought that that was
4 not the right interpretation. The HRS also agreed
5 that that was not a good way to handle things.

6 And so in the guide now, jump ahead to, we
7 now have this table, which is a little bit busier.
8 But we think it is far better than the color chart.
9 Because now for every quantity that we're interested
10 in predicting, and for the five models, we have this
11 delta, which is essentially a bias.

12 So a delta is one. That means that on
13 average, the model and the experiments agree. And
14 then there's a standard deviation. If you jump to the
15 next slide you'll see what we mean by that. This is
16 a --

17 The scatter plot is a typical result from
18 the validation study, in which we're looking at one
19 model predicting, in this case wall temperatures. And
20 we have the measured values on the horizontal axis.
21 And the predicted temperatures on the vertical.

22 And obviously if the point falls on the
23 diagonal line that means the model and the
24 experimental measurement are in perfect agreement. Of
25 course that doesn't happen. There's always some

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1 scatter.

2 We've developed a relatively simple way to
3 calculate the bias. Essentially whether or not the
4 model, on average, over predicts or under predicts the
5 quantity and the standard deviation.

6 And what we're showing here with the red
7 dashed lines are the, what we call the model
8 uncertainty. And we put black dashed lines in there
9 to indicate the experimental uncertainty. And this
10 calculation method that we developed essentially
11 separates out the experimental uncertainty from the
12 model uncertainty.

13 We want to know just how good are the
14 models. Keeping in mind that the models are always
15 compared against experiments that have some
16 uncertainty. Obviously the experimental uncertainty
17 is always less than the model uncertainty.

18 Our goal as model developers is to bring
19 the red lines in line with the black. But we know
20 that, you know, that's a long range goal. We're
21 always going to have to deal with this model
22 uncertainty.

23 So with the bias and with the standard
24 deviation, we also tested the results of the
25 validation study. We tested them for normality. We

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1 found that in most cases the data was normal. You're
2 shaking your head but --

3 MEMBER STETKAR: Yes, in most cases.

4 MR. MCGRATTAN: In most cases, that's
5 true. And that makes the statistical analysis easier
6 because if you -- And this chart in the lower right
7 points out a typical problem, where you're using a
8 model to predict a cable temperature.

9 We know from experiment that this
10 particular kind of cable fails at a temperature of 330
11 degrees. So the question is, what's the probability
12 that this particular fire scenario will cause this
13 cable to fail?

14 Well let's say you predict with your model
15 that the cable temperature reaches a maximum value of
16 300. And you also know from the valuation study that
17 this model tends to over predict by say five percent,
18 with a standard deviation of 20 -- If I can read that
19 slide. I forget exactly what the numbers are.

20 But you can essentially draw a Gaussian
21 distribution about your adjusted prediction. And then
22 work out, via the area under that curve, the
23 probability that the cable fails due to the model
24 uncertainty only.

25 Francisco's going to talk after me about

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1 the parameter uncertainty. Here we're just asking the
2 question, if we knew exactly what the heat release
3 rate from the fire was, if we knew all of the
4 properties of the materials and so forth, what's the
5 uncertainty of the calculation just given the model
6 uncertainty only.

7 And that for us was a big step. Because
8 in all my experience doing fire modeling, you rarely
9 see this happen. You will see someone say, my model
10 predicted 300, the cables fail at 330, thank you and
11 that's all.

12 But we want to, as model developers,
13 regulators and as users, go beyond that and say, no
14 it's not perfect. The models are not perfect. There
15 is the likelihood, or there is some chance that the
16 cable temperature might exceed 330 degrees C. And one
17 more slide. And in the examples --

18 MEMBER BROWN: Do those -- From your fire
19 scenarios there's a difference between heat generation
20 raising the temperature of the cable and exposure to
21 direct flame. Well that means the cable fails faster.

22 MR. MCGRATTAN: Sure.

23 MEMBER BROWN: Or your model doesn't work.
24 It shows that in the model?

25 MR. MCGRATTAN: That is in the model.

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1 MEMBER BROWN: Direct flame as opposed to
2 just --

3 MR. MCGRATTAN: Right. Again, if you go
4 to the more detailed model then they will account for
5 the flame --

6 MEMBER BROWN: Okay.

7 MR. MCGRATTAN: -- and the bypass layer.
8 The empirical correlations, the simpler models, often
9 just say if the cable is in the flame we just assume
10 it fails. That's the simplest approach.

11 And then you move on to actually doing a
12 heat transfer calculation through the cable, to
13 predict when the inner temperature of the cable
14 exceeds the 330.

15 Dave mentioned this THIEF model. That
16 just means Thermally Induced Electrical Failure. It's
17 really just a one dimensional heat transfer
18 calculation into the cable to determine when it
19 actually fails.

20 So in our examples, at the end we
21 developed this chart here to summarize the results of
22 the analysis. And this is just one example where
23 we're looking at a control room cabinet fire, as shown
24 in the pictures.

25 And we used in this case all of the

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1 models. We used an empirical correlation. We used
2 the zone model. And we used a CFD model, the FIVE the
3 CFAST and FDS.

4 Each model has its own bias and standard
5 deviation based on the validation study. We have a
6 critical value. That's the temperature at which
7 something fails.

8 In this case, in a control room we're
9 talking about the operator him or herself, you know,
10 being exposed to a temperature that's untenable. And
11 we're actually now predicting the probability of
12 exceeding this temperature.

13 So we've built into the final presentation
14 of the results the uncertainty analysis. That's
15 essentially to force the user to do it. Because like
16 I said, if they're not forced to do it, they're not
17 going to.

18 And I've been there. I've done fire
19 analyses myself. And sometimes uncertainty analysis
20 is a pain in the neck, and I don't want to do it. But
21 now what we're saying is, look, you've got to do it.
22 You can't just present the results of a model without
23 expressing the uncertainty of it.

24 No one in the lab expresses a measurement
25 without expressing the uncertainty. The same is true

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1 for model results. What this chart now hopes to do,
2 if you look in the final column on the right, is in a
3 lot of cases the probability of exceeding these
4 critical temperatures may be very low.

5 But you'll see right away, from this
6 chart, that there's one number, .362. So one
7 particular model is saying in one particular scenario
8 that there is a probability of about .3 that this
9 operator might be impaired from doing his or her job.
10 And that might be what we look at.

11 So in this case what's failing is the
12 optical density. The smoke density has become too
13 great. And the operator can't see. And this might be
14 what we want to focus on for further analysis.

15 When we look at sensitivity studies we
16 might want to focus on this. We may not want to do,
17 you know, an elaborate sensitivity analysis or a model
18 that's predicting zero probability of failure.

19 We want to focus on the model or the
20 scenario that suggests that there might be a problem.
21 And then do further analysis on that. And I'll pass
22 that on to Francisco to talk about that further
23 analysis.

24 MR. JOGLAR: Thank you, Kevin. My name is
25 Fransico Joglar. I work for Hughes and Associates.

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1 And I've been involved in the EPRI NRC research that
2 has been discussed here, from the first fire modeling
3 users guide through the V&V.

4 And over the last few years I've been
5 working at utilities under fire PRA and 805
6 transitions. All right. So Kevin was discussing
7 model uncertainty.

8 And through the development of this
9 project we came across the issue of parameter
10 uncertainty. And we decided at the time to leave it
11 out. Because this is an issue that is well
12 understood. And people know how to deal with
13 parameter uncertainty.

14 And when we presented that approach to the
15 ACRS subcommittee, well they kind of suggested that we
16 include examples of how to deal with parameter
17 uncertainty in our guide. And we thought it was a
18 good comment, of course.

19 MEMBER STETKAR: And joyfully went ahead
20 and gratefully --

21 MR. JOGLAR: And added, I believe, a
22 couple of examples of how to deal with parameter
23 uncertainty. Now we kept it as a simplistic approach,
24 probably the simplest way of addressing it.
25 Recognizing that there is sophisticated ways to do it,

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1 multiple parameters, numerical methods, all of that.

2 We tried to keep it at the same level as
3 we have the model uncertainty, which is, you know,
4 something that you can probably do by hand. Now at
5 the same time, in my experience in the transitions of
6 the plants, I have come across very specific
7 applications with the tool that we incorporated, and
8 the examples we incorporated in the guide would be
9 very useful.

10 And I think I'm quoting some of the lines
11 we have heard in the discussions we have on these
12 transitions, where we're dealing 805, the maximum
13 expected and limiting scenarios. And there are some
14 margins presented between the two.

15 And we kind of have to discuss that the
16 uncertainty in our maximum expected would not exceed
17 those limiting. And it seems to us that the approach
18 that we are presenting as examples can be used to
19 address that kind of question. So I see it as a very
20 practical and timely to include it here.

21 So as I said, the approach that we put in
22 the guide is the simplest way of addressing parameter
23 uncertainty. We have analyzed certain parameters.
24 And in many cases it is the heat release rate. There
25 can be others like distances.

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1 So we used the probability distributions
2 for that parameter that are available in 6850. And we
3 recognize that the selection of these input
4 distributions is not covered in the guide. And it's
5 up to the user to come up with that distribution. In
6 the guide we went and used something that is
7 referenceable.

8 And so the couple of examples and the
9 slide we have here is the place where we propagated
10 the uncertainty of the heat release rate through the
11 flame height, and came up with a distribution for the
12 flame. So is straight forward application. I have
13 seen practical applications of this in the transition.
14 So we're happy that we got it into the report.

15 MEMBER STETKAR: Francisco, this is -- I
16 thought it was a great example. And I honestly think
17 you ought to do a little more self promotion for this
18 example.

19 The reason it's a great example is that if
20 you look at the actual calculations you find that the
21 98th percentile heat release rate that a lot of people
22 use as guidance for their initial screening that
23 everybody complains about is exceedingly conservative.

24 You know, shows that the flame height
25 always hits the cable, which is good. I mean, that

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1 confirms that indeed it's an appropriate screening
2 value. So that's a good conclusion.

3 A couple other subtleties though are that
4 if you use the mean heat release rate from the
5 underlying uncertainty distribution, and just push
6 that mean heat release rate through that equation,
7 you'll conclude that the flame height does not hit the
8 cable.

9 And I've seen many people do that. They
10 say well now I'm going to do a best estimate
11 calculation. And I will indeed listen to people and
12 use mean rather than median for my best estimate.

13 And then draw the conclusion that indeed,
14 as Kevin was mentioning earlier, well there's no
15 damage. So therefore this scenario will not result in
16 any cable damage, because I've done a best estimate
17 analysis.

18 When you do the full uncertainty analysis,
19 the uncertainty analysis says that the information
20 that needs to be fed from the fire modeling effort,
21 just looking at the parametric uncertainty, says that
22 you return now to the folks that are doing the logic
23 models, a 31 percent probability in this case, that
24 indeed the cables would be damages.

25 And that's a really neat example. And it

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1 doesn't quite come through the fact that, you know,
2 the middle ground is what you're interested in.
3 Because I've seen many, many people just use that,
4 I'll call it point estimate best estimate, to draw the
5 conclusion that indeed, I can toss out the scenario.

6 And the problem is once they toss the
7 scenario out, they never go back and do -- They never
8 post process that scenario for uncertainty and say, oh
9 my God, there was really a 30 percent chance that it
10 should have been in.

11 So there might be a little bit that you
12 can add to sort of cast that in terms of people --
13 Like you said, Francisco, you know that people are
14 doing this out in the NFPA 805, at least through
15 transitions.

16 MR. JOGLAR: This distribution I made the
17 point of saying we referenced 6850 because since those
18 days the research team that put that together was --
19 This was a way of incorporating the actual scenario
20 geometry --

21 MEMBER STETKAR: Sure.

22 MR. JOGLAR: -- into the analysis. And in
23 the case you were discussing, if the tray is further
24 away, but maybe the 98 percentile doesn't catch it.
25 Maybe --

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1 MEMBER STETKAR: Well that's --

2 MR. JOGLAR: So that percentile, that
3 percentage that, let's say, I think used the number 31
4 percent as an example. What's intended to be the
5 fires that were big enough to start the progression of
6 damage through different targets. So since, say fires
7 that were smaller than that would not catch the tray.

8 MEMBER STETKAR: Okay. Right.

9 MR. JOGLAR: And that percentage, since
10 6850 was developed, was intended to incorporate in the
11 risk analysis the percentage of fires that would be
12 large enough. And that's why those distributions are
13 in 6850.

14 MEMBER STETKAR: That's right. And I
15 understand that. All I'm saying is the example in
16 there, in the appendix where we actually go through
17 this calculation. And the area under, on the right
18 side of this curve we're looking at, is indeed
19 calculated to be .31. It's pretty straightforward
20 calculation.

21 My only point is that from a guidance to
22 a user, somebody who's actually going to use these
23 tools and understand how to use the uncertainty
24 results in a practical application. The point being
25 that the 98th percentile shows damage.

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1 And that's clear, that's good. The point
2 being that using only the mean value of that heat
3 release rate would show no damage. So that's
4 something you shouldn't use.

5 As a user you should not use that to
6 return information back to the plant logic model. You
7 must use the results of the uncertainty analysis. You
8 can't just use a point best estimate. And my point is
9 that conclusion isn't really reinforced for the user.
10 It's cast --

11 The uncertainty analysis is done
12 correctly. All of the information is there. But most
13 users will just look at it in the sense of, oh yes, I
14 have to do an uncertainty analysis on my results.

15 Well in this particular case, if you
16 screen out a scenario because your best estimate says
17 no damage will occur, you don't have any results to do
18 the uncertainty analysis on. The uncertainty analysis
19 --

20 MR. JOGLAR: You don't need the --

21 MEMBER STETKAR: -- actually drives the
22 result.

23 MR. JOGLAR: You'll miss the contribution.

24 MEMBER STETKAR: You will miss that
25 contribution. You'll miss, you know, the answer is

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1 not 100 percent that the cable is always damaged, or
2 zero percent that it's never damaged, even though the
3 zero percent is your so called best estimate. The
4 answer is really 31 percent.

5 And it's a wonderful example. It really
6 is. You couldn't have selected a better example I
7 think. Even though it's a simple example. You're
8 only looking at one parameter and so forth, to sort of
9 illustrate some of the things we're talking about,
10 about the importance of actually looking at the
11 uncertainty.

12 Because it can actually influence your
13 decisions going forward. It's not just something that
14 you look backwards at a set of results and say, well
15 here are the uncertainties in my results. This is
16 actually part of the, you know, analysis process.

17 MR. JOGLAR: We appreciate the comment.

18 MEMBER STETKAR: It's a wonderful example.
19 I really like it. It was great.

20 MR. JOGLAR: And actually we drafted three
21 pages of this in discussing among the team. It ended
22 up being what it is. It kind of --

23 MEMBER STETKAR: One more paragraph might
24 do really well.

25 MR. JOGLAR: But the thing that when we

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1 started treating parameter uncertainty, we started
2 well, to include all the techniques that there are and
3 all of that. And we ended up with something that fit
4 nicely, you know. And that is where we are.

5 MR. MCGRATTAN: What I've seen, again in
6 my experience is, you know, such a technique is
7 already described in 6850. And in previous slides
8 you'll see a snapshot from --

9 I think sometimes the analysts are a
10 little intimidated by the statistics. It's not hard,
11 but, you know, a Gaussian or a gamma distribution
12 we're propagating. I mean --

13 MEMBER STETKAR: But heck, I'm a dummy.
14 And I can hit that in Excel.

15 MR. MCGRATTAN: Well that's another --

16 MEMBER STETKAR: As well as anybody else.

17 MR. MCGRATTAN: That's why we tried to
18 point out that this is not that complicated.

19 MEMBER STETKAR: It's not rocket, this is
20 not rocket science.

21 MR. MCGRATTAN: This is doable
22 spreadsheet. You don't need to be a statistician to
23 do this. But sometimes, again, in talking to people
24 they say I don't want to do that. You know,
25 uncertainties, it's too complicated. I don't want to

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1 do it.

2 MEMBER STETKAR: Well something that you
3 said before, unless you're told with pretty much an
4 explicit example that you really ought to do this.
5 And it does make a difference. It's too easy to
6 decide that it's too complicated. Or I'll do it after
7 the fact, after I get the real work finished.

8 MR. MCGRATTAN: Right.

9 MEMBER STETKAR: I mean, that's more of
10 the attitude I think.

11 MR. MCGRATTAN: Yes. I see that a lot.

12 MR. JOGLAR: I annotated here as a comment
13 that one more paragraph to our parameter uncertainty
14 example would be pretty nice.

15 MEMBER CORRADINI: You don't have to be
16 that nice to him.

17 MEMBER STETKAR: I'm not --

18 MR. MCGRATTAN: Well we're already on the
19 hook to add a little bit more description of this
20 example, just to clarify how we actually did it.

21 MEMBER STETKAR: In E. Let it go. That's
22 a little more complicated over in that example E.
23 This is the simpler one.

24 MR. MCGRATTAN: Yes, that's why we made a
25 slide out of it.

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1 MEMBER STETKAR: The easier one.

2 MR. STROUP: You can add a little bit of
3 something to flesh it out.

4 MR. MCGRATTAN: Yes, okay.

5 MR. STROUP: Because I think that --

6 MEMBER STETKAR: But I think that first
7 one, because it's just so -- The other example, the
8 mean values, we get kind of the same conclusion. So
9 it's a little more --

10 MR. STROUP: Complicated.

11 MEMBER STETKAR: -- research, if you will.
12 But the first one, it's Appendix B and it's brought
13 forward into Section 4, or whatever it is, you know,
14 is kind of the tutorial.

15 MR. MCGRATTAN: Okay.

16 MEMBER STETKAR: I think is really neat.

17 MR. MCGRATTAN: Okay.

18 MR. JOGLAR: Kevin also mentioned the real
19 complication of people having to do fire models and
20 fire modeling analysis in scenarios that when you try
21 to match it to our V&V reports, they just fall up.
22 And we tried to cover in our guide what to do. There
23 is a recommendation to try to find V&V studies outside
24 1824. 1924?

25 MEMBER STETKAR: 1824.

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1 MR. JOGLAR: 1824. And also we have
2 examples of what in my opinion is a very powerful
3 thing, which is just do sensitivity analysis. Make
4 the argument that you're reshaping your scenario to
5 something that goes into the conservative side.

6 Making a room smaller, for example.
7 Shortening a distance. And see if those results --
8 If you don't change your conclusions that way. In my
9 practical experience, it's a very practical way of
10 solving this problem. And in many situations it
11 works.

12 So we think that the examples that are in
13 the guide are a reflection of reality. We have been
14 doing this through the transitions. And if it doesn't
15 work it's for a good reason. And perhaps you ought to
16 double check your analysis, okay.

17 This slide is an example of the
18 sensitivity analysis I am discussing. So this is one
19 of our scenarios, which is a multi room complex. And
20 we have a target that is being heated by the fire
21 outside the room of origin. This is one of our
22 "multi-compartment" scenarios.

23 And so we had to reshape the geometry to
24 feed the V&V results. And the graph, the plot to the
25 right shows that there is no difference in the

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1 adjacent room. And we used that to argue, well our
2 conclusions are okay.

3 Because although we rechecked the fire
4 room to meet the V&V criteria, really our answers
5 doesn't change. And we have seen that in my
6 experience, even in the fire room itself. So it's
7 probably the most practical way of addressing this
8 issue.

9 Although we are beginning a V&V project to
10 expand those ranges, this technique will stay. I
11 mean, there are just too many scenarios around to
12 claim that we're going to be able to cover all of
13 them. So that's why we are including it in our
14 report.

15 But our report includes also eight
16 examples. And these eight examples are based on
17 typical nuclear power plant applications. We hope
18 they serve as a template of consistency for the
19 utilities to develop their analysis, and the
20 regulators to know what to expect, what sections to
21 expect, what topics to be covered.

22 And therefore, we kind of streamlined the
23 lines of communications. But it's expected and
24 conducted in the -- For example, on 805 transition, we
25 considered the requirements of NFPA 805 in our

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1 examples. And we really challenged the capabilities
2 of the fire models.

3 Now these examples -- It's perhaps one of
4 the most difficult sections of our guide. Dealing
5 with these examples was not easy. Because we keep
6 scenarios that are typical of nuclear power plants.

7 When we submitted this for public
8 comments, you get comments in the order of, well
9 you're not solving these. Those may be specific
10 issues of plants, right, that we are not addressing.
11 But this is a generic guide. So we walk a fine line
12 between what's generic, what's plant specific.

13 In terms of input parameters we always
14 want to be sure we can reference our inputs in terms
15 of geometry. And we work very hard to try to
16 balancing to what, you know, the comments are asking
17 for. Or these very specific issue in what is really
18 a generic tool.

19 These examples, just by chance, did not
20 meet all the V&V criteria. So we selected them before
21 we actually applied the V&V criteria, to actually go
22 through the sensitivity process. And also these
23 examples, not by coincidence, just match the specific
24 capabilities of the model.

25 That's why in our examples we go from the

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1 engineering jobs, and sometimes have to go through an
2 FDS. And the actual FDS calculation is necessary.
3 It's not, well lets just do it for the example. It's
4 actually necessary to answer the objective.

5 And through the development of the project
6 we expanded our research team. And we brought people
7 from the industry that routinely do this work. And
8 they help us develop and comment on the examples. As
9 I said, this was a subject of numerous public comment.

10 So we think that at the end our examples,
11 you know, strike a balance into what our generic
12 teaching guide is. And provides a solid template to
13 conduct fire modeling calculations that will improve
14 communication between the NRC and the plants. So
15 those are the examples. I guess that's my last slide.
16 I'll pass it to Mark and Rick to wrap this up.

17 MR. SALLEY: So in conclusion you've heard
18 from the team. Again, this is a joint publication.
19 It's worked under the MOU between NRC and EPRI. We
20 believe it's ready for prime time. With that we'd
21 like to request a letter.

22 And an important piece here -- If you
23 look back, again in time line mode of where we were
24 ten years ago and where we are today, we've made some
25 pretty good strides. I mean, you know, one of the

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1 first things we did was like 1805, teaching the
2 inspectors the basics of fundamental fire dynamics.

3 And getting them to think in the fire
4 dynamic way for the STP process. And then we did a
5 PIRT, you know, for fire modeling, which gave us some
6 insights. We then followed up with the V&V, you know.

7 That's the fourth major cornerstone is
8 this application guide. And this is all done by
9 design in the plan of how we did it. When we did the
10 V&V, for example, we didn't -- We wanted to keep user
11 error out of doing the V&V.

12 So we focused in on the model. So kind of
13 divided it into two pieces, this being the second
14 piece to bring it in. The mic doesn't like me. Let
15 me back up here.

16 We're far from done. Like I said, this
17 gives us the really good foundation to work from now.
18 And I think it's our springboard to move forward to,
19 as we'll see expanding the V&V, and starting to look
20 at cataloguing material properties to reduce
21 uncertainties in the calculations. As well as, I'm
22 thinking in the future, get another PIRT together.
23 And see what we go with for the next round of
24 experiments.

25 So that's kind of the conclusions. If

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1 there's any followup questions. But we request a
2 letter to publish this shortly, and move on to the
3 next phase.

4 MEMBER SKILLMAN: Yes. I do have a
5 question. And that is, as this would be rolled out
6 for the meetings that you had with the future users,
7 have you had any push back from the utilities, or
8 those who would support the utilities, relative to
9 their ability to do the calculations? Do they have
10 the talent necessary to do this?

11 MR. MCGRATTAN: You want to handle that?
12 You're one of the guys that did it. Do you have the
13 talent? are you talented enough?

14 MR. JOGLAR: Well correct me if I'm wrong,
15 I heard two questions. If we have received pushback
16 from the utilities. And if there is the talent.

17 MEMBER SKILLMAN: That is accurate.

18 MR. JOGLAR: Okay. I would say that
19 through the public comments we received, we handled
20 the push back through the report. There were a number
21 of comments that really made us go back to the drawing
22 board. And we believe we have resolved them in that
23 way.

24 I believe there is the talent in the
25 utility side. I would think most of it is in the

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1 consulting companies. But I have seen fire modeling
2 studies, like the ones we present in these examples,
3 prepared for the utilities and used for the 805
4 transition. So that's going on.

5 Also, we included this detailed fire
6 modeling as one of the modules in the course that is
7 taught twice a year. And to make sure we have
8 technology transfer. And we get students all the time
9 from the regulator side, from the utilities, from the
10 consulting companies.

11 So I think the answer to your question is
12 yes in both. We have received some push back in the
13 form of public comment that we have addressed. And
14 most of the examples of how to do it for if there's to
15 be what type of problem is being solved.

16 There are some challenges outside. Fire
17 modeling doesn't have the capability to solve all the
18 potential fire scenarios that could happen in a plant.
19 So that is still a challenge that we see. There are
20 some scenarios that simply cannot calculate with our
21 tools. There is talent outside to do this work. And
22 we have courses going on to improve on that.

23 MR. MCGRATTAN: And I'll add that most of
24 these models that we're looking at were developed
25 outside of the nuclear community. and they're widely

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1 used in many sectors. And the people who do this kind
2 of modeling often have bachelors and masters degrees
3 in fire protection engineering.

4 And what we see in our training course,
5 for example the one we'll teach next week, are people
6 who already are familiar with the models. And what
7 they want to know is, what is specific about nuclear
8 power plants? What's different about nuclear power
9 plants?

10 And as Mark said in his introductory
11 remarks, what this guide is, is almost like an
12 advanced course on fire modeling specific to nuclear
13 power. So we assume that someone doing these kinds of
14 calculations already has a fairly decent background in
15 the fire physics.

16 And what this is doing is saying, here's
17 some of the issues you have to think about when you're
18 looking at a typical compartment in a nuclear power
19 plant. So it gives them that next level of expertise.

20 MEMBER SIEBER: I think that it's good to
21 point out that this is an alternate approach to
22 providing power protection to licensed facilities. A
23 licensee could choose between a deterministic
24 approach, which has been in use since the beginning of
25 licensed commercial facilities. Or choose NFPA 805.

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1 And I think half of them have chosen 805.

2 And as a former utility executive, you
3 look at your organization and decide whether you have
4 the talent to do it or not. Or are you willing to
5 contract it.

6 And usually that decision is made based on
7 intricate and perhaps not solvable problems that you
8 have in your plant. And that would drive you to this
9 kind of compliance technique.

10 And some of the older plants were really
11 not basically designed with fire protection as their
12 primary objective. And because of that there's some
13 places in those plants that are difficult to protect
14 from a fire protection standpoint.

15 And you need every tool you can get to
16 analyze that. And I also think that some people were
17 using this application in specific areas in their
18 plant, as opposed to the whole plant.

19 MR. MCGRATTAN: Right.

20 MEMBER SIEBER: And so that gives you the
21 best of all worlds to solve your problems. Even
22 though this requires talent, high level intellect and
23 a lot of work, in my opinion, in order to arrive at a
24 solution.

25 Or find your way through plant

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1 modifications to an optimal solution. So I think this
2 is great stuff actually. And I think it compliments
3 the fire protection obligations of the industry and
4 the NRC.

5 MEMBER SKILLMAN: Thank you.

6 MEMBER STETKAR: Any other members have
7 any other questions, comments? If not, Mr. Chairman
8 --

9 CHAIR ARMIJO: about 30 seconds early.
10 Back to you.

11 MEMBER STETKAR: Before -- Thanks, that
12 was a really good presentation. You crammed a lot
13 into it. And thanks for being so responsive to the
14 subcommittee on this. You did a lot in the last three
15 months. And I know you did even more than may be
16 apparent in the report. So thanks a lot.

17 MEMBER STETKAR: Okay. John, excellent
18 work as usual. We're going to reconvene at 12:45.
19 And we're returning to the St. Lucie Unit 2 power
20 upgrade meeting.

21 (Whereupon, the meeting in the above-
22 entitled matter went off the record at 11:43 a.m. and
23 back on the record at 12:44 p.m.)

24

25

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

(12:44 p.m.)

CHAIR ARMIJO: Okay, we're ready to go. We will now take up the St. Lucie Unit 2 Extended Power Uprate application briefing and Dr. Joy Rempe will lead us through that discussion.

MEMBER REMPE: Thank you, Mr. Chairman. Our subcommittee on Power Uprates reviewed the Florida Power and Light License Amendment Request for St. Lucie Unit 2, EPU on June 22, 2012. Subcommittee members have had the opportunity to review the staff's SER, draft SER, excuse me. The licensee's power uprate license amendment request, staff requests for additional information and other specific topics presented at our subcommittee meeting.

During our subcommittee meeting we reviewed topics similar to what we've reviewed in the past for other EPU's. At the conclusion of our subcommittee meeting I believe that most of the remaining subcommittee questions related to the performance of the two replacement steam generators since they were installed at St. Lucie Unit 2, and the anticipated effects of the EPU on their performance.

So today, at our request, we've asked the staff and the licensee to devote most of this briefing

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1 to this topic. I should mention to you that some of
2 their presentations contain proprietary information,
3 so part of our session will be a closed session, as
4 indicated on the agenda.

5 And I should note that there are actually
6 two different types of closed sessions so we'll need
7 to stop at the beginning of Item 4 to change the
8 individuals that are participating on the phone lines.

9 And at this point I'd like to turn this
10 meeting over to the staff. And I believe that Ms.
11 Michele Evans will start the presentations?

12 MS. EVANS: Yes. Okay. Good afternoon,
13 my name is Michele Evans. I'm the Director of the
14 Division of Operating Reactor Licensing in NRR. I
15 appreciate the opportunity to brief the ACRS today on
16 the St. Lucie Unit 2 Extended Power Uprate
17 Application.

18 Today the licensee and the NRC Staff will
19 address selected areas and open items generated during
20 the subcommittee briefing. These include training,
21 safety analysis and steam generator performance.
22 During the course of our review the staff had frequent
23 communications with the licensee, including conference
24 calls, letters, audits and public meetings.

25 We issued multiple rounds of requests for

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1 additional information to the licensee that spanned
2 multiple technical disciplines. We believe this open
3 dialogue contributed positively to the overall review.

4 Overall I'm pleased with the thoroughness
5 of the staff's review. There were a diverse set of
6 technical issues and the staff interacted extensively
7 with the licensee over the course of our review.

8 At this point I'd like to turn over the
9 meeting to our NRR Project Manager, Tracy Orf, who
10 will introduce the discussion.

11 MR. ORF: Thank you, Michele. Good
12 morning. My name is Tracy Orf, I'm the Project
13 Manager in the Office of NRR assigned to St. Lucie.
14 First, I'd like to take this opportunity to thank the
15 ACRS members for your effort in viewing the proposed
16 EPU Application. I also want to express my thanks to
17 the NRC staff for conducting a thorough review of a
18 very complex application and also for providing
19 support during these meetings.

20 During today's Full Committee meeting you
21 will hear from both the licensee and the NRC staff in
22 providing you with the details of the EPU Application.
23 The objective is to provide additional followup
24 information relating to the details of the St. Lucie
25 Unit 2 EPU Application and provide a status of open

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1 items generated during and after the ACRS Subcommittee
2 meeting on June 22nd.

3 Before I cover the agenda items for
4 today's meeting I would like to provide some
5 background information related to the proposed EPU.
6 On February 25, 2011 the licensee submitted its
7 license amendment request for the St. Lucie Unit 2
8 EPU. The proposed amendment will increase the Unit's
9 license worth power level from 2,700 megawatts thermal
10 to 3,200 megawatts thermal.

11 This includes a 1.7 percent measurement
12 uncertainty recapture resulting in an 18 percent
13 increase from the original licensed thermal power.
14 The staff's method of review was based on Review
15 Standard RS-001, which is NRC's review plan for EPUs.
16 As you know it provides a safety evaluation template
17 as well as matrices that cover the multiple technical
18 areas that the staff is to review.

19 There were numerous supplements to the
20 applications, responding to multiple staff RAIs.
21 Overall there were approximately 70 supplemental
22 responses which supported our draft safety evaluation.
23 Also the staff completed several audits to complete
24 its review and resolve open items.

25 During the June 22nd subcommittee meeting

1 the ACRS requested additional information regarding
2 the St. Lucie training program, inputs to the LOCA
3 analysis effecting peak cladding temperature, thermal
4 conductivity degradation and steam generator
5 performance. These items will be discussed this
6 afternoon.

7 Unless there are any questions I'd like to
8 turn the presentation over to Mr. Joe Jensen. Joe is
9 the site vice president for St. Lucie.

10 MEMBER POWERS: I take it that the
11 leadership on this particular issue has not provided
12 us copies of the NRC.

13 MEMBER REMPE: I'm sorry. Say that again,
14 Dana, I couldn't quite hear you.

15 MEMBER POWERS: You have not provided us
16 copies of the NRC viewgraphs?

17 MEMBER REMPE: I think what you have are
18 just the introductory of slides that we don't have
19 copies of. And then later there will be some NRC
20 viewgraphs. And I noticed that that was there, but do
21 you really want the title --

22 MEMBER POWERS: This is a deficiency in
23 our leadership here?

24 MEMBER REMPE: You never know, Dana, I
25 prefer to stay in favor.

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1 MEMBER SHACK: We emailed it to you, Dana.

2 (Laughter)

3 MEMBER POWERS: I am not in a position to
4 refute that statement.

5 CHAIR ARMIJO: Okay, please go ahead.

6 MR. JENSEN: Good afternoon. My name is
7 Joe Jensen, I am the site vice president for the St.
8 Lucie Nuclear Plant. And I want to thank the
9 Committee for the opportunity to speak on behalf of
10 FPL and for my team to be able to be here today and be
11 able to address the Committee as well, regarding the
12 extended power uprate at St. Lucie Unit 2.

13 With me here today to share information
14 about the St. Lucie Unit 2 EPU are Jack Hoffman, our
15 licensing manager for the St. Lucie EPU. Rudy Gil
16 who's the manager of our major component inspections
17 group. Dave Brown, our senior operations
18 representative on the EPU Team. And Jay Kabadi, the
19 manager of the nuclear fuels group for St. Lucie as
20 well as Chris Wasik, the licensing manager.

21 This is a significant undertaking that
22 will not only increase the output of the plant but
23 will also provide equipment upgrades to improve plant
24 availability and reliability. We appreciate the
25 opportunity to discuss the EPU license amendment

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1 request for St. Lucie with the ACRS.

2 Since the ACRS subcommittee meeting, FPL
3 and NRC staff have worked diligently to address the
4 actions from subcommittee members. We recognize and
5 appreciate the importance of the subcommittee's
6 questions, particularly those on steam generator
7 performance.

8 FPL's top priority is safety. We continue
9 to proceed with caution through the remaining steps of
10 the EPU. We look forward to any remaining questions
11 that the Committee has this afternoon.

12 A little background about St. Lucie, to
13 reintroduce ourselves to you. The St. Lucie site is
14 located on Hutchinson Island, southeast of Fort
15 Pierce, Florida and is a primary electrical generating
16 source for St. Lucie County.

17 It's a combustion engineering PWR NSSS
18 system with Westinghouse turbine generators. The
19 original AE was Ebaso and our nuclear fuel supplier is
20 Westinghouse.

21 The gross electrical output was 907
22 megawatts electric prior to EPU modifications. Now
23 note since we replaced LB turbines during the last
24 refueling outage we've gained another 31 megawatts,
25 increasing our current gross electrical output to 938

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1 megawatts electric.

2 MEMBER BANERJEE: Is that a beach there?

3 MR. JENSEN: Yes, sir. It is. I have
4 been to most of the plants in the country and I
5 thought Diablo Canyon was the most beautiful facility.
6 I now think that the St. Lucie plant is the most
7 beautiful facility. It's a lovely, lovely spot.

8 With regard to some of our key milestones
9 and major equipment replacements at St. Lucie, the
10 original operating license was issued in 1983. In
11 2003 a renewed operating license was issued for Unit
12 2, extended the operation until 2043. Also in 2003 we
13 installed a new single failure-proof crane to support
14 dry fuel storage operations.

15 The steam generators were replaced in
16 2007, with AREVA Model 8016 Generators. And
17 additionally, in 2007, we replaced the reactor vessel
18 head to address Alloy 600 issues. Finally we replaced
19 two of four reactor coolant pumps in 2007 and 2011.
20 And our current plan is to replace the other two
21 motors in 2012 and 2014.

22 So that completes my introductory remarks
23 and at this point I'd like to turn the meeting over to
24 Jack Hoffman, who will provide a brief overview of the
25 EPU. Jack.

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1 MR. HOFFMAN: Thank you, Joe. Good
2 afternoon. My name is Jack Hoffman and I'm the
3 licensing manager for the St. Lucie Unit 2 Extended
4 Power Uprate Project. As stated earlier by the NRC,
5 FPL has submitted a License Amendment Request for an
6 approximate 12 percent licensed core increase for St.
7 Lucie Unit 2.

8 This proposed power increase is consistent
9 with that recently approved for St. Lucie Unit 1 and
10 consists of a 10 percent uprate from the current power
11 level of 2,700 megawatts thermal, to a power level of
12 2,970 megawatts thermal.

13 In addition, the amendment request
14 includes a 1.7 percent core power increase as a result
15 of the measurement uncertainty recapture. Together
16 these power increases raise the license core power to
17 3,020 megawatts thermal.

18 A bridge system impact study was performed
19 to evaluate the impact of the EPU on the reliability
20 of the electric power grid. This study was performed
21 for the most limiting configuration of both St. Lucie
22 units at the proposed EPU power level. Results of the
23 grid simulations indicate acceptable grid performance
24 for the most extreme event.

25 Finally, the remaining modifications to

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1 support operation of St. Lucie Unit 2 at the uprated
2 power level will be implemented this year, in the fall
3 of 2012. Next slide.

4 As mentioned previously, the St. Lucie EPU
5 license amendment request was developed using the
6 guidance contained in RS-001. This Amendment
7 addressed lessons learned from several previous
8 pressurized water reactor EPU submittals. In
9 accordance with RS-001, the St. Lucie EPU analyses and
10 evaluations were performed consistent with the Unit 2
11 current licensing basis.

12 The impact of the EPU on license renewal
13 was also evaluated in each license report section.
14 These analyses and evaluations addressed system
15 structures and components subject to new aging
16 effects. SSCs that have been added or modified to
17 support EPU and the impact of EPU on time-limited
18 aging analyses.

19 The proposed measurement uncertainty
20 recapture submittal follows the guidance of NRC
21 Regulatory Issue Summary 2002-03 and the St. Lucie
22 Unit 2 MUR methodology is identical to the uprates
23 recently approved for Turkey Points Unit 3 and 4 and
24 St. Lucie Unit 1.

25 Included in today's presentation is

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1 information to address three ACRS Subcommittee meeting
2 followup items. They include; Number one,
3 acceptability of a single control room simulator for
4 EPU operator training. Second, rackup of the pre-EPU
5 and EPU loss of coolant accident peak clad temperature
6 differences. And three, the continued discussion of
7 the St. Lucie Unit 2 steam generators.

8 So unless there are any further questions
9 for me, I would like to turn the presentation over to
10 Dave Brown who will discuss operator training.

11 MR. BROWN: Good afternoon. I'm Dave
12 Brown. During the subcommittee process a question
13 came up concerning the fact that we have a single
14 control room simulator modeled to Unit 2 specifically
15 for training on both units. A single control room
16 simulator is typical for dual unit sites.

17 It is important to recognize that the
18 simulator training is one facet of a multi-faceted
19 training process, including classroom training, on the
20 job training in both control rooms and in the field
21 training that is conducted with a specific emphasis
22 looking at the Unit 1 control room differences
23 including JPMs and TPEs to evaluate in that area.

24 The operator training program is an
25 accredited program by the Institute of Nuclear Plant

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1 Operations. St. Lucie's methods of training have been
2 evaluated and continue to be evaluated and
3 reaccredited every four years. And that includes the
4 use of a single simulator has determined to be
5 acceptable for that process.

6 Operators at St. Lucie are licensed and
7 qualified on both units and routinely operate both of
8 those units. The differences on the units are
9 emphasized in both classroom and simulator training to
10 make sure the operators are aware of all differences
11 between the units.

12 And we've been working in EPU and in our
13 EPU modifications we've actually been reducing the
14 number of those differences between the units, like
15 taking the steam bypass system and making them the
16 same on both units, et cetera, et cetera.

17 MEMBER POWERS: Is that the most important
18 difference?

19 MR. BROWN: Sir?

20 MEMBER POWERS: Is that the most important
21 difference between the two units?

22 MR. BROWN: The steam bypass control
23 system? I don't know that I would consider that the
24 most important difference. It was one of the systems
25 that we were modifying that we had an opportunity to

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1 make the two systems alike. Probably the most
2 important systems associated with the differences
3 would be the ECCS systems, which were not modified for
4 EPU.

5 Okay, if not anything else I'll turn it
6 over to Jay Kabadi.

7 DR. KABADI: I think in the subcommittee
8 meeting we presented the results of all of our safety
9 analysis, including non-LOCA and LOCA. And in this
10 presentation I'm going to go over some of the PCT
11 deltas that occur between the Pre-EPU and the EPU.

12 MEMBER REMPE: Jay, just to make sure, the
13 agenda had said this part was closed, but it is open
14 and FPL is comfortable with this part being open,
15 correct?

16 DR. KABADI: That is correct.

17 MEMBER REMPE: Okay, thank you.

18 DR. KABADI: Okay. This portion. There
19 is concern that EPU would have some adverse impact on
20 both the small break and large break LOCA. But one of
21 the goals that we had set is try to maintain PCT in
22 the same range as what we had for pre-EPU, so we are
23 looking at what operational constraints we need to put
24 and what other systems we have that are already
25 safety-related that we were not correcting previously

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1 and trying to correct it now.

2 So in the Large-Break LOCA the increase in
3 power we saw roughly in Delta about 54 degrees
4 increase. When we flattened our power distribution by
5 reducing the total radial peaking factor, the Fr, on
6 that one there was a penalty of about 19 degrees.

7 So we wanted to get the benefits, although
8 the Fr gives a penalty in terms of radial power
9 distribution, which affects the radiation heat
10 transfer. But it give a direct benefit in the LOCA
11 peaking factor on the fuel rods and that gives a
12 benefit of 53 degrees.

13 The increase of our RCS flow rate, which
14 was actually not a real change, we had replaced
15 generators about, more than two cycles ago. Actually
16 this is the third cycle we are running. But we have
17 not taken credit for the higher flow which the
18 generators produce and also our flow in the Tech specs
19 and COLA. So that gives us the benefit of about 70
20 degrees.

21 So these two together pretty much balance
22 these penalties there. However, we wanted to gain
23 some additional margin for some of the plant operating
24 parameters, such as containment spray flow. For that
25 one was a penalty of about 23 degrees on that. We

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1 increased some of the heat sinks in the containment
2 that give a penalty of about three degrees.

3 So we looked into our methodology with
4 Westinghouse, the way the metrics were applied
5 compared to what they were previously approved by the
6 staff and there was some additional conservatisms put
7 into the matter figure I used specific for St. Lucie
8 2.

9 MEMBER CORRADINI: So can I just make sure
10 I understand? So you're decreasing containment
11 pressure by containment spray flow rate and
12 containment heat sink so there's more bypass. Is that
13 the reason that you get a penalty?

14 DR. KABADI: That is correct, exactly.

15 MEMBER CORRADINI: I don't understand the
16 nine degrees for the ECCS flow.

17 DR. KABADI: Right. The ECCS flow is --

18 MEMBER CORRADINI: It sounds like a good
19 thing.

20 DR. KABADI: I think what we did is we
21 looked at the ECCS flows again for the full system and
22 it provided little more margin to the IST, so we
23 decreased slightly after there were no changes to the
24 physical components, like the HSPI flow and all. But
25 we left a little more margin for the ISTs and the

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1 flows used in the analysis were slightly lower. So it
2 --

3 MEMBER CORRADINI: Can I say that back to
4 you? So you increased the flow rate but you didn't
5 take credit for it?

6 DR. KABADI: No, no.

7 MEMBER CORRADINI: I'm still not
8 understanding where the nine degrees comes from. I
9 heard what you said but I don't appreciate --

10 DR. KABADI: That is the penalty because
11 we decreased the flow using the analysis. And the
12 decrease in the flow was to give us a margin for the
13 ISTs and the testing.

14 MEMBER CORRADINI: Okay, so just from a
15 viewgraph standpoint that should say decrease instead
16 of increase?

17 DR. KABADI: Oh, I take it back. I think
18 it has two impacts. We did look at the IST but I
19 think this one is for Appendix K methodology. What
20 happens is when you increase the flow, like in our
21 maximum case, we in both cases decreased the flow and
22 increased the flow. Increase the flow actually has a
23 maximum PCT for St. Lucie 2. St. Lucie 2 is always
24 limiting for the max HPSI flow.

25 So this was a analytical max flow

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1 increase. In the real sense I think I started a
2 little differently. In the real sense what we did is
3 we generated our RCS flows and reduced the minimum
4 flow used but also maximized the flow used for the max
5 flow case. Both min ECCS flow and max ECCS.

6 Our limiting PCT for St. Lucie 2 comes
7 from max ECCS flow. So that's why this thing, we
8 increase our containment spray flow higher. And also
9 the other flows at a higher level and we run both min
10 flow and max flow. So min flow will provide it more
11 margin for IST and the max actually was used to
12 maximize our flow in the other direction. And that's
13 what gave the penalty. Because for St. Lucie 2 --

14 MEMBER CORRADINI: He's my foil over
15 there, do you understand?

16 DR. KABADI: I think, let me explain. For
17 the plant schematics and most of the other plans, we
18 don't need a max in both cases.

19 MEMBER CORRADINI: Well I wasn't on the
20 subcommittee so I don't want to take too much of time
21 at the Full Committee.

22 DR. KABADI: But I quickly say that real
23 min flow and the max flow cases for St. Lucie 2, when
24 you put the maximum flow because of the containment
25 pressure decrease, other than the containment spray

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1 flow, we get a penalty. We've too high PCT. So in
2 this case we put on both sides more margin on the min
3 side and on max side, and the max side that's what
4 gives that penalty of nine degrees. On this one.

5 MEMBER BANERJEE: In some way you're
6 splitting the flow, is that what you're saying?

7 DR. KABADI: Right. We run the case
8 running both the HPSI flows and both the LPSI flows
9 and a flow increase. And we also run one HPSI flow,
10 one LPSI flow and predicting the minimum flow. And
11 the maximum PCT comes from the max flow case. Then we
12 try to put max --

13 MEMBER BANERJEE: Why does it come from
14 the maximum?

15 DR. KABADI: Because the containment
16 pressure. It has a big impact on the containment
17 pressure.

18 MEMBER CORRADINI: So I'm bypassing more
19 --

20 DR. KABADI: And that one gets the
21 penalty.

22 MEMBER CORRADINI: Got it.

23 MEMBER BANERJEE: It's a bypass.

24 DR. KABADI: Right, that's exactly happen.
25 So we ran both sides, do AST margin by minimizing, but

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1 also ran with the max flow and that one gives the more
2 higher --

3 MEMBER CORRADINI: Right. Thank you.

4 MEMBER SIEBER: These numbers apply only
5 to the cycle following the EPU fuel loading, right?

6 DR. KABADI: That is correct.

7 MEMBER SIEBER: Cycles beyond that can
8 have different numbers?

9 DR. KABADI: No, these are bounding values
10 at every cycle when they do IST testing, these will be
11 bounding. That is correct.

12 MEMBER SIEBER: Okay, so you have to watch
13 the loading pattern in order to achieve the --

14 DR. KABADI: Yes. We have a IST criteria
15 that they test, they check, and as long as we fall
16 within that range this analysis remains --

17 MEMBER SIEBER: Your fuel analysis method
18 maintains this envelope and each cycle has to fit
19 inside the envelope?

20 DR. KABADI: That's correct. We check all
21 the parameters going to the analysis of the reload and
22 verify that we are within the limits what we can
23 expect.

24 MEMBER SIEBER: We can expect you never to
25 get above, what is it, 2,087?

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1 DR. KABADI: Correct, 2,087, that is
2 correct.

3 MEMBER SIEBER: Okay.

4 DR. KABADI: And the other changes I
5 mentioned, more of a -- were assumptions used in the
6 methodology analysis which were "a little more
7 conservative" than what the methodology requires, we
8 reduced them slightly. And that gave a benefit of
9 about 60 degrees.

10 So overall the PCT adequacy, if you rackup
11 come out as 22 but when you put that in the integrated
12 all things are together then we get about a benefit of
13 17 degrees for the large break.

14 For small break, small break is one which
15 is very, very sensitive to flows coming in only in the
16 transient. So EPU by itself was giving us a penalty
17 of about 335 degrees on this one. So a couple of
18 changes which we did not include before.

19 One, is we have actually blankets in the
20 fuel, but we never took credit for that. So when we
21 actually took the credit for actual blanket our peak
22 loads start to went down and gives a benefit of about
23 80 degrees.

24 We used the replacement generator
25 parameters which were not used before. That gave

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1 about 100 degrees, and we took credit for charging
2 flow, which is very, very important for small break in
3 terms of gaining margin. And that gave a margin of
4 about 169.

5 MEMBER SKILLMAN: Are your tech specs
6 changed to limit the plugging to ten percent or less?

7 DR. KABADI: That is correct.

8 MEMBER SKILLMAN: Thank you.

9 DR. KABADI: So it is actually not in the
10 directly in tech spec, but that's one of the analysis
11 of that we do have to reload. Tech spec does not have
12 a tube plugging limit. But there is a limit on the
13 axis flow that we verified that with ten percent
14 plugging we meet that. If we do too much plugging
15 then that flow may not be sufficient to meet that.

16 MEMBER SKILLMAN: Thank you.

17 MEMBER CORRADINI: And then, just so I
18 understand, ten percent is what, 900 tubes, 1,000
19 tubes? What are we talking about here?

20 DR. KABADI: We have close to 9,000 tubes.

21 MEMBER CORRADINI: So 900 tubes is ten
22 percent for generating. Just wanted to get a number.
23 Thank you.

24 DR. KABADI: No, that's okay. So this is
25 what the integrated impact came out about 40 degrees

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1 benefit. Our PCT was 1,943 and the new one came out
2 1,903. So this is the last time we presented these
3 numbers but did not, in the subcommittee meeting did
4 not provide these rackups which are presented here.

5 MEMBER SIEBER: And how many tubes are
6 plugged now?

7 DR. KABADI: Right now very little and
8 Rudy probably can answer that.

9 MEMBER SIEBER: So steam generators are
10 five years old, right?

11 DR. KABADI: This is the third cycle we
12 are running.

13 MR GIL: This is Rudy Gil with FPL.
14 Between the two generators we have about 33 tubes.
15 And so you might have 20 at the most in one generator
16 against that 900. So a quarter of one percent is the
17 maximum in one of the generators.

18 MEMBER SIEBER: And what was the mechanism
19 of deterioration that caused you to --

20 MEMBER REMPE: We're going to hear a lot
21 about that later. So let's just wait and we'll hear
22 about it, okay?

23 MR GIL: It is wear and I'll have a full
24 presentation on that.

25 MEMBER REMPE: That's what we're going to

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1 focus on today.

2 MEMBER SIEBER: Oh, all right.

3 DR. KABADI: Yes I think those are the
4 slides I was going to present. And is there any
5 questions, we'll proceed to the next part.

6 MEMBER STETKAR: Are you charging pumps in
7 the tech specs now?

8 DR. KABADI: Yes.

9 MEMBER STETKAR: Were they before?

10 DR. KABADI: Before they were in some
11 sections of the tech spec, but not enough.

12 MEMBER STETKAR: But now they're in the --

13 DR. KABADI: For simplicity too they were
14 in the ECCS.

15 MEMBER STETKAR: Thanks.

16 DR. KABADI: That's right. Exactly. And
17 the two we had in the tech specs.

18 MEMBER STETKAR: Okay.

19 MEMBER REMPE: The staff has a
20 presentation and we're going to close the meeting with
21 the Westinghouse participants, correct?

22 (Off the record comments.)

23 MEMBER REMPE: Is the room appropriately
24 closed?

25 (Off the record comments)

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1 (Whereupon, the open session of the Full
2 Committee meeting went off the record at 1:11 p.m. and
3 resumed in closed session. Open session resumed at
4 2:47 p.m.)

5 MEMBER REMPE: Is anyone out there? Is
6 there any member of the public out there that wants to
7 make a comment?

8 (Off the record comments)

9 MEMBER REMPE: Okay. Again, I'll ask, is
10 member of the public out there on the phone line?
11 Just if you're there, say you are there just to --
12 okay. So I don't hear any public comments, so at this
13 point I think I'd like to turn it back to you, Sam.

14 CHAIR ARMIJO: Okay. Well, thank you very
15 much, Joy, and thanks for all the presentations. I
16 think very well done. Right now I'd like to reconvene
17 at 3:05. We've got a deal with an EST issue that
18 you'll be battling.

19 MEMBER SHACK: Don't the staff want to
20 make a presentation?

21 CHAIR ARMIJO: No, the staff made their
22 presentation.

23 MEMBER REMPE: No, that's it.

24 CHAIR ARMIJO: Yes. So I believe
25 everybody that's wanted to say something has had a

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1 chance and so we'll take a recess now until 3:05.

2 (Whereupon, the foregoing matter went off
3 the record at 2:48 p.m. and went back on the record at
4 3:05 p.m.)

5 CHAIR ARMIJO: Okay. We're back in
6 session. We're now going to cover the technical basis
7 for regulating extended storage and transportation of
8 spent nuclear fuel, and I'm going to turn this over to
9 Dr. Michael Ryan who will lead us through the
10 presentation.

11 MEMBER RYAN: Thank you, Mr. Chairman.
12 The NMSS staff, EPRI, NEI, and DOE briefed the
13 subcommittee on September 22nd and June 5th, that's
14 September 22nd of 2011 and June 5th of this year, on
15 the staff's development of a technical basis for
16 regulating extended storage and transportation of
17 spent nuclear fuel.

18 The EST program is focused on identifying
19 and addressing the technical and regulator
20 considerations for ensuring effective regulation of
21 spent nuclear fuel storage and subsequent
22 transportation over extended periods. During the June
23 meeting, the staff discussed a draft report entitled,
24 Identification and Prioritization of Technical
25 Information Needs Affecting Potential Regulation of

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1 Extended Storage and Transportation of Spent Nuclear
2 Fuel.

3 The report addresses staff's evaluation of
4 the degradation phenomena that may affect dry cask
5 storage systems and how these phenomena may affect the
6 ability of the systems to fulfill their regulatory
7 functions. Industry representatives discussed their
8 perspectives and efforts on EST and we'll hear from
9 some of those participants from the subcommittee
10 meeting here today.

11 I might, just by way of introduction, say
12 I think we had a very thorough subcommittee briefing
13 and we're going to have a short version of that today,
14 so I'm sure there's a lot of details and maybe we'll
15 have time for questions, but I'll turn the meeting
16 over without delay to Jim Rubenstone of NMSS. Jim,
17 welcome.

18 MR. RUBENSTONE: Thank you, Mike, and on
19 behalf of me team I'm very happy to be here to brief
20 the full ACRS on what we've been doing on the extended
21 storage and transportation issue, and especially the
22 initial step, which is identifying the technical
23 information needs related to dry storage.

24 Just take make a minute to introduce some
25 of the other players in the group here. The two

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1 technical leads, Bob Einziger and NMSS, and Darrell
2 Dunn from Office of Research, will be there. My
3 counterpart as branch chief is Mirela Gavrilas, who's
4 sitting over there next to Chris Jacobs, who's the
5 project manager, and some of our other technical staff
6 are here if we have any questions that we need to go
7 into that level of detail.

8 So what I'll be talking to you about today
9 are what we're doing to get started on this question
10 of extended storage and transportation and what
11 changes, if any, need to be made to NRC's regulatory
12 framework; rules, guidance, other documents that may
13 need to be enhanced in order to handle a changing
14 policy environment where it looks like storage of
15 spent nuclear fuel, either at reactor sites or at some
16 other sites will be happening for extended periods
17 into the future.

18 As I said, we were looking at our
19 regulatory framework. The current framework, dry
20 storage is done under 10 CFR Part 72 and
21 transportation under 10 CFR Part 71, and looking at
22 the current framework, if there are things that may
23 need to be enhanced within that to handle future
24 needs.

25 The first step, as I said, is to identify

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1 those technical information needs so NRC can see what
2 needs to be done in a regulatory space and I'll
3 closeout by just discussing what the next steps are.

4 Just a quick background, this is where we
5 stand now and where we're going in the spent fuel
6 storage situation. This is from an EPRI report from
7 a couple years ago. It's not complicated graphics,
8 but the idea is that, right now, we have about 18,000
9 metric ton of commercial spent fuel in dry storage out
10 of about, getting close to, 70,000 metric ton total.

11 That's about 1500 casks that are currently
12 loaded. The industry produces about 2000 metric ton
13 of new spent fuel every year. What are our needs?
14 Potentially, we may need to change the regulations to
15 accommodate a period of longer than originally
16 anticipated storage for spent fuel. And the first
17 step, from our point of view, was to identify those
18 technical information needs that we would need to
19 support any potential changes in future licensing
20 reviews.

21 So as a first step, we've tried to go
22 through systematically and identify what technical
23 issues need more work in order for NRC to know what
24 the regulations need to be and then perform some
25 focused research on those issues, especially those

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1 that have significance, and I'll explain in a little
2 more detail how we identified those.

3 So this is the report. This is,
4 literally, the report right here that we've produced.
5 I think you've all been provided electronic versions
6 of this. It was put out for public comment in early-
7 May. The public comment period just closed about a
8 week ago after a request for an extension. We've
9 gotten about a dozen commenters coming in with a
10 number of comments and those commenters include NEI,
11 EPRI, a number of state organizations, and some
12 individuals, and also one Native-American Tribe
13 provided comments.

14 What we're doing in this report is looking
15 at the potential degradation phenomena that may affect
16 dry storage systems, structures, and components;
17 consider their impact on the safety functions that are
18 identified within the regulations for storage and
19 transportation; and what level of understanding staff
20 feels they need in order to do a regulatory review.

21 We started with some previous technical
22 gap assessments for this problem that were out there,
23 including one which we sponsored through the Savannah
24 River Lab. The Department of Energy has done their
25 own gap assessment nuclear waste technical review

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1 board and EPRI also have done gap assessments for dry
2 storage.

3 We looked at the level of knowledge for
4 the various degradation processes and three things
5 which were most important about the processes, the
6 time and the conditions for them to initiate, how fast
7 they progress, and then what's the end state? And
8 some of these will progress to an end state that
9 doesn't really affect much, so they've become less
10 important.

11 Many have an end state where a system
12 becomes fully degraded; can't perform its function
13 anymore. And then we took that set of information on
14 the level of knowledge and crossed that against the
15 need to meet the regulatory criteria. So what we
16 ended up with in terms of our prioritization are those
17 areas which had relatively low level of knowledge
18 about one of these aspects relating to the degradation
19 process and a high impact on a regulatory criteria.

20 Those criteria are spelled out as design
21 criteria in 10 CFR 72. There are five specific design
22 criteria that have safety functions; confinement,
23 control of criticality, shielding from radiation,
24 structural integrity, and control of heat generating
25 and ability to dissipate that heat.

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1 There's an additional criteria in the
2 regulations which is the ability to retrieve stored
3 fuel by normal means. It's the retrievability at the
4 assembly level is the way NRC treats that now. And we
5 also looked at the possible impacts on transportation
6 under Part 71, especially for fuel that has been
7 stored for an extended period when some of the systems
8 being used are no longer in their pristine state and
9 may be affected by some of this degradation.

10 We came up with a set of high priority
11 areas and just focusing on those areas that we have
12 considered high priority. There were three that rose
13 to, sort of, the first priority and then three cross-
14 cutting areas. These are outlined on this slide.

15 I should stress that some of these issues,
16 even though we're looking at them in the extended
17 framework, because of the uncertainties about these
18 progression rates and time of initiations, overlap to
19 issues that are being looked at within the current
20 regulatory framework, and, you know, issues for
21 already loaded casks, not just casks that may exist at
22 some distant point in the future.

23 The first is a good example of that,
24 that's the phenomena of stress corrosion cracking of
25 stainless steel canisters in marine environments.

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1 We've had discussions at the subcommittee level.
2 Certainly, this is a well-known phenomena, stress
3 corrosion cracking in the presence of chloride. For
4 these canisters, when they are loaded, the heat
5 generation is such that the surface temperatures are
6 probably high enough, in almost every case, that this
7 is not a major issue, because there's no water
8 present.

9 As chloride salts can be deposited on
10 these stainless steel canisters, and not all the
11 systems use the same canisters, but a large fraction
12 of the U.S.-loaded inventory uses a stainless steel
13 canister, 304316 series stainless steels in concrete
14 overpacks. When these are sitting in places where
15 they're exposed to marine fogs or marine atmospheres,
16 you can get accumulation of salts on the surface, and
17 those salts, when the temperatures drop low enough,
18 can deliquesce and begin pulling moisture out of the
19 air.

20 This is an issue because there are
21 stresses built into these canisters from the welding
22 and the forming of the canisters. And, as I said,
23 this is well-known as a phenomenon in these stainless
24 steels. When exactly this can occur in terms of the
25 loaded systems now is what we're looking at in some

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1 detail to try to track that down and there is
2 complimentary industry work, and I'll talk about that
3 in a little more detail in a few slides.

4 Some of the other issues that came up,
5 degradation of cask bolts. Bolted systems are not
6 predominant in the U.S., but there are a number of
7 them out there. They're more common in Europe. Cask
8 bolts serve an important safety function in keeping
9 the pressure on the seals so that these bolted systems
10 stay tight.

11 The last group in this first category are
12 effects of swelling and pressurization on cladding.
13 And the stress on the cladding is an issue that can
14 have further issues tiering off it, so to speak. How
15 the cladding behaves over time, there are a number of
16 things that change in the cladding with heating during
17 the drying process and then with the storage.

18 If there's no pressure on the cladding, a
19 number of these issues are not particularly relevant.
20 If there are mechanisms by which you can start putting
21 directed stresses on the cladding, especially focused
22 stress that you might get if the fuel pellets are
23 pressing directly on the cladding, then there may be
24 issues with cladding failures over time.

25 So we're looking at the stress as the

1 first level issue, to understand that a little better,
2 if that becomes less of an issue then a lot of these
3 other issues also drop in importance.

4 We have three areas that we identified as
5 cross-cutting and they're cross-cutting for two
6 reasons. One, they can affect a number of components
7 within the system. And secondly, they bear on a
8 number of the phenomenon and how fast they can
9 progress. These are, basically, the thermal state of
10 the entire system, the fuel itself, the cladding, the
11 internal bits, and the canister's surface.

12 Again, a good example of that for the
13 stress corrosion cracking, if the temperature is high
14 enough, you don't have stress corrosion cracking
15 because there's no water present, as temperatures drop
16 over time, it's important to understand when that
17 could happen and when this may become a phenomenon you
18 need to worry about.

19 There's also questions regarding residual
20 moisture within the canister after drying. There are
21 drying procedures which are in place, predominantly,
22 vacuum drying. There's very little information to
23 benchmark exactly how much moisture is left after that
24 drying.

25 We've done some preliminary studies that

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1 suggest that if we are getting down to the levels that
2 we think we are, this is not a big issue, but there
3 are a couple possible ways where you can retain
4 additional moisture within the canister, perhaps a
5 fair amount of moisture, and if that's true, then
6 there could be some issues of degradation that come
7 off that.

8 CHAIR ARMIJO: Jim, just there. We do not
9 have a specification for residual water in the
10 canister or --

11 MR. RUBENSTONE: The specification is not
12 written in terms of how much water is left. It's more
13 a procedural spec, and Bob can explain that.

14 MR. EINZIGER: Yes. We have a procedural
15 spec that was developed by PNNL, basically, it says
16 that they have to pump the cask down to 3 tor, shut
17 the valve off, and then watch the rate of rise, and if
18 it's below a certain value, then they're okay to go.
19 If you do some calculations, that should be equivalent
20 to a little less than a quarter of a mole.

21 The problem with the specification, if you
22 look into it deeper, is that, one, it's never been
23 tested that it actually -- is that when you do that,
24 that you actually get the water out. The second thing
25 is, for it to be a valid calculation, you essentially

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1 have to be in thermodynamic equilibrium and there's a
2 lot of little nooks and crannies in the cask.

3 And so knowing that you're at a certain
4 pressure at the outlet tube of a pump doesn't
5 necessarily mean that there's not liquid water sitting
6 around somewhere in the cask.

7 CHAIR ARMIJO: Okay. Thank you.

8 MR. RUBENSTONE: The last one is a very
9 broad category. It's looking at methods by which
10 these casks, when they're in service, could be
11 monitored for some of these potential effects. Right
12 now, the dominant method for monitoring and inspecting
13 casks is visual. Basically, walkarounds, make sure
14 the ports for the air circulation are clear.

15 There's a lot of, sort of, hidden
16 components that are not easily accessible, and there
17 may be methods out there where one could do monitoring
18 or inspections to see how these phenomena are
19 progressing and catch them before they become issues.
20 So trying to look at what the modern techniques
21 available are, we saw that as a priority cross-cutting
22 issue.

23 These are some of the other high-priority
24 areas that didn't quite get as high up on the list.
25 This first one is the one that tiers off the stress in

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1 cladding and that's propagation of various flaws,
2 fatigue of the cladding, low-temperature creep, which
3 these are all stress-dependent phenomenon. If our
4 initial investigations show that there's no good
5 mechanism to develop these stresses, then these issues
6 are not issues at all, so that's why we're doing this
7 somewhat stepwise.

8 There are a number of other issues that
9 come up over the long term; behavior of the hardware
10 inside the neutron absorbers, microbial influence,
11 corrosion is an area that needs to be explored a
12 little bit in some environments as things get cooler,
13 and degradation of concrete, again, there's plenty of
14 opportunity for visual inspection of the exposed
15 concrete, but many of these systems have concrete and
16 rebar that are not easily inspected, so we wanted to
17 understand what issues might come up in concrete.

18 And this is, again, an area that's very
19 well-known, and well-studied, and in many contexts.
20 It hasn't been looked at specifically in dry storage
21 systems.

22 CHAIR ARMIJO: But the concrete is really
23 just a shielding issue, isn't it?

24 MR. RUBENSTONE: Well, structural
25 integrity, shielding, are the two main purposes of the

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1 concrete.

2 CHAIR ARMIJO: And microbial influenced
3 corrosion, has that been shown to actually occur in
4 the radiation environments at the surface of a cask
5 with a lot of spent fuel in it? Is it possible that
6 microbes could live?

7 MR. DUNN: There are some microbes that
8 have been responsible for microbially-influenced
9 corrosion that can live in fairly high radiation.

10 CHAIR ARMIJO: Those are tough suckers.

11 MEMBER RYAN: Most of those critters are
12 tens of thousands of rad.

13 CHAIR ARMIJO: Okay. Please go ahead.

14 MR. RUBENSTONE: So, yes, they are.

15 CHAIR ARMIJO: They're tough little
16 buggers.

17 MR. RUBENSTONE: They're more robust than
18 one might think. And again, there's been a lot of
19 work in a number of environments, mostly in buried
20 environments, but as these things get cooler and
21 moisture is present, and the potential for nutrients
22 coming in by surface deposition, we thought it was
23 worth looking into.

24 MEMBER SHACK: What new phenomena would
25 you expect to see in the concrete degradation that you

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1 haven't seen?

2 MR. RUBENSTONE: I don't think there are
3 new phenomenons so much as looking at how one would be
4 able to be ahead of the curve on this, that there's a
5 number of phenomena that have been identified that
6 could happen. There have been even some examples
7 where through inadvertent mistakes of leaving weather
8 caps off, water has gotten into concrete structures
9 and they've started chipping already.

10 It's mainly a question that you have some
11 of these structures, the systems are built where you
12 have concrete inside of a steel case. So you could be
13 getting water inside, degradation of the concrete, and
14 not necessarily be aware of it until you try to move
15 it. So we're trying to avoid the situation of
16 discovering things when you're ready to move.

17 MEMBER SHACK: You know, are you aiming at
18 this by inspection or, you know, you're not going to
19 make concrete impervious to everything.

20 MR. RUBENSTONE: No, no, I don't think
21 there are things -- there are some phenomena, I think,
22 that you're aware that, if you have tight control on
23 what you put in the concrete you can minimize those
24 possibilities. This is mainly aimed toward inspection
25 and monitoring methods. So we know what the phenomena

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1 are that we're looking for. So you know what you're
2 looking for and you can design your procedures to go
3 for that, you know, for things that aren't immediately
4 visible.

5 MR. EINZIGER: One of the goals of this
6 exercise was to provide guidance to the inspectors of
7 how frequently to inspect and what to inspect for.
8 And so while we know these mechanisms are occurring,
9 the level of knowledge so that we can give them that
10 guidance isn't that great. So there's a need to
11 improve the information basis for improving that
12 guidance.

13 MR. RUBENSTONE: These are a few areas
14 that we have begun work on or will imminently begin
15 work on. I've talked about them a little bit. The
16 next slide goes into a little more detail on what
17 we're doing on the stress corrosion cracking, so I'll
18 skip over that. The moisture, we talked about a bit.
19 We've done some preliminary scoping work and there's
20 some follow up planned.

21 The thermal models, we've started looking
22 into developing more realistic thermal models. The
23 biggest issue, traditionally, thermally, has been,
24 what's the maximum temperature you should let cladding
25 experience?

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1 If you're familiar with the loading
2 process, these casks are loaded in the pool, and then
3 the water is taken out, and they're dried, and that's
4 the period where they experience the greatest
5 temperature excursion before they're backfilled with
6 the inert gas.

7 So most of the models have been focused on
8 what should be the maximum temperature we allow the
9 cladding to reach during that process. NRC's
10 guidances are, standard is 400 C.

11 MR. EINZIGER: Maximum, 400 C for normal
12 conditions.

13 MR. RUBENSTONE: Right. So all, I would
14 say, of the thermal models are conservative to that
15 side and make some assumptions in order that you don't
16 breach that 400 degree limit. As we've discovered by
17 looking into some of these other phenomenons, lower
18 temperatures may become an issue. For the cladding,
19 there is a fairly well-established ductile to brittle
20 transition that happens at lower temperatures in the
21 cladding.

22 That won't happen during the loading
23 period, but it could potentially happen down the line
24 as these things have sat for a long time and the
25 thermal loads have decayed away. And again, the

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1 question of what the temperatures on the outside of
2 the canisters are for these questions of other
3 corrosion mechanisms for the canisters are important.

4 And then the other area we're just
5 beginning to look at are the inspection and monitoring
6 techniques to gather, sort of, what the modern state-
7 of-the-art methods are that are out there that might
8 be applied to these, you know, somewhat unique
9 conditions where you don't have great access to the
10 insides of these canisters and you have to work with
11 the radiation thing.

12 MEMBER SHACK: What kind of access do you
13 have?

14 MR. EINZIGER: Very limited. In some
15 cases, virtually 1/4-inch spaces. So part of the
16 whole problem with this is getting access and knowing
17 how much access you have. You might be able to get
18 access to part of the cask, but is it the right part
19 of the cask? You might be able to stick a thermal
20 couple in there to get a temperature, but is the
21 thermal couple making contact with the right surface?

22 If it's not, you could have considerable
23 error in your measurement. So it's a matter of
24 monitoring what's going on. In some cases, with
25 respect to the inside of the canister, we really don't

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1 have any access. And if you go to, especially a lot
2 of the international reports, somewhere in the report
3 you'll see a little statement like, we don't expect
4 anything to happen inside the canister because we have
5 an inert atmosphere.

6 But now, there's an assumption that you
7 put the inert atmosphere in there that, for the full
8 length of the time it's going to remain there. Do we
9 know that? If a crack occurs will we be able to know
10 when we lose that? If it occurs at a higher
11 temperature, then certain effects take place. If it's
12 at a lower temperature that a crack -- and we lose the
13 atmosphere, losing the atmosphere has a number of
14 consequences.

15 It could change it from an inert
16 atmosphere to an oxidizing atmosphere. It also
17 changes the thermal conductivity. And so here's a
18 region where there's an assumption made where we
19 really don't have any current monitoring techniques.
20 So one of the things we hope the industry is going to
21 do is look at, what are ways to insert monitoring
22 techniques? Is there a way we can use the decay heat
23 as power; a sensor that'll stay in the high-radiation
24 field?

25 How do we transmit the signal out? That's

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1 what their job is. Our job is to make sure we're
2 prepared to evaluate if they come into us with various
3 techniques. Do we think it'll work? Do we have to
4 change a regulation; the way that we have access to
5 the canisters? So that's where this comes in.

6 CHAIR ARMIJO: Well, you know, but let's
7 just assume that you had access to some stainless
8 steel canisters that are out there right now in a
9 marine environment and have been there for many years.
10 And you had enough access you could go out and look
11 and you found some stress corrosion cracks. What is
12 the regulatory position? Would you insist on repair,
13 reloading, or what?

14 MR. EINZIGER: Right now, the regulations
15 as they're stated says that, for storage, the canister
16 or the cask, depending on what type of system you're
17 in, is the primary containment vessel. If we started
18 inspecting these and seeing cracks, we would have to
19 evaluate what the temperature of the canister is, how
20 that translates into the temperatures that are inside
21 the canisters, and subsequently, what would be the
22 degradation we would expect?

23 For instance, if a canister needs to be
24 down below 80 degrees C, let's say, you're starting to
25 get deliquescence and getting water formed, well, that

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1 may mean that the temperature of the fuel is a 150,
2 let's say. Well, at a 150, we know that if we have
3 breached fuel and we get oxygen in there that there is
4 no effect.

5 And we've identified, I guess, about a
6 dozen to nine different effects that could go on if
7 you breach the canister. Obviously, if, let's say,
8 you had a bad weld, or a weld stress state in the
9 seal, that you split the longitudinal canister over,
10 that would affect retrievability.

11 CHAIR ARMIJO: I'm just saying, is there
12 a position now to --

13 MR. EINZIGER: No, our position right now
14 is, until we've analyzed what the potential safety
15 ramifications are of having a breach, we have not put
16 any guidance out to the industry of actions that they
17 have to take.

18 CHAIR ARMIJO: Okay. So if anybody found
19 some cracks on the surface and could demonstrate that
20 it wasn't breached, it wasn't actually leaking, the
21 inert atmosphere hadn't come out, you could buy off on
22 it and say, well, as long as they're not growing.

23 MR. EINZIGER: If we saw cracks on it we
24 would have to sit down and decide, how deep are the
25 cracks? Do we have to do a better visual examination

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1 to see how deep they are? Do we have to put a
2 monitoring process in place --

3 MEMBER RYAN: We can't go through all the
4 details because we've only got another hour.

5 MR. EINZIGER: But the bottom-line is we'd
6 have to do work.

7 MEMBER RYAN: I was going to say. I think
8 what I'm taking away from Bob's, you know, very well
9 and very detailed thought process is that there would
10 have to be a plan developed for that specific case and
11 then execute that plan of monitoring to see what, and
12 to what extent, things have happened, and then what
13 might be happening over time as time progresses. Is
14 that a fair summary?

15 MR. EINZIGER: Good summary.

16 MEMBER RYAN: Yes, okay.

17 MEMBER CORRADINI: So can I ask one
18 question about the aging? So you had in your slide
19 earlier, a number of dry casks, and I can't remember
20 if it was -- what is it, a 1000?

21 MR. RUBENSTONE: It was about 1500.

22 MEMBER CORRADINI: 1500. And there are
23 various ages.

24 MR. RUBENSTONE: Correct. The first casks
25 were loaded in the late-1980s.

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1 MEMBER CORRADINI: So is there an
2 inspection program that is age-related such that you
3 are looking at older casks in a different way than
4 newer casks? Has that been thought through?

5 MR. RUBENSTONE: That's exactly what we're
6 getting at; what we're moving towards now.

7 MEMBER CORRADINI: Okay. And right now,
8 the dry casks are licensed for 25 years?

9 MR. EINZIGER: It originally was they were
10 getting 20-year licenses because it was anticipated
11 things were going to move into a repository.
12 Recently, the regulation has been changed to grant
13 them a 40-year license with the extensions of 40
14 years. In the process of going for a license
15 extension, one of the requirements is to inspect a
16 cask.

17 With that said, the criteria for
18 inspecting it and what you're going to inspect it for
19 has not been thought out completely yet and it's sort
20 of a bootstrap process.

21 MEMBER CORRADINI: Okay. So if I treat
22 this like a power plant, what's the first cask to come
23 up for a renewal?

24 MR. EINZIGER: The first one that we've
25 seen so far is Calvert Cliffs. No, wait, under this

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1 system, is Calvert Cliffs, that's a canisterized
2 system, and just recently, there was an inspection
3 done of two canisters in that system and we're waiting
4 the results of those inspections.

5 MEMBER CORRADINI: Okay. All right. So
6 we're early into the whole renewal process and, in
7 essence, guidance has yet to be developed.

8 MR. EINZIGER: Well, there is guidance out
9 in a 1927 Standard Review Plan, but this is the first
10 renewal that that review plan is being exercised under
11 there's changes that are going to have to occur. It's
12 a learning.

13 MEMBER CORRADINI: Okay. Thank you.

14 MR. RUBENSTONE: That's what we see as the
15 longer term product of this whole program, is to
16 develop what guidance needs to be for this extended
17 period.

18 CHAIR ARMIJO: In the meantime,
19 particularly with the issue of stress corrosion
20 cracking, is the staff reconsidering the criteria for
21 which they will accept stainless steel canisters for
22 marine environments that haven't been fabricated in a
23 way that would make them highly resistant, if not
24 immune?

25 MR. RUBENSTONE: I think that's one of the

1 areas we're looking at is fabrication and
2 qualification of what materials for certain
3 environments.

4 CHAIR ARMIJO: Okay.

5 MR. RUBENSTONE: Because traditionally,
6 there hasn't been that distinction made.

7 CHAIR ARMIJO: Yes, because there's going
8 to be a lot more going out the door and you already
9 know that there's problems.

10 MR. RUBENSTONE: Yes.

11 MR. EINZIGER: The answer to your question
12 is, yes, we are considering it. We have not gotten
13 very far in the consideration process.

14 MR. RUBENSTONE: Yes, we're early in the
15 game.

16 CHAIR ARMIJO: Got it. That's all I want
17 to do. I want to get that on the record.

18 MEMBER RYAN: That's a key point in our
19 recommendations. We'll get to it and get the letter
20 writing.

21 MEMBER REMPE: You said you have inspected
22 a couple of canisters?

23 MR. EINZIGER: Last week.

24 MEMBER REMPE: And what exactly was done?
25 And they were in an ISFSI? I always have trouble

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1 saying that acronym, but you pulled it out? Was it
2 just opened or what did you do?

3 MR. EINZIGER: No, I think you have a
4 picture here.

5 MEMBER RYAN: The NUHOMS.

6 MR. EINZIGER: It's a NUHOM system with a
7 canister inside a concrete overpack.

8 MEMBER REMPE: Right.

9 MR. EINZIGER: They snaked a camera in the
10 entrance and the exit --

11 MR. RUBENSTONE: That's the system that
12 was examined and I think John Kessler will speak about
13 this as well.

14 MR. EINZIGER: And they also slid a probe
15 in to try to take a measurement of the salt content on
16 the surface.

17 DR. KESSLER: Yes, this is John Kessler.
18 I have a slide or two in my presentation that'll
19 describe that in a little bit more detail.

20 MEMBER REMPE: Okay. Great. Thanks.

21 MR. RUBENSTONE: Yes. This is where I
22 was? Yes. This is just a little more detail on what
23 we're doing on the stress corrosion cracking because
24 this is, as you may have noticed, a high-interest
25 area.

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1 MR. EINZIGER: Yes.

2 MR. RUBENSTONE: There was some earlier
3 work done, contract work, a couple of years ago,
4 looking at this phenomenon when deliquescing could
5 occur on these containers, and at what humidities;
6 what temperatures. Building off that, we have another
7 set of experiments going right now. We've gotten some
8 preliminary results. We're trying to tighten up what
9 were rather loose bounds on what the conditions were
10 there using more realistic amounts of salt deposition,
11 more realistic temperatures and humidity conditions,
12 and seeing when one could initiate SCC.

13 Some of those preliminary results suggest
14 that, even with relatively low amounts of salt on the
15 surface, and at, perhaps, lower humidity levels than
16 people had initially thought, considering just pure
17 sodium chloride, you can get deliquescence occurring
18 with sea salt and the potential for SCC. So we're
19 finishing up those experiments now.

20 So NRC's angle on this problem has been
21 focused on trying to better understand under what
22 conditions this could occur you would be in, sort of,
23 the window for SCC. Industry is working in parallel
24 with this and their current efforts, and John will
25 talk about this in a few minutes, are focusing on what

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1 are the actual conditions of installed canisters now?

2 What sorts of surface temperatures are in
3 place now, especially for these that have been loaded
4 for some time. And in marine environments, what
5 amounts of salts have been deposited? And as he will
6 talk about it, it's a challenge to try to get surface
7 measurements on these materials because of the
8 radiation fields. There's been no efforts to actually
9 physically pull these out of the containers because of
10 the high consideration when you take them out of the
11 concrete. That's a non-trivial exercise.

12 The first cut is seeing, how can we get
13 into these using the existing installation.

14 CHAIR ARMIJO: Just a ballpark estimate,
15 do you have an idea of how many years it would take
16 with the existing systems before the surface
17 temperature got below a 100 degrees centigrade?

18 MR. EINZIGER: That's going to depend upon
19 the particular temperature at the loading and the
20 burnup of the fuel.

21 CHAIR ARMIJO: Yes, just pick a number.

22 MR. EINZIGER: The casks that are out
23 there at Calvert are supposedly below the deliquescent
24 temperature already. We're trying to confirm that.

25 CHAIR ARMIJO: Okay.

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1 MR. EINZIGER: If you have high burnup
2 fuel that you transferred in early, let's say in three
3 years instead of five, it may take 25, 30 years; in
4 that range.

5 CHAIR ARMIJO: Okay.

6 MR. EINZIGER: I've seen estimates of it
7 may be even longer.

8 CHAIR ARMIJO: Thanks.

9 MR. RUBENSTONE: Yes, so this is where --

10 CHAIR ARMIJO: Just to put it in
11 perspective so everybody understands.

12 MEMBER SHACK: So this is like a 20 to 40
13 year kind of thing, is that what we're talking about?

14 MR. EINZIGER: No, it's a little bit
15 broader than that. If you take the data that's out
16 there now and try to make an estimate of when you
17 would initiate stress corrosion cracking, you have the
18 very narrow band of somewhere between 10 years up to
19 maybe 420 years.

20 MR. RUBENSTONE: This is one of the
21 reasons we think it's worth attacking it from a couple
22 of angles, which is the better, more realistic thermal
23 calculations, the industry's efforts to actually go
24 out and make some measurements that help us benchmark
25 those models, and the lab experiments that say, well,

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1 what is the window where you have to worry about this?

2 CHAIR ARMIJO: And some of the really old
3 fuel that was barely warm when it went into a cask --

4 MR. RUBENSTONE: Yes.

5 CHAIR ARMIJO: -- if it happened to be put
6 into a stainless steel canister on a seaside --

7 MR. RUBENSTONE: May be your worst case.

8 CHAIR ARMIJO: -- could be your worst
9 case.

10 MR. RUBENSTONE: And happened to be put on
11 a coastal environment, yes.

12 MR. EINZIGER: I want to say a few things.
13 One is, we're not only considering coastal
14 environments. This could be a case by a system where
15 there's an ISFSI next to a road that, in the winter,
16 just gets a lot of salt. It could be near a system
17 where there's cooling towers and you have
18 condensation. And we're also looking at industrial
19 pollution.

20 The other thing is, this isn't a U.S.
21 problem. We are taking full advantage of the work
22 that's been going on in England, Japan, Korea, I think
23 those are the major actors in this game who all are
24 attacking this problem.

25 MR. RUBENSTONE: Yes, the Japanese, in

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1 particular, have been on top of this for some time.
2 Swedes don't have much dry storage, but the Japanese,
3 almost all of their sites are coastal environments,
4 and that's what is simulating a lot of the further
5 work because they have some systems in place to try to
6 measure salt deposition, not directly on canisters,
7 but in sort of an analog box to simulate the airflow
8 and such.

9 MR. EINZIGER: Well, the systems at
10 Fukushima were under water.

11 MR. RUBENSTONE: Yes.

12 MR. EINZIGER: Under salt water.

13 MR. RUBENSTONE: Well, that became an
14 issue as well. They have pointed out that, yes, there
15 is probably chloride on the surface of those
16 canisters. But if you use some of the Japanese data,
17 the salt deposition can be very rapid.

18 CHAIR ARMIJO: Yes, I mean, but if they
19 fabricated very carefully, solution heat, a bunch of
20 things, they may not be a problem.

21 MR. RUBENSTONE: Right. There's certainly
22 things you could do upfront that would make this --

23 MR. EINZIGER: The Japanese are working on
24 a number of ways to try to mitigate stress.

25 MEMBER SHACK: I mean, chloride cracking,

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1 yes, I mean, you'd really have to get the stresses low
2 with those welds.

3 CHAIR ARMIJO: Yes. Solution heat
4 treatment or polish --

5 MR. RUBENSTONE: Well, basically, we have
6 two classes. We have what's out there now. We have
7 the future loadings, as you can see from that curve,
8 that's only going to be going up. So, you know, we
9 want to be looking at both issues of the best way to
10 deal with it. So, like I said, this is one of our
11 number one priorities. There's active work going on
12 by us and industry, and as Bob said, we're harvesting
13 as much as possible and cooperating with the
14 international players in this as well.

15 So I think we're on top of this. There's
16 still more to find out, but we think we've got a good
17 start on it. Just so we don't lose sight of the fact
18 that in addition to the technical areas that we've
19 looked there is some regulatory issues that will come
20 up for extended storage and transportation. And this
21 is not intended to be a comprehensive list.

22 Our next effort, as we move into the
23 finalization of this report, is to do a similar
24 analysis on the regulatory issues, go through them,
25 and make sure that we've captured all the things that

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1 come up. There's always the integration issues from
2 the various parts of the fuel cycle and coordination
3 with some efforts that are under way now for process
4 improvements in the licensing of current storage and
5 transportation.

6 So our immediate next steps, we are
7 finalizing this report. Bob's been working on the
8 comments. As I said, we have about a dozen
9 commenters. Although we haven't made a final
10 decision, I think we'll probably end up adding an
11 appendix to this report discussing the comments that
12 we got and how we are addressing them.

13 We're going to complete a research plan
14 for all the technical investigations going out over
15 the next couple of years. As I said, look at these
16 potential regulatory issues, continue the work we've
17 done on the technical investigations, again, that's
18 just to get NRC the information it needs to determine
19 what the issues are and how we're going to be prepared
20 to review applications and renewals as they come in.

21 We're engaging industry, other
22 stakeholders, and looking at what's going on elsewhere
23 in the technical world.

24 MR. EINZIGER: I think it's necessary to
25 say that, because we identify an issue as a high

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1 priority doesn't mean that we believe that that issue
2 is going to really cause a lot of problems with dry
3 storage. It just means we don't have enough
4 information to evaluate it. Likewise, because we
5 identify an issue as being low priority, that doesn't
6 mean that we don't think that, maybe, the industry
7 doesn't need to get more data. It only means that we
8 think we have enough information in order to make a
9 regulatory decision.

10 That's why you might see a difference in
11 the priorities you see what we give to an item and
12 what DOE, or EPRI, or somebody else, gives the
13 priority. As I say, our job is to get information to
14 determine whether there's an issue, their job is to
15 solve the issue.

16 MR. RUBENSTONE: That's a good point to
17 remember because the ultimate goal of this whole
18 project is any necessary changes in regulations and
19 guidance, and staff training to review future
20 applications. Industry's goal is a little different.
21 We all are looking for safety, they're coming at it as
22 the ones who are actually holding the materials.

23 I put this slide in because the Blue
24 Ribbon Commission had some recommendations that touch
25 on our extended storage and transportation issues. As

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1 you probably know, the Blue Ribbon Commission put out
2 its final report this past January and the response
3 from the Department of Energy is due to Congress this
4 month.

5 These are the three specific ones that
6 touch on extended storage and transportation. And I
7 think the second one there about developing one or
8 more consolidated storage facilities is something that
9 we have to keep in mind as we look at technical issues
10 that may affect storage and transportation.

11 What this brings into the fold, which
12 hasn't been the traditional practice, is the idea that
13 you may be having material in storage for some time,
14 then transporting it to another storage facility,
15 leaving it there for another period, and then
16 transporting it again.

17 So the idea of multiple transportation
18 stages with some periods of indeterminate, perhaps
19 long storage in-between, is an important consideration
20 for the technical issues, especially for these
21 degradation issues and how they could affect both
22 transportation and storage.

23 MEMBER POWERS: Has anybody looked at what
24 I would call the macro risk of all that? I mean, we
25 have the spent fuel stored at the individual sites.

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1 It seems to be working well. Poses some sort of risk
2 by itself, but now if you think about transporting it
3 from those sites to some centralized location and, as
4 you say, perhaps from there to some place else, that
5 seems to entail another set of risks, and I have no
6 idea what the combined risk is.

7 MR. RUBENSTONE: We've started looking at,
8 sort of, a systemwide approach with these various
9 steps and some of these things you can do relatively
10 straightforward. Some of them get a little more
11 complicated. I think one thing that's clear from all
12 risk studies that have been on the backend and the
13 handling question is that, your highest risk period is
14 when you're actually moving things around, not
15 necessarily moving them in a transportation load, but
16 loading canisters, moving them off pads onto trucks,
17 or trains, et cetera, like that.

18 So when you add those steps, yes, you're
19 adding more risk. Is it an acceptable risk? That
20 remains to be seen from the various things, but, you
21 know, something sitting on a pad, there are very few
22 spontaneous things that can happen there.

23 MEMBER POWERS: Which is nice.

24 MR. RUBENSTONE: You're picking something
25 up with a crane, yes.

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1 MEMBER POWERS: A lot of things.

2 MR. RUBENSTONE: So I think that's where
3 we're trying to get this bigger picture view, and
4 we've started some work on that, and we're not very
5 far along, but we are doing that. I think one of the
6 pushes for the consolidated storage facilities was the
7 question of decommissioned sites and that's something
8 that, going forward, we're going to have to look at,
9 especially if the number of the decommissioned sites,
10 where all that's left is a fuel storage facility, if
11 that starts growing, especially questions that came up
12 in the Blue Ribbon Commission.

13 Framework is, these decommissioned sites,
14 many of them have only an ISFSI and they really don't
15 have facilities for handling anything except the
16 stored systems now. Could that be a potential problem
17 if these things exist for a long time? Would you want
18 to have a facility where you could actually have a
19 more comprehensive handling capability than at a
20 decommissioned site?

21 MR. EINZIGER: One of the things that has
22 been put on the radar, though, from the point of
23 possibly transporting it more than once and storing it
24 more than once, is that, most of the analysis that are
25 done to determine whether systems are safe are

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1 dependent upon what the initial condition of the
2 system is, but when you start now, after you've been
3 in storage and are going to transport it, you're no
4 longer dealing with a pristine system.

5 You're dealing with one that's aged some
6 and vice versa for storage after transportation. And
7 so that degradation has to be taken into account in
8 determining the safety.

9 MR. RUBENSTONE: And that's why some of
10 these monitoring issues come up is that, the more you
11 know about the system the more competent you are that
12 you're actually making the right analysis. And as Bob
13 said, as something's been stored for awhile, there are
14 a number of assumptions that gon into the
15 transportation that may need to be challenged, tested,
16 evaluated, as to what the condition of the material is
17 in.

18 The question Sam brought up about cracks.
19 Even if these cracks don't develop to the point where
20 they're through growing, you need to analyze, what's
21 their affect on the structural integrity before you
22 start picking things up again. So there's a lot of
23 interconnection and the system approach, I think, will
24 help point that out. We don't really have any
25 conclusions yet.

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1 CHAIR ARMIJO: Okay.

2 MR. RUBENSTONE: So that's all I have,
3 basically. These are the conclusions. I think we've
4 hit most of these. If you have further questions we
5 can take those.

6 MEMBER RYAN: Let's see. Okay. That's
7 great. I think what we'll do is maybe hold questions
8 to the end. We really don't have that much further to
9 go, unless there's some pressing issue that you
10 haven't touched on yet. Hearing none, it's Mr. Jeff
11 Williams from DOE.

12 (Pause)

13 MEMBER RYAN: Go ahead, Jeff.

14 MR. WILLIAMS: Okay. Thank you. Yes, for
15 those of you who don't know me, I'm with the Office of
16 Nuclear Energy and DOE, and with the withdrawal of the
17 license with Yucca Mountain, and the termination of
18 licensing activities, we embarked upon a program to do
19 research on alternative geologic disposal environments
20 as well as extended storage.

21 And, let's see, I just have a few slides
22 here. When the program was initiated in the 2009/2010
23 time frame, we put together a report to Congress, all
24 of NE did, on our research objectives. And we're
25 still following that report to Congress which is

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1 called the NE Roadmap. And the approach was a
2 science-based engineering-driven approach that
3 originally defined our program and continues today.

4 In terms of the dry storage work that
5 we're doing, we're doing this from a total system
6 approach, from looking at the fuel pellets all the way
7 to the cladding, to the fuel assembly hardware, to the
8 canisters, to the concrete casks, and to the pads.
9 And the first thing we need to ask ourselves is, how
10 do we know we're doing the right kind of work?

11 And what we were doing in the first couple
12 of years here is trying to identify the work that
13 needs to be done. We started by doing a functional
14 requirements analysis, looking at the safety functions
15 that Jim had on his slides, thermal shielding,
16 containment, criticality, retrievability, and
17 structural integrity.

18 And then we conducted a technical gap
19 analysis that was completed earlier this year. NRC
20 has done them, NWTRB has done them, EPRI has done
21 them, and we compared our gap analysis that was done
22 independently with the NWTRB's, with NRC's, that came
23 subsequent to that, and we shared it throughout the
24 industry to, basically, validate the gaps that we
25 identified.

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1 And right now we believe that we're
2 competent that we're going after the right things,
3 although we could go after a lot more if we had a lot
4 more money, but we had to focus on certain items that
5 we could do. This is a slide I showed before that,
6 this year what we did, in 2011 and '12, was we did a
7 gap analysis. We came out with a whole bunch of gaps
8 that needed data gathering.

9 And since we don't have infinite
10 resources, we decided we were going to try and
11 prioritize those gaps. And we tried to quantify
12 qualitative discriminators. And the gaps are
13 identified in the left here, that we identified,
14 mainly, cladding, different aspects of cladding, the
15 assembly hardware, the neutron poisons that are
16 included, the welded canister itself, bolted casks,
17 and the concrete.

18 And then we identified several different
19 criteria to use and some criteria weren't real
20 discriminators, but then we identified likelihood of
21 occurrence, consequences, difficulty for remediation,
22 and tried to quantify those, and then add them up,
23 over to the right side, to identify what are the most
24 important ones.

25 Last time when we talked, I didn't talk

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1 about what those numbers are in there, it went from 1
2 to 4 likelihood of occurrence. This was based on
3 subject matter experts opinion's, but they were
4 quantified in terms of; a 1 meant it's not expected to
5 occur; a 2 means it may occur; 3, it's likely to
6 occur; and 4, it's very likely to occur.

7 And then with consequences, we basically
8 --

9 MEMBER SHACK: What's the second number in
10 the likely --

11 MR. WILLIAMS: Oh, okay. I'm sorry. Yes,
12 what we were trying to do there was to say about the
13 near-term and long-term. The one on the left is near-
14 term, like, on the order of five years or so, and
15 again, this is subjective. Subject matter experts got
16 together and tried to identify that. And the second
17 number is --

18 MEMBER RYAN: So just so everybody's
19 focused right. I think it's important to say, this is
20 really just a scoping analysis --

21 MR. WILLIAMS: Yes, what it's trying --

22 MEMBER RYAN: -- based on an expert
23 elicitation.

24 MR. WILLIAMS: Exactly.

25 MEMBER RYAN: Okay.

1 MR. WILLIAMS: It's taking our team of
2 people from the national labs and trying to define
3 where we should spend our money.

4 MEMBER BROWN: So in the short-term, you
5 say, 3, it's not very likely, but --

6 MR. WILLIAMS: No, no; 1 is, not expected,
7 2 is, it may occur; 3 is, it's likely; and 4, it's
8 very likely.

9 MEMBER RYAN: Start with 4 and work down
10 Charlie.

11 MEMBER BROWN: But that's a near-term.
12 The first one is a near-term. The second term is a
13 far-term.

14 MR. WILLIAMS: Yes, right.

15 MEMBER BROWN: Okay.

16 MR. WILLIAMS: And then they're added up
17 across there and you can see the ones that came out to
18 be important are the cladding effects, hydride
19 effects, reorientation and embrittlement, and then the
20 welded canister ones down here. All the ones that are
21 the 11s and the 10, and that's where we've started to
22 focus our work on.

23 We also are looking into aging management
24 plans a little bit. I think you were briefly talking
25 about that in that, let's say we determined that there

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1 was some sort of corrosion on the canister or
2 something, is there any kind of aging management plan
3 that could address that? That's something we've just
4 started, so I don't have any results from that.

5 I think Jim talked about concrete, and
6 inspections, and so forth, and there are ways to
7 remediate concrete degradation. You can see the
8 remediation one wasn't much of a discriminator. They
9 were all rated 3 by our team, except for the bottom
10 two, were 1 and 2. I could really spend an hour or so
11 on this slide, but I know I only have five minutes.

12 CHAIR ARMIJO: But you can't. At least
13 you put the numbers. We understand them now.

14 MR. WILLIAMS: Right. Okay. So I'll just
15 go on to the next one. I only have --

16 MEMBER RYAN: Before you leave that I just
17 want to ask one question of you both while you're both
18 up there. I took away from the subcommittee meeting,
19 Jim, that Jeff's kind of qualitative alignment here on
20 some of the priorities really were not dissimilar from
21 what your work has led you to believe, so you're both
22 really on the same page. Is that a fair summary?

23 MR. RUBENSTONE: Yes, I think if there's
24 one general statement you can make for what we've
25 done, what DOE has done, what EPRI has come up with,

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1 and TRB, is that, there's fairly good alignment on
2 what the major issues are. As Bob pointed out, we
3 have a little bit of a different angle on it because
4 of what we're trying to get as opposed to where DOE is
5 going.

6 MEMBER RYAN: And that's reasonable.
7 Sure.

8 MR. RUBENSTONE: But I don't think there's
9 big discrepancies in somebody saying you really should
10 be doing this and we're saying, no, you don't need to
11 do that.

12 MEMBER RYAN: Fair enough.

13 MR. RUBENSTONE: All right.

14 MR. WILLIAMS: Right.

15 MEMBER SHACK: Of course, you probably
16 asked the same people.

17 MR. WILLIAMS: Well, it wasn't really all
18 the same, but, yes, we --

19 MEMBER SHACK: There's only so many people
20 out there.

21 MR. WILLIAMS: Yes, right. You know, we
22 sent out our report through the John Kessler escape
23 process that you've heard about to get comments and so
24 forth. So we've tried to vet it through everybody we
25 know that are experts on this. Okay. And this is the

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1 other slide, I think, that you asked me touch on and
2 it's in another, we call them, work packages, and this
3 is an engineering analysis.

4 It's all related in the storage and
5 transportation area and this is just to describe some
6 of the additional work we're doing. One thing that
7 we've got some money earmarked for was to develop
8 multi-purpose canister systems. So that's something
9 we've just started some work on and we're in the
10 procurement stage so I can't really talk much about
11 that.

12 Conduct thermal analysis of the Calvert
13 Cliffs system and what we're trying to do there, we're
14 participating in this inspection, is looking at how
15 does our modeling match up with the measured
16 temperatures? And I just received an email that the
17 coldest, you were asking about the coldest
18 temperature, it was, we modeled it at a 112 and it was
19 measured at a 110, or vice versa, for the --

20 MR. RUBENSTONE: Fahrenheit.

21 MR. WILLIAMS: Yes. Right.

22 CHAIR ARMIJO: Yes, surface temperature
23 after what?

24 MR. WILLIAMS: Right.

25 CHAIR ARMIJO: Fifteen years or ten years?

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1 MR. WILLIAMS: That was the oldest one, so
2 that was about 20, maybe 18 or so, and then the hotter
3 one was a 124 versus it was modeled at a 120. And
4 they even have suggested some rationale for why there
5 was a difference, which I don't think there was much.

6 CHAIR ARMIJO: Hot off the press thing.

7 MR. WILLIAMS: Right. Like I said, just
8 15 minutes before I left I got an email about this.
9 I wasn't able to make the examination. Okay. Then on
10 hydride reorientation, we're trying to do some actual
11 calculations to try and predict how they would happen,
12 the theory behind it, and then tie that up with our
13 testing that we're doing down at Oak Ridge with doped
14 cladding to see if we can actually predict how it's
15 happening, and this is work that's just under way
16 right now.

17 Another bit of work that we're doing --

18 MEMBER POWERS: Just the zircaloy clads?

19 MR. WILLIAMS: Yes. Well, I believe
20 that's where they're starting. I'm not sure, the
21 details, on all the different cladding ranges, but
22 it's just getting underway. I haven't seen any
23 reports out of it yet, so I would think that the first
24 priority would be on the zircaloy clad.

25 And then the last bullet down there, one

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1 of the other important elements that's been identified
2 in here, I think Bob or Jim touched on it, was the
3 transportation, you store it, and then you transport
4 it, and then maybe you transport it again, what are
5 the stresses? And so we're looking to setup some
6 actual vibration testing of fuel cladding to look at
7 the testing.

8 And this work will support the gap
9 analysis that we've done and so, basically, where
10 we're going in DOE is, we've done this work trying to
11 identify the gaps and now we're starting on the
12 experimental programs. And one other one that we want
13 to put in here is a full-scale demo that we just
14 started to work on, again, with the industry.

15 We're just laying out the scope of that
16 demo this year, trying to determine where it would be
17 done, what fuels would be done, focusing on high
18 burnup fuel, and how casks would be instrumented, and
19 so forth. And that's just getting underway as well.

20 So in conclusion, basically, DOE/NE is
21 supporting the development of the technical basis for
22 certification of very long-term storage followed by
23 subsequent transportation.

24 We're looking at the development of a plan
25 to support the experimental data gathering, we're

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1 conducting experiments, we're working with NRC to
2 properly integrate the information, we're
3 participating closely with industry to make sure we're
4 doing the right thing, as well as with the
5 international programs that Bob mentioned, the
6 Japanese, and the Spanish, the Koreans, and I think
7 the Germans also, and so this is mainly a little bit
8 of our program.

9 MEMBER RYAN: That's great, Jeff. Thanks.
10 That's a great summary. I think the takeaway message
11 from the subcommittee was that it has pretty good
12 coordination and alignment with what DOE is doing and
13 what the NRC is sponsoring, so there's good
14 communication and hopefully, you know, a better
15 dataset from the combined effort, so appreciate that.

16 MR. WILLIAMS: Yes. We feel we have some
17 resources, and, you know, money, and facilities that
18 maybe we can help answer some of the questions.

19 MEMBER RYAN: That's great.

20 MR. WILLIAMS: Okay.

21 MEMBER RYAN: Thank you very much, Jeff,
22 appreciate it. We have John Kessler on the phone.
23 John?

24 DR. KESSLER: Yes, I'm here. Can you hear
25 me okay?

1 MEMBER RYAN: Okay. You have 18 slides
2 and not that many minutes, about seven or eight.

3 DR. KESSLER: Not to worry. Jim and Jeff
4 have covered some of this stuff and a lot of them go
5 fast, so I should be okay.

6 MEMBER RYAN: Okay. Great.

7 DR. KESSLER: Some of the committee
8 members, I can barely hear when they ask questions, so
9 you may have to repeat them, but let's get going here.
10 Okay. Slide 2, you kind of heard about this already
11 and it's, extended storage is an international issue.
12 It's not a U.S.-specific one in the sense that most
13 nuclear countries to or are already facing extended
14 storage because they don't have reprocessing, they
15 don't have disposal, and while some of them have
16 centralized or consolidated storage, it's still
17 storage.

18 And so with everybody having the same
19 issue and starting to do work on it, there is a major
20 need to share data and collaborate. Slide 3, so in
21 2009, EPRI launched the Extended Storage Collaboration
22 Program, or it's now dubbed ESCP. The purpose that we
23 had was to bring together U.S. and international
24 organizations engaged with active or planned R&D
25 programs in this area.

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1 And across the, you know, globe now we
2 have a lot of storage and transportation vendors. We
3 have regulators and their R&D contractors, one of
4 which is NRC. We have lots of national waste
5 management organizations. We have R&D organizations,
6 DOE and EPRI, as well as with a lot of outside ones,
7 and industry, which includes utility and cask vendors.

8 We have participants from roughly 20
9 countries now and we have roughly a 150 people that
10 have shown up to various meetings from those
11 countries. Slide 4. This is getting into a bit of
12 what Jim talked about, but in terms of this ESCP
13 program, the purpose is just what Jim talked about for
14 NRC; provide the technical bases to ensure continued
15 safe long-term used fuel storage and future
16 transportability.

17 That program that we're working on is in
18 three phases. Phase 1, you've heard about already,
19 pretty much, reviewing the current technical bases and
20 conduct gap analyses for the storage systems. Phase
21 2, you just heard from Jeff, is that conducting
22 experiments, field studies, and additional analyses to
23 address those gaps. We're all getting going on that
24 next. Phase 3, this long-term performance
25 confirmation effort that, again, Jeff alluded to right

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1 at the end.

2 Slide 5. So again, not to spend too much
3 time on it, this is a summary of the highest priority
4 gap analyses that I pulled together from the various
5 gap analyses that you heard about. Definitely welded
6 stainless steel canisters, stress corrosion cracking
7 is at the top of the list, high burnup cladding,
8 because of hydriding effects that could cause
9 embrittlement, is on the list, bolted casks, those
10 kinds of corrosions, and then fuel pellet swelling,
11 you heard from Jim earlier.

12 Slide 6. Cross-cutting needs was also
13 addressed a bit by Jim. There's quite a few listed
14 there. The two that are at the top of the list, the
15 improve thermal modeling, Jim already talked about in
16 terms of why that's valuable. The degradation
17 monitoring systems, I think it was Bob talked a little
18 bit about, which is, you know, can we do things from
19 the outside or what kind of R&D, and I think it's a
20 very long lead time R&D to do things from the inside,
21 setting signals right out through the canister.

22 There's other cross-cutting needs like
23 stress profiles, you heard about adequacy of drying,
24 some criticality issues, et cetera. I'm not going to
25 go into those details. Slide 7. Now I'm going to

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1 switch from ESCP to what EPRI's plans are and actually
2 activities we have now.

3 The first one I'm going to talk about is
4 the in situ inspection of stainless steel canisters
5 that you already heard a bit about. Slide 8. I
6 really don't think I need to go through it again. You
7 heard a pretty good detail from Jim and a bit from
8 Jeff about, what are the conditions to cause stress
9 corrosion cracking? What we care about is at the
10 bottom.

11 What we don't know are, what are the
12 conditions on the canisters and how well do those line
13 up with these lab experiments and other R&D in terms
14 of, do we have the same conditions on the canisters
15 that could support stress corrosion cracking? So
16 that's what we're setting out to do. Slide 9. Jim
17 and Bob mentioned the inspection at Calvert Cliffs
18 that was done just two weeks ago, or whenever the
19 dates are.

20 We picked that because, yes, it's about a
21 half mile from the Chesapeake Bay, so it's semi-marine
22 environment. We also wanted to pick canisters that
23 were in service for a while so that they were cooler
24 and you heard temperature measurements from Jeff that
25 are the ones that I understand they've collected too.

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1 And also, if they're older, they've had a chance to
2 pick up some salt on to the surfaces, so we wanted to
3 look at those.

4 There were two canisters that were
5 inspected as Bob mentioned. HSM-15 was where they did
6 the visual inspection, that was the warmer of the two,
7 for their license renewal. This is Constellation I'm
8 talking about. And then HSM-1, which was their
9 oldest, coldest one, is kind of the R&D canister, for
10 lack of a better word.

11 In addition to doing some further
12 inspections, we took surface temperature measurements
13 that you heard from Jeff as well as took a look at
14 some of the deposits on the surface of the canister.
15 We have those deposits collected and EPRI is looking
16 now to find somebody to do the analysis for it. We're
17 pursuing some leads there.

18 Current situation is that Constellation is
19 preparing a report for NRC that is due later this
20 year. You did hear about we're planning to do more
21 inspections, starting our focus with systems that are
22 near the coast. We may go inland. We are planning to
23 do several more and for the follow-on ones, the
24 Department of Energy is providing co-funding, which we
25 appreciate.

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1 Slide 10. This entailed the Calvert
2 Cliffs system. This gives you kind of a cutaway view
3 of what we're looking at here. You can see, if you
4 look in the bottom left, kind of a slanted green thing
5 there, that is the air inlet that brings in air
6 underneath canister, which is sitting horizontally in
7 the middle, it's convection cooled from the decay
8 heat, and the air then goes out those outlet vents.

9 The boroscope that Bob mentioned was
10 inserted through those air outlet vents and fished in
11 and around the outside of the canister, and they got
12 a pretty decent look at the canister there. And then
13 through the front door that we took off, or
14 Constellation took off, we did the temperature and
15 surface contaminant that's on the left.

16 Slide 11. This is a picture of the two
17 guys during the drop-in, slipping in the tool right
18 around that door entrance where we had a 3/4-inch gap
19 to put in something to collect surface contaminants.

20 Slide 12. This is from the mockup. I mean, in real
21 life, from that picture, you'd be standing right
22 inside the module, but for the mockup, we could
23 actually see that instrument making sure that it would
24 actually sit on top of the canister.

25 This is one where they were deploying

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1 what's called a SelfSmart, which is essentially a
2 glorified -- that you could get wet and it dissolves
3 the salts that are on the surface of the canister for
4 a certain area so that you can determine the salt
5 concentration. So that's just an example of the kind
6 of tool that was used.

7 Slide 13 is another photo. This is a
8 surface deposit collector. It's literally a glorified
9 Scotch-Brite sponge that you use in your house where
10 they pulled a vacuum with a particular filter behind
11 that sponge and then we've collected the sponge as
12 well as the particulate filter for more of a gross
13 contaminant analysis to, you know, backup that
14 SelfSmart measurement.

15 Slide 14. So where are we headed with all
16 this? This was mentioned a bit before. Industry's
17 goal is to develop this industry-wide stainless steel
18 canister aging management plan. And this gets to the
19 I think one of you had earlier, which was, are they
20 all being inspected on the same schedule or should
21 some be inspected differently?

22 That's exactly what we want to address in
23 the aging management plan. Which containers might be
24 susceptible to stress corrosion cracking, where are
25 they, and when might they be entering the range of

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1 susceptibility? And so then you might want to do
2 inspections at the right locations and at the right
3 time, you know, stepped up inspections of those, and
4 that's the idea.

5 We want to develop the inspection plan and
6 then part of the aging management plan will be
7 mitigation, additional inspections if required, all
8 the way through replacement of the systems if
9 necessary. So that's the goal, is an aging management
10 plan and we've got to collect a lot of information to
11 get there.

12 CHAIR ARMIJO: Jim, quick question.

13 DR. KESSLER: Slide 15. Now I'm going to
14 switch to talking about the stainless steel --

15 CHAIR ARMIJO: John. I'm sorry.

16 MR. RUBENSTONE: Hang on. We have a
17 question.

18 CHAIR ARMIJO: Quick question.

19 DR. KESSLER: Okay.

20 CHAIR ARMIJO: In your mitigation plans,
21 what is your thinking now? I know you don't have
22 specific plans, but --

23 DR. KESSLER: I can barely hear you. Can
24 you get closer to your mic or something?

25 CHAIR ARMIJO: Yes.

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1 MEMBER RYAN: The microphone is up there
2 is where you need to talk.

3 CHAIR ARMIJO: Okay. I'll talk as loud as
4 I can. What are your mitigation plans? What are you
5 thinking about as far as this stainless steel stress
6 corrosion cracking problem?

7 DR. KESSLER: Mitigation could be, one of
8 the things that we've talked about internally is, if,
9 say, we have stress corrosion cracking and it's minor,
10 in the sense that it's not extensive, but you may have
11 one or two places, we've talked about maybe simply
12 applying some patch which would not be a structural
13 patch, but would be enough to (telephonic
14 interference) a crack, assuming there is one.

15 We're doing analyses, in fact, analyses
16 already exist about the consequences of, if you did
17 have a through-wall crack, what might that mean for
18 release? I believe that Constellation has already, in
19 their safety assessment, that kind of a calculation.
20 We are also going to start looking at, you know, do we
21 need to develop dry transfer systems?

22 Everything from, can we pull this canister
23 out and take the fuel out into a new canister?
24 There's been discussions about maybe taking the
25 canister and just sliding it into a brand new canister

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1 that's a little bigger. We have not gotten that far
2 in terms of mitigation techniques, but we are thinking
3 about that.

4 We're also encouraging Department of
5 Energy to work with us in terms of developing some of
6 those techniques, particularly the dry transfer
7 systems could be of use for R&D as well as general use
8 for, say, at a centralized storage facility. So we're
9 just getting going in trying to address that question.

10 MEMBER RYAN: Next.

11 DR. KESSLER: All right. So back to
12 Slide 15. Switching gears now and talking about this
13 high burnup confirmatory data collection effort,
14 preferably full-scale in the end. Jeff Williams
15 mentioned it, this is the very end of his talk. Slide
16 16. So what is it that we need from this high burnup
17 demo? Ultimately, what we're after is confidence and
18 understanding of longer term behavior of dry storage
19 systems.

20 And that's going to require the model
21 development and the benchmarking data you've heard a
22 bit about. We certainly need these small-scale
23 separate effects testing, everything from lab scale,
24 understanding what each of the effects may be on the
25 system to, maybe, some small-scale more than just

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1 single effects testing type of experiments that could
2 go on for quite a few years.

3 Ultimately, we think we're going to have
4 to do a confirmatory test under prototypic conditions
5 to really have confidence in our understanding to
6 develop aging management plans and understanding how
7 long these systems will last. Prototypic means full-
8 scale. We have representative dry storage conditions,
9 that would be the way it's dried, the temperatures at
10 the beginning, the way the temperatures evolve, et
11 cetera.

12 We would like to take a look at multiple
13 high burnup fuel types because not all fuel is the
14 same. There's ZIRC4, M5, ZIRLO, et cetera, and it
15 would be good to have high-burnup fuel from all those
16 kinds involved in this test. Slide 17. For the
17 activities that need to go on for this full-scale
18 high-burnup demo are listed here.

19 And one of the things that industry is
20 interested in is getting this demo going sooner rather
21 than later because both NRC and the industry are aware
22 of when some of these license extension requests are
23 coming up, especially for some of the high-burnup
24 systems, which are starting to hit in, say, 15 years
25 or so, so the sooner we get some of these demos going

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1 so we've got some data to support those license
2 extension requests, the better off we are.

3 So back to what the activities are. First
4 bullet there, obtain t=0 data from sister rods. We
5 want to, essentially, understand what's the condition
6 of the rods in the spent fuel assemblies as they are
7 being put into the dry storage system so that later
8 one when we take some back out and look at them we
9 know what's changed.

10 And the t=0 data is everything from
11 profilometry so we know whether the cladding cracks
12 during storage to how many hydrides, you know, the
13 concentration of hydrides in the zirconium, the
14 orientation of those hydrides, helium pressure, et
15 cetera.

16 Then, the things that need to be done for
17 this special demo are the next set, which is to modify
18 some existing casks with a special lid that includes
19 things like thermocouples and ability to gas samples
20 for helium, fission product gases, in case there's
21 been a leak at one of the pieces of cladding. Water,
22 also, you heard Bob talk about adequacy of drying, so
23 being able to get some water samples in terms of, you
24 know, water vapor, oxygen ingress, all those kinds of
25 things would be of interest.

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1 DOE may have interest in doing a few other
2 things like, maybe, strain gauges. Then the idea
3 would be to load the cask, and replace the modified
4 lid, and you're going in terms of collecting data.
5 The data collection, as soon as the lid goes on,
6 because you're starting to get the thermocouple data
7 and the gas data from day one of storage.

8 And so we'll periodically capture the
9 temperature data and the gas evolution during drying.
10 Then it could sit there. The bottom bullet. So it
11 sits at this host site for maybe ten years or so,
12 continuing to take temperature and gas measurements.
13 Then at that point, you reopen it, you take some rods
14 out, you visually inspect them, compare them to the
15 t=0 properties, and now you have a pretty good idea
16 how much the cladding has changed, how much the
17 internals of the canister have changed over this X
18 year time period.

19 This is the kind of thing that was done
20 for the lower burnup casks that are sitting at Idaho.
21 We want to repeat this now for a higher burnup system
22 that's going to be required. Slide 18. Again,
23 getting back to this industry need to get things going
24 sooner rather than later. A high-burnup demo option
25 that keeps the startup time short would be to, let's

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1 get this demo going at a reactor site.

2 So you don't have to worry about
3 transportation upfront to a national lab to get all
4 the assemblies in one place. It avoids having to wait
5 for a full-scale hot cell to be funded and constructed
6 because, right now, the U.S. no longer has a hot cell
7 big enough to handle a full-sized cask, and it keeps
8 the cost lower prior to test initiation.

9 Right now, Dominion and Transnuclear are
10 proposing an option where Dominion would host this at
11 either North Anna or Surry, they could maybe get it
12 going in three to five years. North Anna has three
13 different kinds of high-burnup fuel, which is good.
14 TN is going to supply some casks at a lower cost. We,
15 at EPRI, are providing initial funding for the
16 instrumented lid design.

17 We are going to invite NRC and DOE to
18 provide us input in terms of how that lid should be
19 designed and we are very strongly looking for co-
20 funding because this is going to be quite an effort to
21 get this done. So those are the two things that I
22 wanted to talk about in terms of particular projects
23 that EPRI is working on as well as a bit about the
24 ESCP program.

25 CHAIR ARMIJO: Is that lid on a bolted

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1 cask or is it on a welded? You better repeat it.

2 MR. RUBENSTONE: John, did you hear the
3 question?

4 DR. KESSLER: No, I really could barely
5 hear.

6 MR. RUBENSTONE: The question is, the lid
7 of this demo, is that on a welded or a bolted system?

8 DR. KESSLER: Yes, it'll be a modified
9 bolted lid because we will have penetrations through
10 for the thermocouples through the lid as well as
11 penetration through to take a gas sample. But it's a
12 TN 32 bolted lid design with a modified bolted lid.
13 And the modifications and getting the license
14 approvals is something that is where we obviously will
15 need to interact with NRC as well as making sure that
16 the data we collect are the data that people need.

17 MEMBER RYAN: Okay. John, thank you very
18 much. We appreciate you being on the phone and going
19 through your slides. I think that worked quite well,
20 so we appreciate you taking the time to do that today.
21 I know you're busy.

22 DR. KESSLER: You're welcome. I'll go
23 back on mute and listen.

24 MEMBER RYAN: Okay. Great. Our last
25 speaker is Rod McCullum from the Nuclear Energy

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1 Institute. Welcome, Rod.

2 DR. MCCULLUM: Thank, Dr. Ryan, and I want
3 to thank the committee for taking its time to consider
4 this topic. The topic of extended storage is
5 something that is of great interest to the industry
6 and something we consider a high priority, and we
7 think that this committee's consideration, input, and
8 recommendations will be highly valuable in that
9 regard.

10 It is very important that as -- you know,
11 there's a lot of uncertainty in the world of
12 repositories and ultimate disposal, and such, but one
13 thing that is certain is that we will be storing used
14 fuel for extended periods of time. So I'm encouraged
15 that, hearing from my colleague at DOE, there's work
16 going on there and also from the NRC staff.

17 We definitely need the regulatory
18 framework to be sharp and able to address the
19 challenges of extended storage, and the DOE role here
20 is huge. The fact that we are moving into extended
21 storage is a direct result of DOE's decision making.
22 DOE also has the infrastructure and capabilities to do
23 the work and certainly, a lot of DOE decisions yet to
24 be made will influence how the system works, that I
25 will get to in a minute.

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1 In the interest of time I was going to
2 spend a fair amount of time here on this first slide
3 talking about why we believe there already is a strong
4 basis for extended storage. I'm not going to go over
5 these things. I would just encourage the committee to
6 consider the record that exists. I will correct. It
7 says over 1700 casks. It's really right around 1600
8 now. That's where we'll be by the end of the year.

9 I was looking at my projection somehow.
10 But anyway, and also, to point out one thing that was
11 in your earlier discussion, Calvert is not the first
12 one to go for renewal beyond 20 years. HB Robinson
13 and Surry have been renewed, as has Oconee, and when
14 you look at the record, you'll find that those things
15 are --

16 CHAIR ARMIJO: You never know what's --

17 DR. MCCULLUM: -- that there's a lot of
18 information gleaned from those. Sorry, John. And
19 what I want to focus on is the going forward piece.
20 Now, the last thing I'll say is that there really is,
21 you know, a lot of safety margin here, what you see in
22 the PRAs, I would look at those as well. But looking,
23 and this is what John Kessler talked about, is the
24 opportunities to verify.

25 You know, the confidence we have going in

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1 that we can safely store these things for extended
2 periods of time, to further verify and further provide
3 assurances, to further support the changes in the
4 regulatory framework that we know will be coming. The
5 first thing I would encourage is, we have done a
6 substantial project.

7 The DOE INL dry storage characterization
8 project looked at a 14-year-old cask, opened it up,
9 examined the fuel, and found the fuel in pretty much
10 the same condition it went in after it was stored for
11 14 years and transported. The project John talked
12 about, the demo, that's going to repeat that project
13 with a higher level of sophistication in looking at
14 higher burnup, more challenging fuel.

15 And of course, John also talked about the
16 canister inspections. These last two pieces, above
17 what was done for the previous renewals, above what
18 was done in the Idaho project, and above all that
19 we've learned from our experience with these 1500,
20 1600 casks is more pointed towards extended storage,
21 which is now more known as a certainty.

22 And this is where, really, all the gap
23 analyses and risk prioritization work that you were
24 hearing about comes in together. It's important to
25 industry that we get a good common understanding of

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1 what is needed, that we look at, you know, what the
2 risks really are and what is needed to mitigate the
3 risks, recognizing the safety margin we have going in
4 and that these are dry casks.

5 So we were thankful to be able to comment
6 on the staff's RIS prioritization, on DOE's, we've
7 been commenting on DOE's gap analyses, we've been
8 participating, our utility members in the EPRI
9 project, because we believe that we are in a position
10 where we already, again, when you look at the record,
11 have a strong safety basis, have the opportunity to
12 extend that in a timely matter to consider further
13 extended storage, and making sure that we're looking
14 at the right things, and not simply chasing
15 speculation, is very important.

16 It's also important to look at this in the
17 context of the system that it exists in. This was, I
18 think, alluded a little bit in Dr. Powers' questions
19 earlier in terms of, you know, the real risks here are
20 when you start moving it around and doing stuff with
21 it. You know, we envision storing at reactor sites
22 for multiple decades.

23 You know, again, some systems have been
24 licensed for as long as 60 years already. The
25 regulation allows for 80 years. Transporting it,

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1 perhaps transporting it to a consolidated storage
2 site, and it's at the consolidated site where we
3 believe a lot of the demonstration, research, and
4 development work can be best accomplished if that's
5 the way it comes together, which we hope it would.

6 And what I'm talking about is an
7 integrated system here, perhaps transporting again,
8 perhaps not, if the consolidated storage site becomes
9 a repository site, and then ultimate disposal.
10 Industry filed contentions in the Yucca Mountain
11 licensing proceeding to seek to amend the Yucca
12 Mountain license application to allow for direct
13 disposal of the casks we already loaded.

14 We believed that was possible. I thank
15 EPRI, even though I hung up on them, for the work that
16 supported that and we believe that now, if we have to
17 design a new repository, we should be looking to
18 integrate that to be able to dispose of the existing
19 casks. Again, we have to integrate around the system
20 we have; 1600 casks, soon to be 1700 casks into this.

21 We can't design the system. We can't
22 reverse engineer it from the beginning. We think that
23 the casks we have, you know, again, it's a strong
24 safety basis to go forward and do that. That's why
25 the DOE component of this is so critical. So you have

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1 the regulatory component and you have the DOE
2 component designing the whole system around the part
3 of the system that is irreversibly now already in
4 place.

5 The last point here, which is vitally
6 important, is that, as we integrate this system it
7 must be supported by a more efficient regulatory
8 framework. This is a topic, perhaps, of a different
9 meeting. Industry will be coming forward later in the
10 year with proposals to improve Part 72. Right now,
11 we're in a situation, and it has to do with how the
12 regulatory framework evolved as dry cask storage came
13 in place before it was a mature industry, which it is
14 now.

15 The dry cask storage is regulated at a
16 greater level of detail right now than reactors, even
17 though the risks, I think you'd all agree, of dry cask
18 storage are much less than those of the reactors;
19 remember the PRA number I had on the first slide. So
20 it's basically, to us, the long and the short of it
21 is, if we're going to be cutting down more trees, or
22 cutting down bigger trees, or longer lived trees, in
23 the case of extended storage, we have to have a
24 sharper saw.

25 And so I would appreciate the opportunity

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1 to talk to this committee and relevant subcommittees
2 about that in the future. So in conclusion, you know,
3 we believe and we encourage the committee to look at
4 the things that we've referenced here. There is
5 already a strong basis going forward. We are being
6 proactive and we're trying to work with DOE, which has
7 the capability to really do the lion's share of the
8 work, to further verify the basis for extended
9 storage.

10 And this can't be done in a vacuum, it has
11 to be done considering the ultimate system that we're
12 putting in place and have already put in place, and
13 must, you know, be considered. We fully endorse the
14 recommendations of the recent risk management task
15 force. Those are consistent with some direction the
16 staff got in the SECY for looking at extended storage
17 long-term waste confidence, that we need targeted
18 regulatory improvements to go so this whole system
19 works together.

20 So I'm sorry for rushing through that,
21 but, you know, we're only four minutes late.

22 CHAIR ARMIJO: Pretty well done.

23 DR. MCCULLUM: And I would certainly love
24 to entertain any questions, and again, encourage
25 continued discussions on this issue with the

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1 committee.

2 MEMBER RYAN: If I may, Mr. Chairman, I
3 just asked the question, you mentioned waste
4 confidence, how does that play into your
5 considerations for this issue?

6 DR. MCCULLUM: Well, we think that
7 extended storage is about extending waste confidence.
8 And although there was a recent court decision which
9 remands the rule and vacates it, that court decision
10 focused on three specific defects, none of which go to
11 dry storage. You know, the question of doing the
12 environmental analysis of the case, which there's
13 never a repository, which, fine, you can do that.
14 That's not an eventuality I think we'll ever get to.

15 And then two tasks with respect to fuel
16 pool fires and fuel pool leakage, which we think can
17 also be addressed and analyzed. The court did not
18 contend to rule at all the basis for confidence in dry
19 cask storage that exists in the 80 years of regulatory
20 coverage was in any way deficient.

21 So what we see the linkage to waste
22 confidence, it's really about extending waste
23 confidence to longer periods of time. Keeping in mind
24 waste confidence ultimately goes to a repository.
25 Will we have a repository in the next 20, 40, 60, 80

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1 years? I certainly hope so, but, you know, I deal
2 with technical issues. That's a political issue.

3 And our industry is committed to providing
4 safety in dry cask storage, hopefully at a
5 consolidated site, as long as we need to. And we have
6 a high confidence. You know, these are very robust
7 systems. There are no moving parts. They basically
8 are structures. And if you look at the way these
9 structures are designed and built, and look at all the
10 structures all over the world that have withstood
11 decades and centuries --

12 MEMBER POWERS: Like Seabrook.

13 CHAIR ARMIJO: But, Jeff, you know, you
14 just had to activate me. You know, it seems to me
15 that the industry is really neglecting, particularly
16 on this issue of chloride stress corrosion cracking
17 potential on certain kinds of casks in a marine
18 environment. The industry is ignoring preventative
19 maintenance, simple things that could be done.

20 If you can get a wand in there to scrape
21 salt, and sample salt, and measure temperatures, you
22 certainly can get a hose in there and rinse these
23 suckers off every once in awhile. So, you know, just
24 simple practical stuff that doesn't --

25 MEMBER SHACK: You wouldn't get it all.

1 CHAIR ARMIJO: You'd have a whole lot less
2 than you had before.

3 DR. MCCULLUM: There are differing
4 opinions as to whether or not spraying it down with a
5 hose is the right thing to do or not. And I would
6 point out --

7 CHAIR ARMIJO: It may not be the thing,
8 but there ought to be some preventative maintenance on
9 things where you know you've got a risk out there.
10 The chloride stress corrosion cracking happens in a
11 marine environment.

12 DR. MCCULLUM: Well, and that's what the
13 effort that John Kessler alluded to, and even before
14 that effort was launched, we had been engaged in what
15 we call a regulator issue resolution protocol on this
16 very issue. Mark, this has been well over a year,
17 year and a half, two years, yes, it's been about two
18 years where we've been focused with NRC staff on that
19 very issue.

20 So I guess I take to great heed your call
21 for us to get more action on it, but we're trying to
22 assess the need for maintenance, identify what the
23 right maintenance would be, and I think we have high
24 confidence that we have the time to put those programs
25 in place.

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1 CHAIR ARMIJO: Well, just don't wait until
2 you find a bunch of stress corrosion cracks.

3 DR. MCCULLUM: I think I can credibly say
4 we are ahead of that.

5 CHAIR ARMIJO: Okay.

6 DR. MCCULLUM: And we are not going to
7 drag our feet.

8 CHAIR ARMIJO: Happy to hear that.

9 DR. MCCULLUM: And we're going to continue
10 to stay ahead of that.

11 MEMBER RYAN: I'm reminded of the pilot at
12 10,000 feet that was asked, how are the landing gear?
13 He said, okay, so far.

14 MEMBER BROWN: Can I ask one question?

15 MEMBER RYAN: Please.

16 MEMBER BROWN: Along with this demo
17 project that, you know, they're proposing building
18 something, stuffing stuff in it, monitoring it, and
19 sticking it out there and just looking at it for 10 or
20 15 years, whatever the case is. If you've already got
21 stuff sitting around, you did a 14-year inspection,
22 then why can't you just keep looking at casks that
23 have been sitting around? I mean, you looked at it
24 and it was --

25 MR. EINZIGER: I think I can address that

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1 one. First off --

2 DR. MCCULLUM: Well, Bob, if I could.
3 There's, I think, a distinction here between what goes
4 on inside the casks and the cask. You're absolutely
5 right in terms of looking at -- the canister is the
6 primary barrier and I kind of glossed over -- you
7 know, when I talk about integrating the system, I'm
8 specifically talking about the role of retrievability.

9 If these canisters could be disposable,
10 that puts more emphasis on the canister itself. The
11 demo is intended to look at, what is the condition of
12 the fuel inside the canister? We've done that once
13 with low-burnup fuel. We intend to do that again now
14 with high-burnup fuel, hoping we'll get the same
15 results.

16 MEMBER BROWN: Oh, okay. So you already
17 have a thought in process to look at existing dry cask
18 storage of high-burnup -- okay.

19 DR. MCCULLUM: Right. It's a defense in-
20 depth approach, yes.

21 MEMBER BROWN: Yes, but one you can now
22 and the other one is going to take a long time.

23 DR. MCCULLUM: Right. And the one that's
24 going to take a long time, we're already thinking
25 about how we factor that into license renewals so that

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1 there's a link to, you know, as those things go into
2 their extended license period, actions they would take
3 depending on what we learn from the demo project. So
4 again, it needs to be an integrated effort, and I
5 think it is, and we're committed to continuing it.

6 MEMBER RYAN: Bob, just for the court
7 reporter, tell us who you are again.

8 MR. EINZIGER: Bob Einziger from the NRC.
9 The examination that was done before, as Rod
10 mentioned, was low-burnup fuel. We don't see big
11 issues with that, but one of the things that came out
12 of that examination is that there was a difficulty and
13 an uncertainty added into the interpretation of the
14 data because there was no baseline.

15 In other words, if we had any major
16 changes in the fuel from what you would normally
17 expect, there would have been a problem in identifying
18 what those changes were. The stuff that's already in
19 storage, we have no baseline on.

20 MEMBER BROWN: So nobody has looked at it
21 for this type of an assessment.

22 MR. EINZIGER: That's right. And so any
23 demo that's going to start now would establish that
24 baseline and follow through so we have something to
25 compare it with.

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1 DR. MCCULLUM: Yes, I agree. This is
2 going to be a much more sophisticated test. We're
3 going to build on what we've learned.

4 CHAIR ARMIJO: I just hope you guys don't
5 turn this into a great science program when it's
6 really an engineering issue. You don't necessarily
7 need a baseline to measure change if you have
8 acceptance criteria on ductility, or fracture
9 toughness, or strain energy to fracture, or something
10 that says this is my acceptance criteria and this
11 stuff that's been in storage for a long time, I don't
12 know the baseline, but it meets it.

13 MR. EINZIGER: The acceptance criteria is
14 that it's been in a reactor, it's been irradiated, and
15 it hasn't had a gross failure.

16 CHAIR ARMIJO: No, but also, when --

17 MEMBER SHACK: What he's saying, you need
18 the rates for is so to set inspection intervals. You
19 know, it meets the acceptance criteria now, when do I
20 next look at it again or do I ever have to look at it
21 again?

22 CHAIR ARMIJO: Well, that's my argument,
23 you know, that you've got stuff that's been out there
24 for a long time. It's been in, you know, hot cells.
25 It's been sitting around. Well, there's a lot of old

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1 fuel sitting in dry environments, not all of it in
2 casks. And so you can measure the fracture toughness,
3 or ductility, whatever it is you're worried about,
4 right now and see if it's susceptible to the kinds of
5 things you're worried about.

6 DR. MCCULLUM: Absolutely. Again, that's
7 exactly the type of input I was hoping to get from
8 this committee and, you know, that's exactly why
9 reaching a common set of agreements on these gap
10 analyses and risk prioritizations is so important, so
11 that we do focus on, you know, what those criteria
12 need to be and making sure that everybody understands
13 what it is to say that they're met.

14 MEMBER RYAN: Thank you, Rod. Any other
15 questions for our speakers from the panel today?

16 CHAIR ARMIJO: Excellent.

17 DR. MCCULLUM: Thank you.

18 MEMBER RYAN: I want to thank all the
19 speakers today, the NMSS staff, and our
20 representatives from DOE, and NEI, and EPRI for
21 participating in this full committee meeting. We had
22 a very productive subcommittee meeting -- okay. And,
23 Chris, you're going to open up the bridge line? I
24 guess so. John was on the line. He dialed in to the
25 other line, he just couldn't speak, so I think he's

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1 been listening effectively. Our end worked okay, I
2 guess it was his end that dropped off. I'm not sure.

3 MEMBER POWERS: There's one question that
4 comes to my mind is, we've spoken a lot about
5 chlorides and stainless steel for locations near big
6 chloride sources, such as oceans and things like that.
7 What about other kinds of things? I know that
8 certainly the gaseous effluents from internal
9 combustion engines affects a lot of things. I don't
10 know how much it affects stainless steels and whatnot.

11 MEMBER SHACK: Well, I think Bob sort of
12 alluded to, you know, the other things that you might
13 worry about besides chlorides, but I don't know that
14 effluents from engines, or something, but I mean,
15 there's an awful lot of contaminants out there in the
16 world.

17 MR. EINZIGER: We're concerned about
18 sulfides?

19 MEMBER POWERS: It's what comes
20 immediately to mind, Bob, but I don't know that that's
21 the only thing.

22 MR. EINZIGER: No, but there is a part of
23 the plan to investigate that further.

24 MEMBER POWERS: Sulfides and sulfuric
25 acids, you know, just come immediately to mind.

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1 MR. EINZIGER: Right.

2 MR. DUNN: This is Darrell Dunn from the
3 Officer Nuclear Regulatory Research. We have looked
4 at the composition of atmospheric deposits that we
5 would expect to occur in non-marine environments. It
6 certainly includes things from, you know, coal-fired
7 power plants, for example, and other types of
8 deposits.

9 So we have looked at what type of deposit
10 chemistries we would expect and we've actually
11 initiated testing to look at the effects of those
12 deposits on the stainless steel materials that are
13 used in dry casks, but that's ongoing work that we
14 have right now.

15 MEMBER RYAN: Thank you.

16 MEMBER POWERS: Anything written up on
17 them?

18 MR. DUNN: I'm sorry?

19 MEMBER POWERS: If you have anything
20 written up on that it'd be real interesting to see.

21 MR. DUNN: Yes, it is ongoing testing
22 that's scheduled to be completed in September of this
23 year.

24 MEMBER RYAN: Actually, just a list of the
25 projects you've got going, you know, by title, would

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1 be helpful just to get a sense of where you're going.

2 MS. GAVRILAS: We'll give them to Chris.

3 MEMBER RYAN: Okay. Great. That's

4 terrific. Thank you. Any other questions? Okay.

5 Are there any members of the public on the bridge line

6 who wish to make a comment? Hearing none, Mr.

7 Chairman, I'll turn the meeting back to you.

8 CHAIR ARMIJO: Okay. Thank you. I thank

9 everybody for good presentations. We're going to have

10 a recess now for about 15 minutes. Be back at 5

11 o'clock. Thank you.

12 (Whereupon, the meeting in the above-

13 mentioned matter went off the record at 4:44 p.m.)

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Development of Interim Staff Guidance (ISG) Supporting the Tier 1 Fukushima Orders

July 11, 2012

Background

- SRM-SECY-12-0025, the Commission directed the staff to take certain actions related to lesson learned from Fukushima
- On March 12, 2012, the staff issued Orders EA-12-049, 050, and 051, which evolved from the NTTF Recommendations 4.2, 5.1, and 7.1.
- Developing Interim Staff Guidance
 - Draft ISG Public Comment Period ended July 7
 - Final ISG scheduled to be issued by August 31, 2012

Mitigation Strategies Order ISG

- NEI 12-06 Guidance
- Draft JLD ISG-12-01
- Additional Information

NEI 12-06, Diverse and Flexible Coping Strategies Implementation Guide

- NEI document provides licensees with guidance on how to implement FLEX for their site
- Each site is to follow an assessment process
 - Initial conditions and boundary conditions
 - Establish plant-specific baseline coping capability
 - Determine applicable extreme external hazards
 - Define site-specific FLEX capabilities
 - Programmatic controls
 - Offsite resources

Define Site-Specific FLEX Capabilities

- Aggregation of FLEX capabilities for the site based on hazards
 - Protection of equipment
 - Deployment of equipment
 - Procedural interfaces
 - Off-site resources
- Need to have N+1 sets of portable on-site equipment (to accomplish the 3 key safety functions)

JLD ISG-2012-01

- Endorsement of NEI-12-06 with exceptions
- Reporting requirements
 - Overall integrated plan
 - Status report
 - Full implementation letter

Additional Information

- NEI 12-06, Revision C Received
- Consensus standards
 - INPO AP-913, Equipment Reliability Process Description

Reliable Hardened Vents Order ISG

- Overview of Order
- Order Requirements
- Interim Staff Guidance

March 2012 Order

- BWR Mark I and Mark II containment designs.
- Requirements focus on strategies relating to preventing core damage.
- HCVS to protect containment from failure due to overpressure until core damage is averted and the plant stabilized, or until core damage is imminent.

March 2012 Order

- HCVS shall be capable of reliable operation under a range of plant conditions, including a prolonged loss of AC power and inadequate containment cooling.
- Does not provide any requirements for severe accident service (e.g., hydrogen).
- Severe accident service and filtration to be treated as separate issues in an upcoming Commission Paper.

Reliable Hardened Containment Vent

- The HCVS shall be designed to minimize:
 - reliance on operator actions,
 - personnel exposure to occupational hazards, such as extreme heat stress, while operating the HCVS system,
 - personnel exposure to radiological consequences that would impede actions needed for event response.
- Capacity to vent the steam/energy equivalent of 1 percent of licensed/rated thermal power (unless a lower value is justified by analyses)

Reliable Hardened Containment Vent

- Remote or manual operation allowed
- Drywell and/or wetwell venting allowed
- Include a means to prevent inadvertent actuation
- Minimize cross flow between units
- Discharge effluent above main plant structures
- Include a means to monitor the effluent discharge for radioactivity that may be released
- Capable of functioning following a seismic event; Not required to be safety-related beyond 2nd containment isolation valve

Draft Interim Staff Guidance

- Draft ISG prepared by NRC staff (No industry guidance to endorse)
- Stakeholder interactions key
- ISG aligned with requirements for mitigating strategies order (NEI 12-06 points to HCVS Order requirements).
 - The HCVS shall function with permanently installed equipment providing electrical power (e.g., DC power batteries) and valve motive force (N₂/air cylinders) for first 24 hours.
 - Durations of less than 24 hours will be considered if justified by adequate supporting information from the licensee.
 - Licensees are allowed to credit manual actions, such as moving portable equipment to supplement electrical power and valve motive power sources.

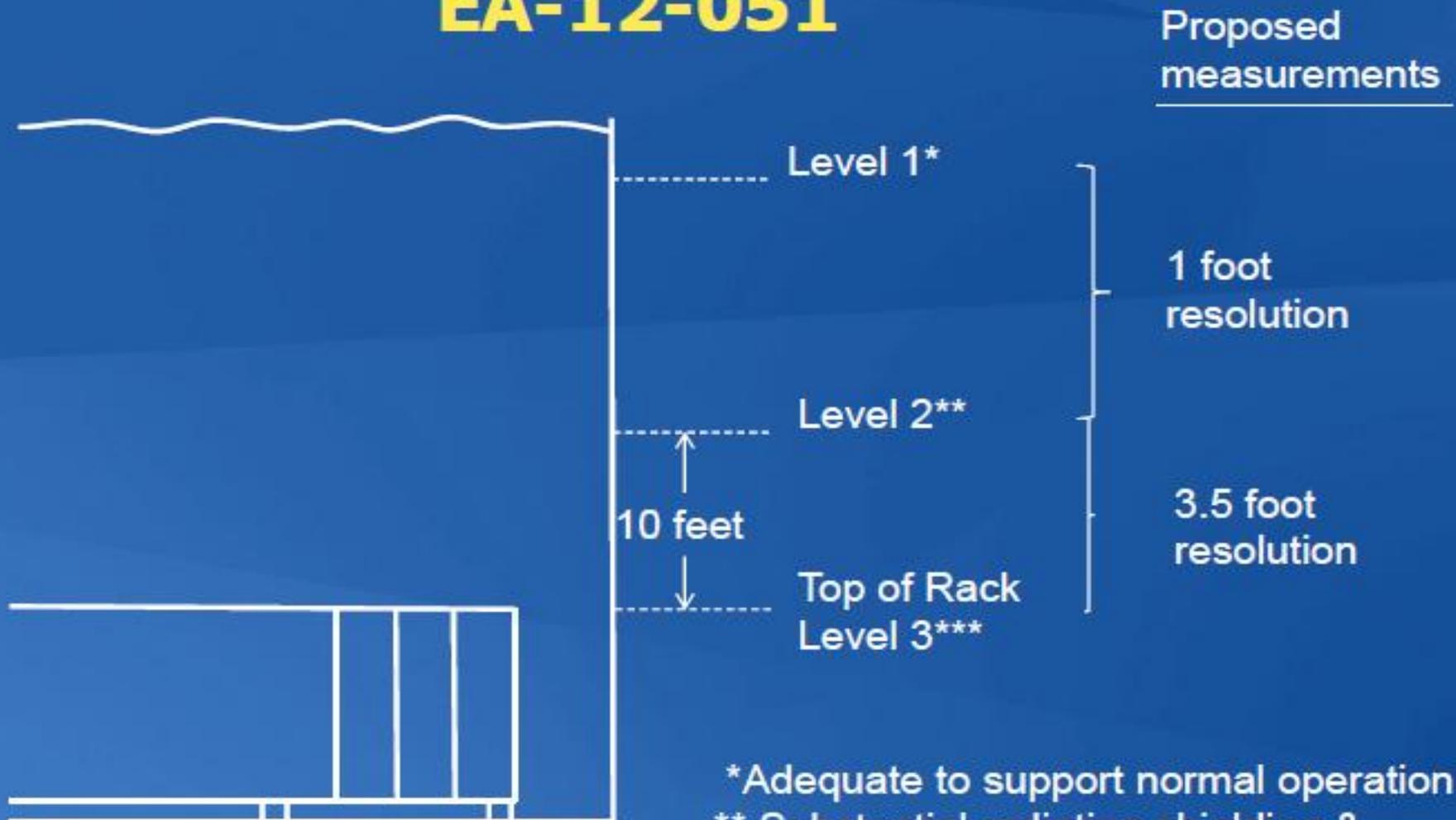
Spent Fuel Pool Instrumentation Order ISG

- NEI 12-02, Revision B
- Draft JLD-ISG-12-03

NRC Instrumentation Criteria

Design Features	NRC Expectations in ISG
Instruments	<ul style="list-style-type: none"> • Permanent fixed primary level instrument • Backup level instrument (portable or fixed)
Monitoring Availability	<ul style="list-style-type: none"> • Continuously available, indication on-demand • Calibration maintained through power interruption
Display Locations	<ul style="list-style-type: none"> • Control Room, Alternate Shutdown Panel, or other • Portable device usable from accessible location
Supports Prompt Identification of these Pool Conditions	<ul style="list-style-type: none"> • Level adequate for operation of forced cooling • Level threatening access – inadequate shielding • Level at just above top of stored fuel
Qualification	<ul style="list-style-type: none"> • Augmented quality (e.g., fire protection QA) • Optimize missile protection using existing structures • Seismic Category I mounting of equipment • Demonstrated to function in harsh environment • Equipment resistant to radiation and vibration
Power Supply	<ul style="list-style-type: none"> • Non-safety power plus alternate (battery replacement or external power connection)

Level Indications EA-12-051



- *Adequate to support normal operation
- ** Substantial radiation shielding &
- ***Actions to implement makeup water should no longer be deferred.

NEI 12-02 Guidance Document

- NEI 12-02, Revision B, submitted on May 11 for NRC review and endorsement
- Instrument Design Features
- Program Features

Draft JLD-ISG-2012-03

Endorsement of NEI-12-02 with exceptions:

- Specify that instruments must be able to resist beyond design basis external events
- More explicit discussion on differences between resolution and accuracy
- Modify guidance used to establish Level 2 (dose rates limit access to pool deck)
- Specified that level readings are to be available when required / promptly accessible
- Provided detailed integrated plan template

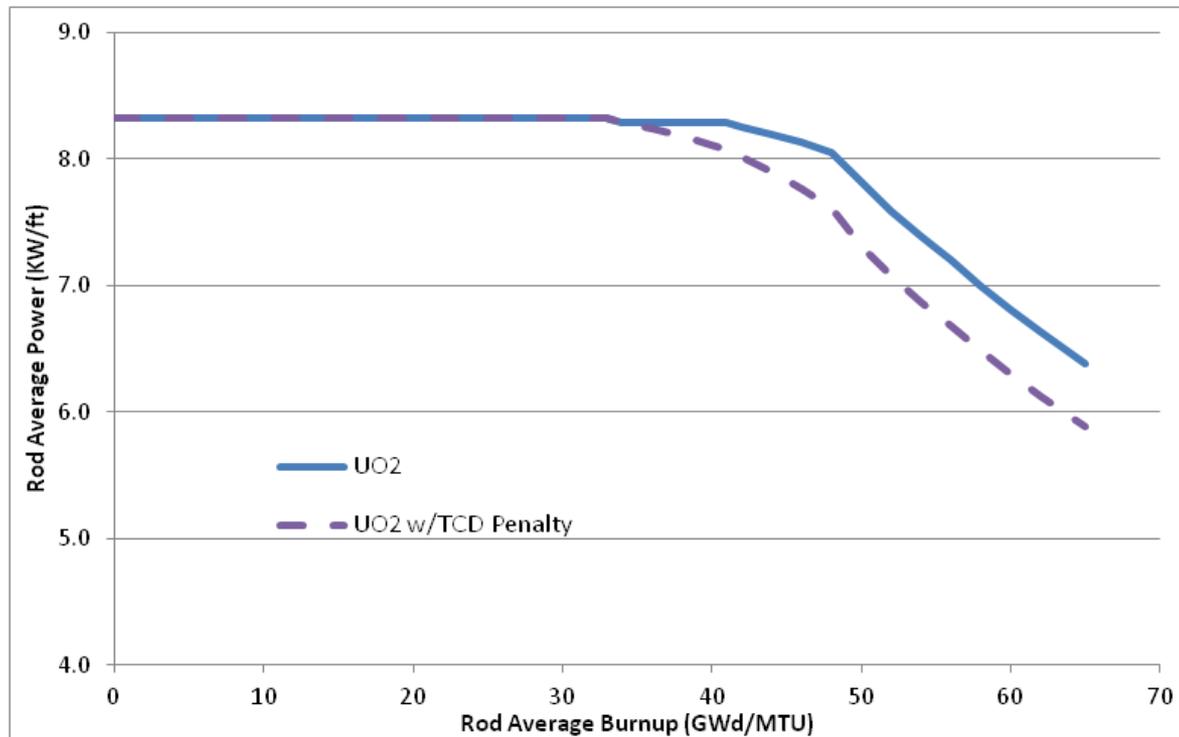
Two stage approach:

1. Reviewed SL2 EPU fuel thermal-mechanical design.
 - Reviewed FATES-3B fuel rod design calculations w.r.t. TCD.
 - Negotiated TCD penalty based on comparison to expanded Halden fuel temperature database.
 - Audited Westinghouse calculations.

2. Performed FRAPCON-3.4 confirmatory calculations for UO₂ and Gadolinia fuel rod designs.
 - End of life rod internal pressure
 - LOCA initialization fuel stored energy
 - AOO power-to-melt limits
 - AOO cladding strain

TCD Penalty – UO₂ Fuel

- Fuel design calculations based upon original rod power profiles.
- More restrictive rod power profiles, preserved via reload design checklist, maintains TCD penalty.



Confirmatory Calculations

- NRC staff performed FRAPCON-3.4 fuel rod design calculations on the SL2 16x16 CE HID-1L design (ML12082A196).
- Calculations confirm that SL2 fuel rod designs satisfy design requirements at EPU conditions.
 - Sufficient plenum volume to accommodate EPU FGR.
 - Penalized radial fall-off ensures BOL stored energy limiting.
 - AOO power-to-melt limits found acceptable.
 - AOO pre/post power limits found acceptable.



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Protecting People and the Environment

NUREG-1934/EPRI 1023259

Nuclear Power Plant Fire Modeling Analysis Guidelines

ACRS Committee

July 11, 2012

Mark Henry Salley, NRC/RES

Rick Wachowiak, EPRI



**Office of Nuclear
Regulatory Research**



*Fire Research
Branch* 



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Protecting People and the Environment

Purpose of the Meeting

- NRC and EPRI have completed the project
- ACRS PRA Subcommittee – March 21, 2012
- Today we would briefly like to discuss:
 - Need & Use of the Report
 - Stakeholder Involvement
 - Response to Comments
 - Future Work in Fire Modeling
- Request a Letter from the ACRS

Purpose of Report

- Replaces 2001 EPRI Fire Model User's Guide
- Provides updated fire model information, 2007 V&V study enhancements, model validity ranges, uncertainty analysis, more realistic examples
- Serves as the text book for NRC/EPRI Fire PRA Advanced Modeling course
- Provides a consistent framework for reporting the results of fire modeling calculations

- NRC/EPRI Memorandum of Understanding
 - Fire Research Addendum
 - Provides for Joint Publication
- Team Composition
 - NRC Experts
 - Industry Experts
 - NSSS Vendors
 - Consultants
 - National Institute of Standards & Technology
 - Universities

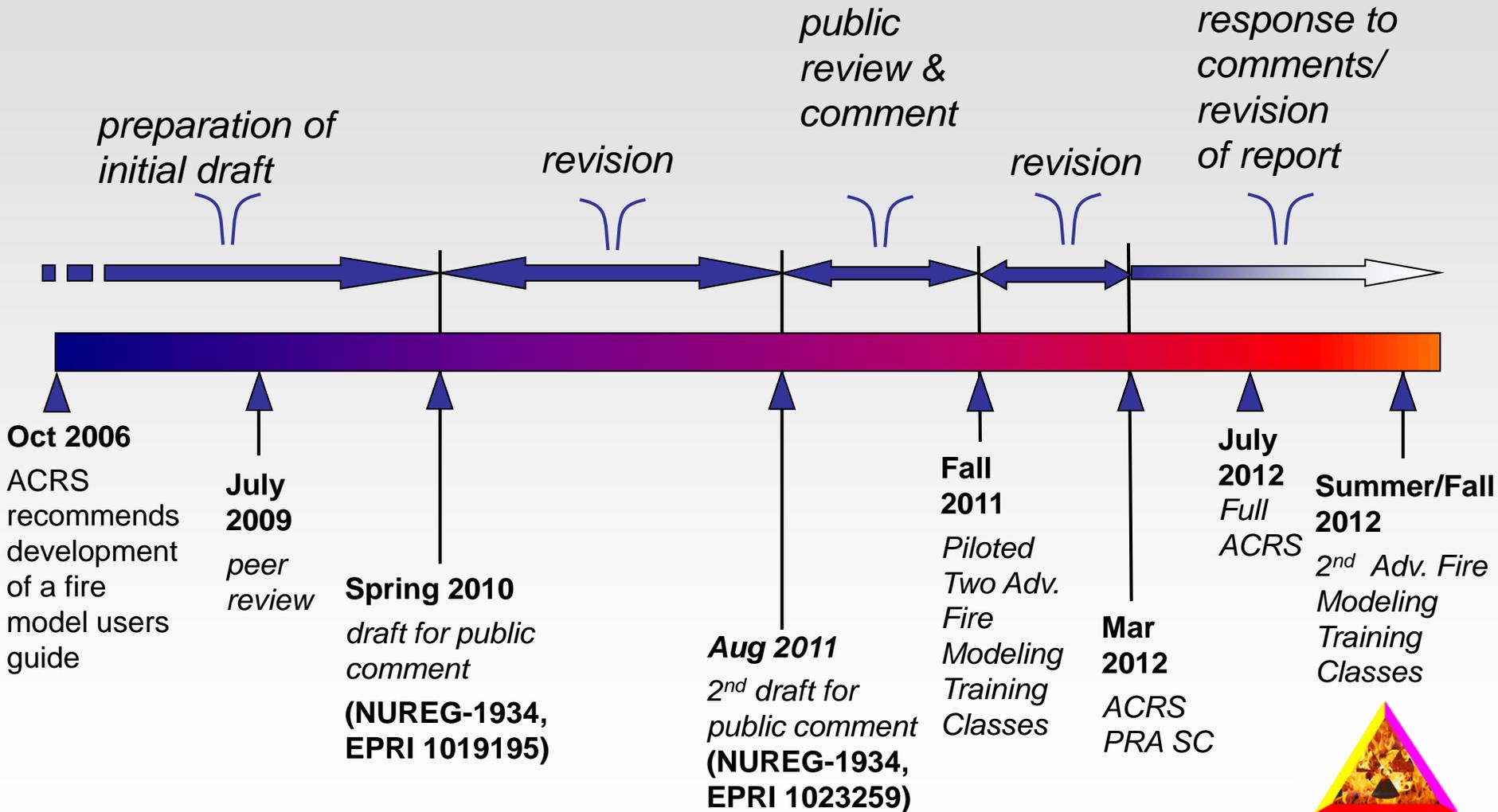


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Protecting People and the Environment

Project History





Today's Presenters

- David Stroup, NRC
- Kevin McGrattan, NIST
- Francisco Joglar, Hughes Associates



Fire Modeling Process

- 1) Define objective(s)
- 2) Describe fire scenario(s)
- 3) Select fire model(s)
- 4) Calculate fire-generated conditions
- 5) Conduct sensitivity and uncertainty analyses
- 6) Document the analysis

Two Rounds of Public Comments

- Expand uncertainty discussion
- Selection of fire scenarios and model inputs
- Use of fire models beyond their range of validation

ACRS Subcommittee Comments

- Use of Models Outside V&V Range
- New Models (THIEF, FLASHCAT)
- Consistent Selection of Models
- Sensitivity Analysis – Conservative
- Parameter Uncertainty Propagation
- Clarity
- Editorial



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ACRS Review of NUREG-1824

ACRS Recommendation 1:

The user's guide should provide estimates of the ranges of normalized parameters to be expected in nuclear plant applications.



UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D.C. 20555-0001
ACRSR-2219

October 25, 2006

Mr. Luis Reyes
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington DC 20555-0001

SUBJECT: DRAFT FINAL NUREG-1824, "VERIFICATION AND VALIDATION OF
SELECTED FIRE MODELS FOR NUCLEAR POWER PLANT APPLICATIONS"

Dear Mr. Reyes:

During the 536th meeting of the Advisory Committee on Reactor Safeguards, October 4-6, 2006, we met with representatives of the NRC staff, Electric Power Research Institute (EPRI), and the National Institute of Standards and Technology (NIST) to discuss the draft final NUREG-1824 (EPRI 1011999), "Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications." Our Subcommittee on Reliability and Probabilistic Risk Assessment (PRA) also reviewed this matter during its meeting on September 21, 2006. During our review, we had the benefit of the documents referenced.

CONCLUSION AND RECOMMENDATIONS

1. The report provides a systematic evaluation of the predictive capability of five commonly used compartment fire models. It should be published.
2. The user's guide to be developed by the staff should include:
 - a. Estimates of the ranges of normalized parameters to be expected in nuclear plant applications.
 - b. Quantitative estimates of the uncertainties associated with each model's predictions, preferably in the form of probability distributions.

BACKGROUND

Fire models are used in a number of safety evaluations, including fire risk analysis; demonstrating compliance with, and exemptions to, the regulatory requirements for fire protection in 10 CFR Part 50, Appendix R; the significance determination process of the Reactor Oversight Process; and establishing the risk-informed, performance-based voluntary



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Normalized Parameters

Quantity	Normalized Parameter	Validation Range
Fire Froude Number	$\frac{gD}{v^2}$	0.4 – 2.4
Flame Length Ratio	$\frac{L}{D}$	0.2 – 1.0
Ceiling Jet Distance Ratio	$\frac{Z}{D}$	1.2 – 1.7
Equivalence Ratio	$\frac{m}{m_{st}} \sqrt{\frac{\rho_{air}}{\rho_{fuel}}}$	0.04 – 0.6
Compartment Aspect Ratio	or	0.6 – 5.7
Radial Distance Ratio	$\frac{r}{D}$	2.2 – 5.7

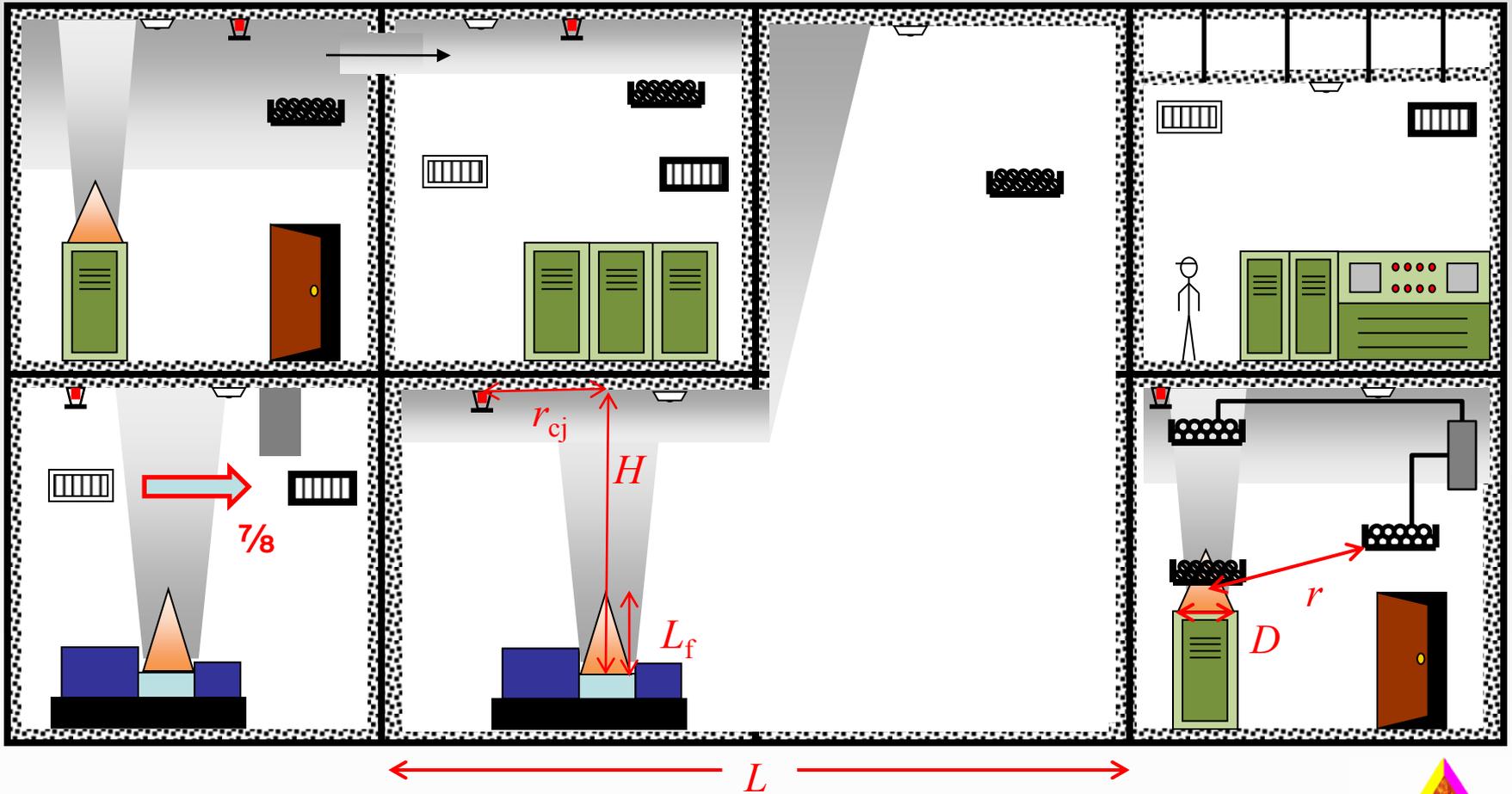


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Typical fire scenarios and important parameters





Summary of NUREG-1824 V&V Study

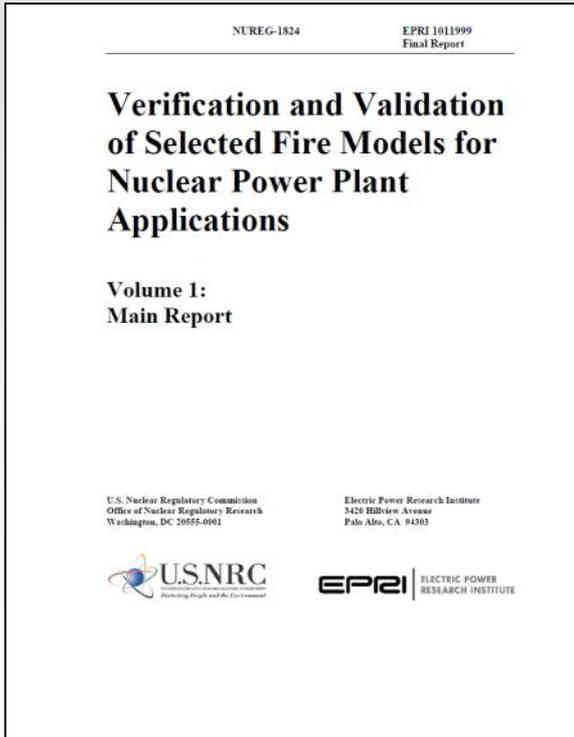


Table 3-1: Results of the Validation & Verification of the Selected Fire Models for Nuclear Power Plant Fire Modeling Applications

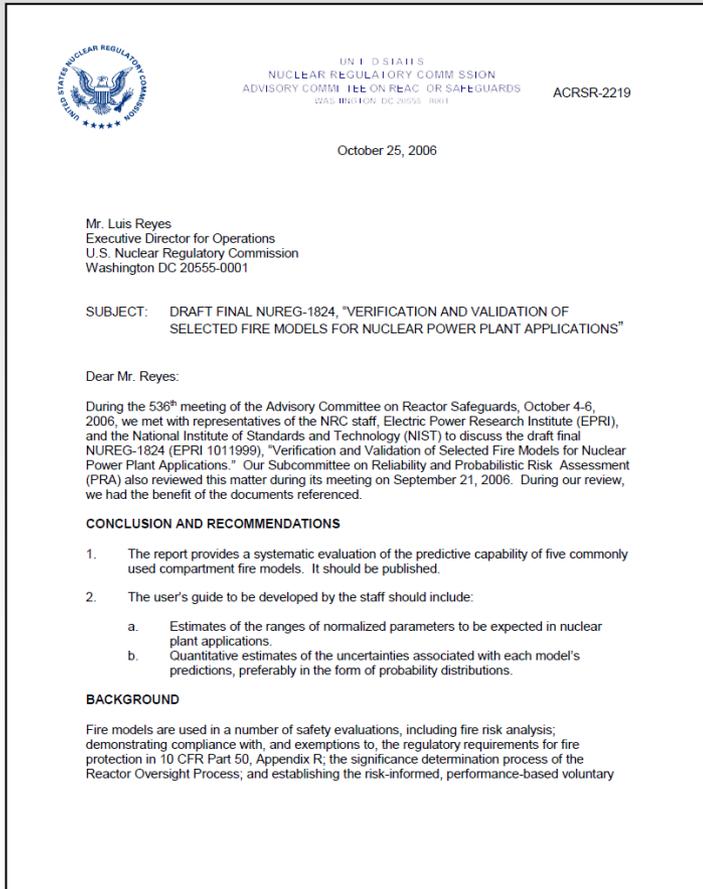
Parameter ⁵		Fire Model				
		FDT ⁵	FIVE-Rev1	CFAST	MAGIC	FDS
Hot gas layer temperature ("upper layer temperature")	Room of Origin	YELLOW+	YELLOW+	GREEN	GREEN	GREEN
	Adjacent Room	N/A	N/A	YELLOW	YELLOW+	GREEN
Hot gas layer height ("layer interface height")		N/A	N/A	GREEN	GREEN	GREEN
Ceiling jet temperature ("target/gas temperature")		N/A	YELLOW+ ²	YELLOW+	GREEN	GREEN
Plume temperature		YELLOW-	YELLOW+ ²	N/A	GREEN	YELLOW
Flame height ³		GREEN	GREEN	GREEN	GREEN	YELLOW ¹
Oxygen concentration		N/A	N/A	GREEN	YELLOW	GREEN
Smoke concentration		N/A	N/A	YELLOW	YELLOW	YELLOW
Room pressure ⁴		N/A	N/A	GREEN	GREEN	GREEN
Target temperature		N/A	N/A	YELLOW	YELLOW	YELLOW
Radiant heat flux		YELLOW	YELLOW	YELLOW	YELLOW	YELLOW
Total heat flux		N/A	N/A	YELLOW	YELLOW	YELLOW
Wall temperature		N/A	N/A	YELLOW	YELLOW	YELLOW



ACRS Review of NUREG-1824

ACRS Recommendation 2:

The color designations provide no quantitative estimate of the intrinsic uncertainty.



Improved Model Uncertainty Metrics

Table 4-1. Results of the V&V study, NUREG-1824 (EPRI 1011999).

Output Quantity	FDTs		FIVE		CFAST		MAGIC		FDS		Exp
	δ	$\tilde{\sigma}_M$	$\tilde{\sigma}_E$								
HGL Temperature Rise*	1.44	0.25	1.56	0.32	1.06	0.12	1.01	0.07	1.03	0.07	0.07
HGL Depth*	N/A		N/A		1.04	0.14	1.12	0.21	0.99	0.07	0.07
Ceiling Jet Temp. Rise	N/A		1.84	<u>0.29</u>	1.15	<u>0.24</u>	1.01	0.08	1.04	0.08	0.08
Plume Temperature Rise	0.73	<u>0.24</u>	0.94	<u>0.49</u>	1.25	0.28	1.01	0.07	1.15	<u>0.11</u>	0.07
Flame Height**	I.D.	I.D.	I.D.								
Oxygen Concentration	N/A		N/A		0.91	<u>0.15</u>	0.90	0.18	1.08	0.14	0.05
Smoke Concentration	N/A		N/A		2.65	<u>0.63</u>	2.06	<u>0.53</u>	2.70	<u>0.55</u>	0.17
Room Pressure Rise	N/A		N/A		1.13	0.37	0.94	0.39	0.95	0.51	0.20
Target Temperature Rise	N/A		N/A		1.00	0.27	1.19	0.27	1.02	0.13	0.07
Radiant Heat Flux	2.02	<u>0.59</u>	1.42	0.55	1.32	0.54	1.07	0.36	1.10	0.17	0.10
Total Heat Flux	N/A		N/A		0.81	0.47	1.18	0.35	0.85	0.22	0.10
Wall Temperature Rise	N/A		N/A		1.25	0.48	1.38	0.45	1.13	0.20	0.07
Wall Heat Flux	N/A		N/A		1.05	0.43	1.09	0.34	1.04	0.21	0.10

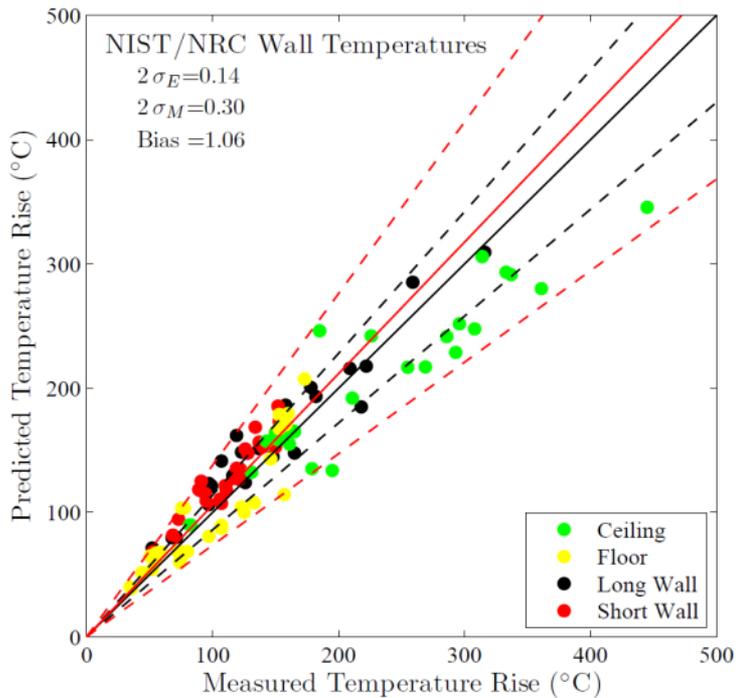
I.D. indicates insufficient data for the statistical analysis.

N/A indicates that the model does not have an algorithm to compute the given Output Quantity.

Underlined values indicate that the data failed a normality test because of the relatively small sample size.

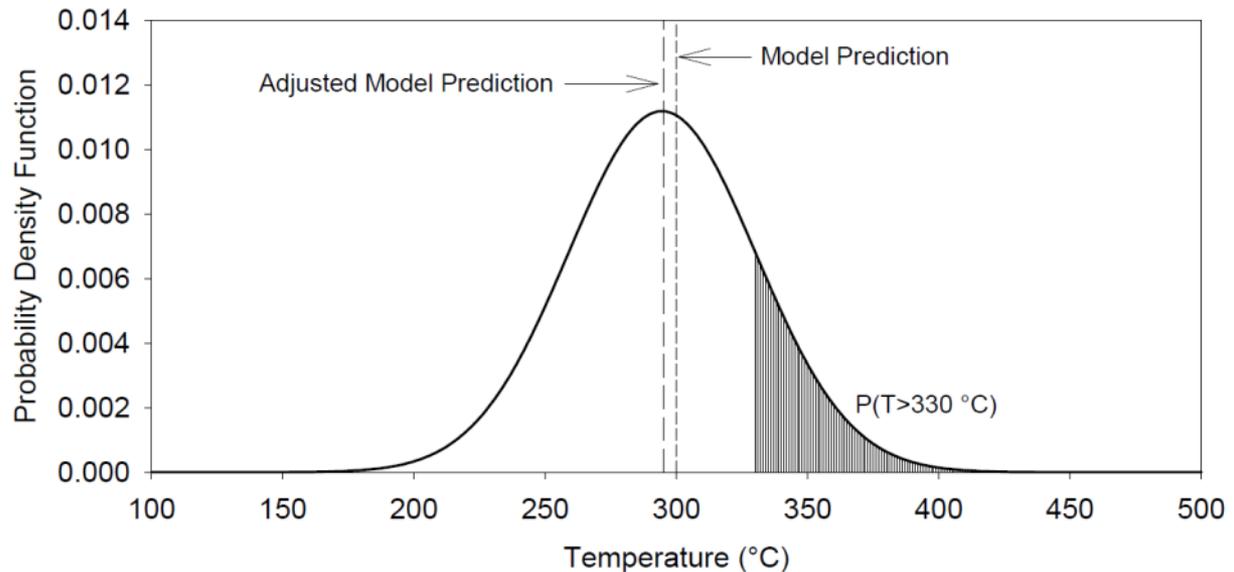
* The algorithm used to compute the layer temperature and depth for the model FDS is described in NUREG-1824.

** All of the models except FDS use the Heskestad Flame Height Correlation (Heskestad, *SFPE Handbook*). These models were shown to be in qualitative agreement with the experimental observations, but there was not enough data to further quantify this assessment.



(Left) Typical results from a validation study. The black lines indicate the experimental uncertainty and the red lines indicate the model uncertainty.

(Below) Given a model prediction of 300 °C, what is the probability that the actual temperature might exceed 330 °C, the failure temperature of the given target?



How Model Uncertainty is Applied

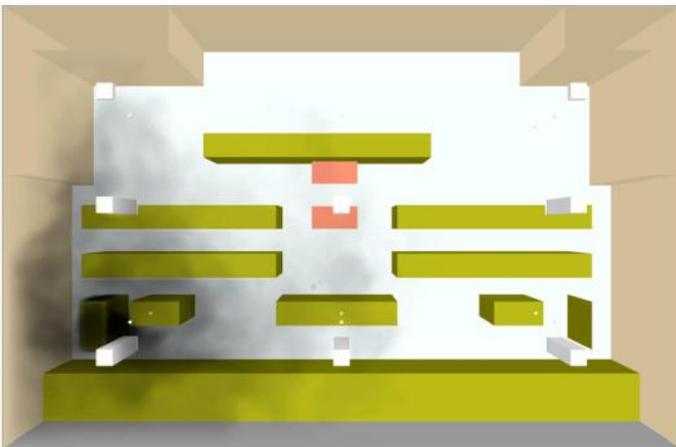
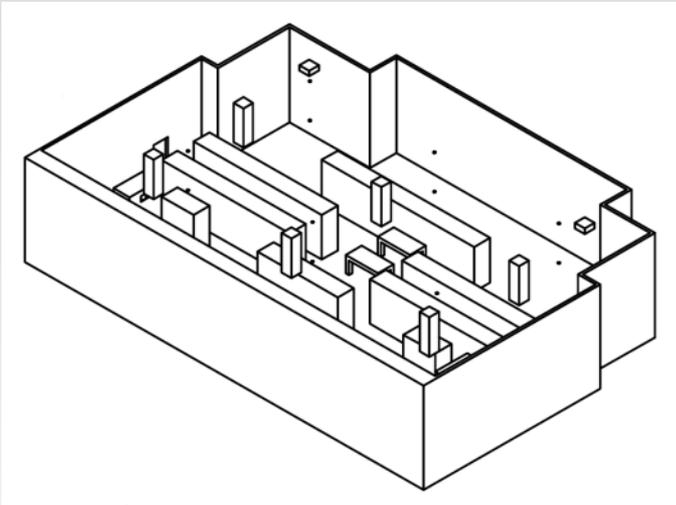
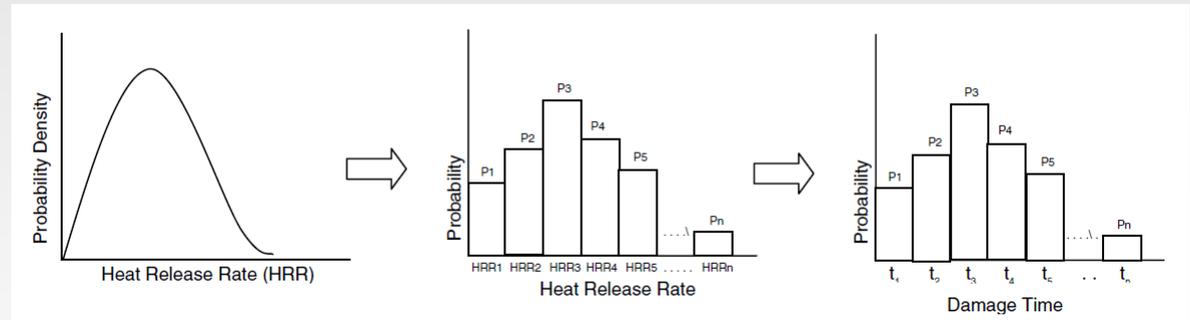
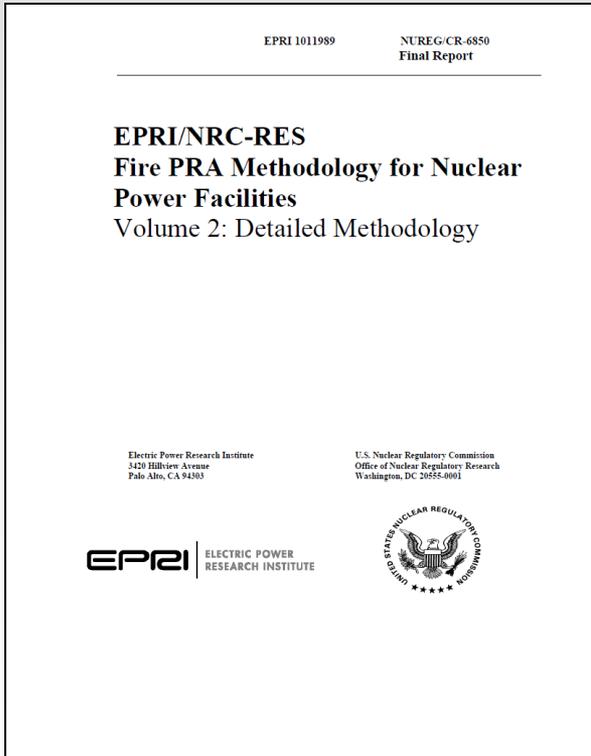


Table A-4. Summary of the model predictions of the MCR scenario.

Model	Bias Factor, δ	Standard Deviation, $\tilde{\sigma}_M$	Ventilation	Predicted Value	Critical Value	Probability of Exceeding
Temperature ($^{\circ}\text{C}$), Initial Value = 20 $^{\circ}\text{C}$						
FIVE (FPA)	1.56	0.32	Purge	70	95	0.000
CFAST	1.06	0.12		60	95	0.000
FDS	1.03	0.07		48	95	0.000
CFAST	1.06	0.12	No Vent.	82	95	0.009
FDS	1.03	0.07		70	95	0.000
Heat Flux (kW/m^2)						
FIVE	1.42	0.55	Purge	0.4	1	0.000
CFAST	0.81	0.47		0.1	1	0.000
FDS	0.85	0.22		0.2	1	0.000
CFAST	0.81	0.47	No Vent.	0.6	1	0.228
FDS	0.85	0.22		0.4	1	0.000
Optical Density (m^{-1})						
CFAST	2.65	0.63	Purge	6.5	3	0.362
FDS	2.7	0.55		0.5	3	0.000
CFAST	2.65	0.63	No Vent.	47	3	0.906
FDS	2.7	0.55		31	3	0.909

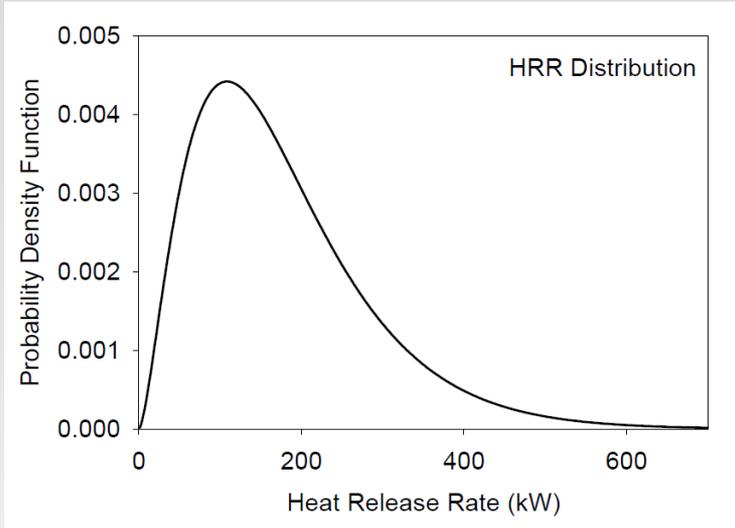
Parameter Uncertainty Propagation

E APPENDIX FOR CHAPTERS 8 AND 11, SEVERITY FACTORS



Currently, NUREG/CR-6850 contains a simple method for propagating parameter uncertainty. Several examples have been added to the Fire Model User's Guide.

Model Input Parameter Distribution

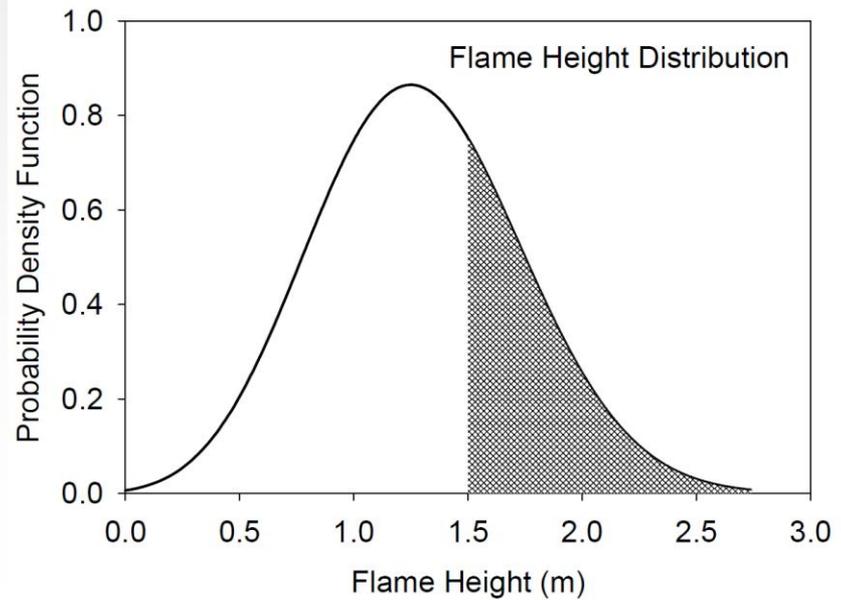


Model: Flame Height Correlation

$$L_f = 0.235 \dot{Q}^{2/5} - 1.02 D$$



Model Output Distribution

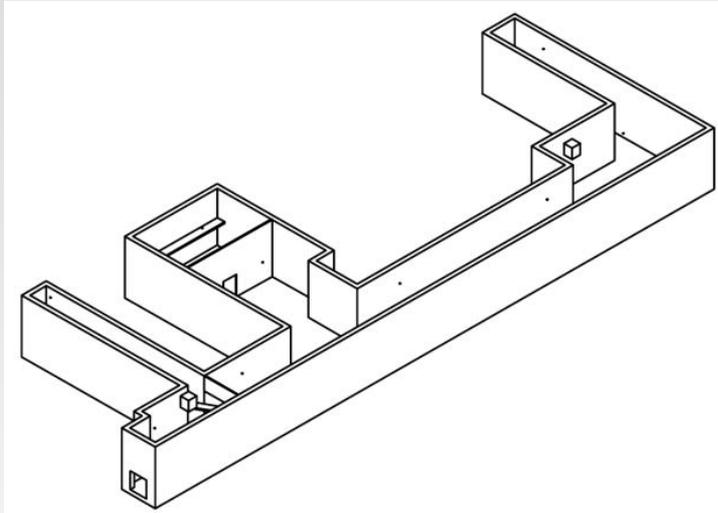


Question: What is the probability that the flames from a particular type of cabinet fire will reach a target 1.5 m above the cabinet?

What to do if the scenario is out of the validation range?

1. Sensitivity Analysis – Perform a calculation for a similar scenario that is more severe yet in range.
2. Reference other validation studies performed by model developers or others (i.e. universities, professional societies)

Example of Sensitivity Analysis



Problem: The corridor length to ceiling height ratio (L/H) is outside of validation range.

Solution: Redo calculation (or apply a simple correlation) to determine if a similar (yet more challenging) scenario increases the probability of failure.

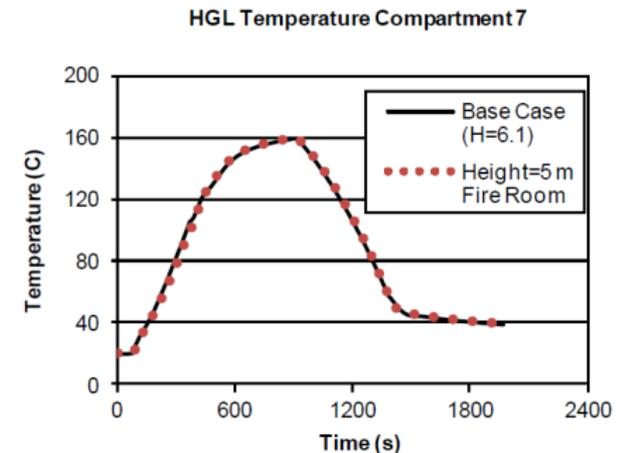
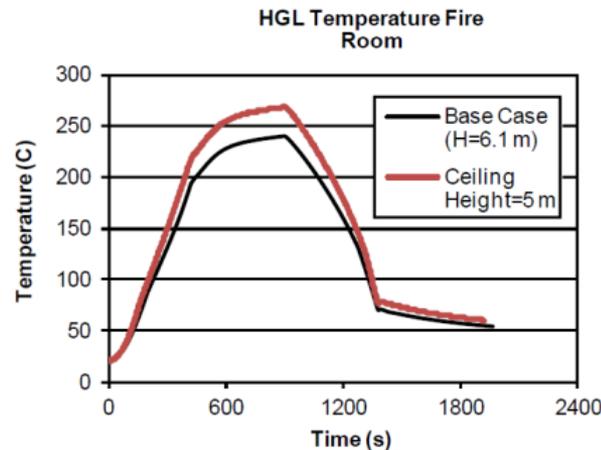


Figure G-10. Hot Gas Layer Temperature for Reduced Ceiling Height by MAGIC.

- Eight example applications, each documented in an individual appendix
 - Based on typical fire scenarios in NPP's
 - Serve as a template for consistency in the analysis and documentation of fire modeling calculations
 - Consider the fire modeling requirements of NFPA 805
 - Cover the routinely used capabilities of the fire models

- Team believes NUREG-1934/EPRI 1023259 ready for publication:
 - Fulfills the need to support Quality Fire Model Implementation and Review
 - Fulfills the need to support Education and Training
 - Request a ACRS Letter
- Future Fire Modeling Projects
 - Fire Model Material Properties Catalogue
 - Revisit Fire Model V&V - NUREG-1824 Update

Backup Slides

A. Cabinet Fire in the Main Control Room

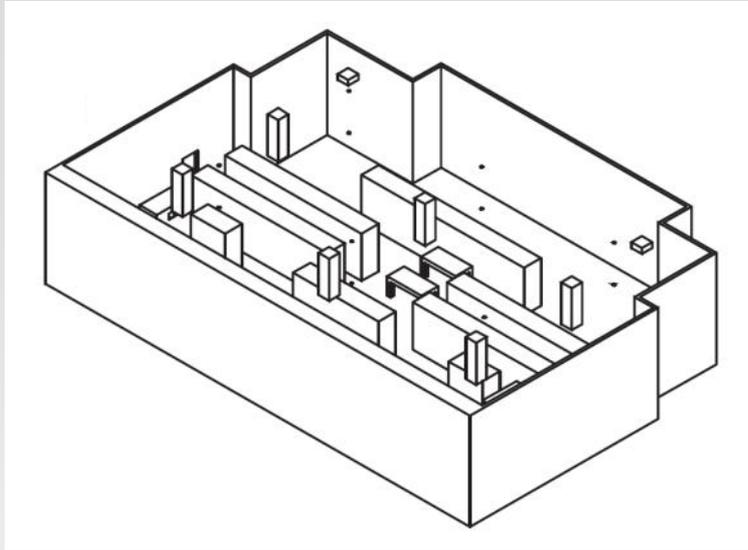


Figure A-11. FDS/Smokeview rendering of the MCR, as viewed from above.

B. Cabinet Fire in a Switchgear Room

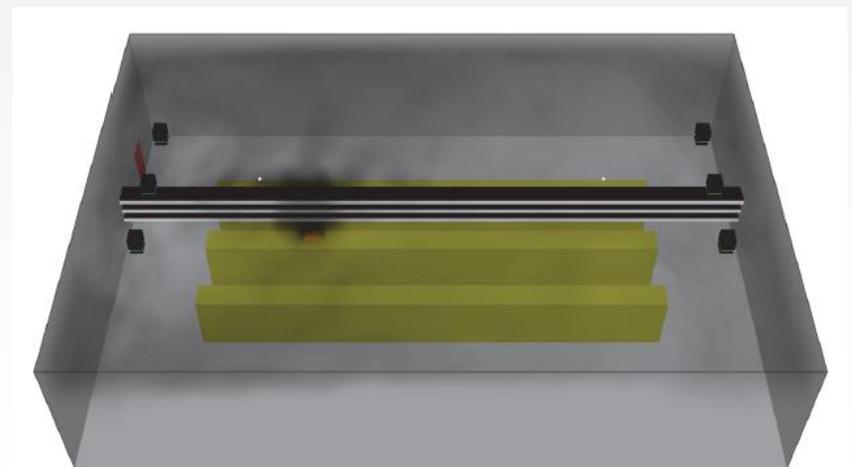
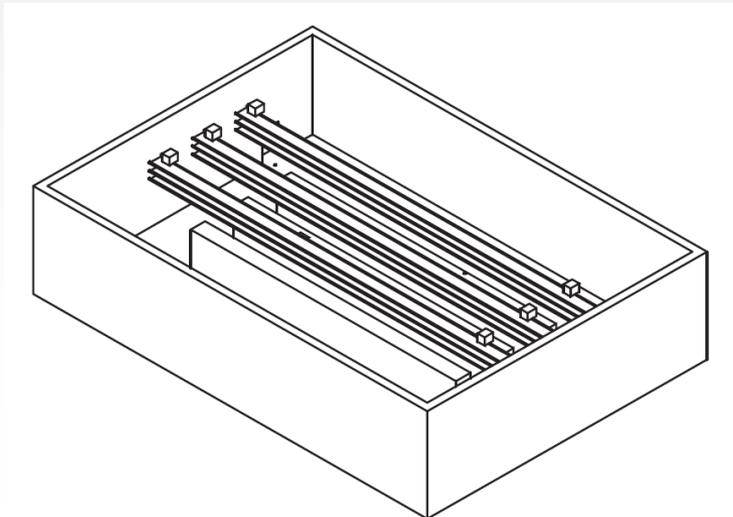
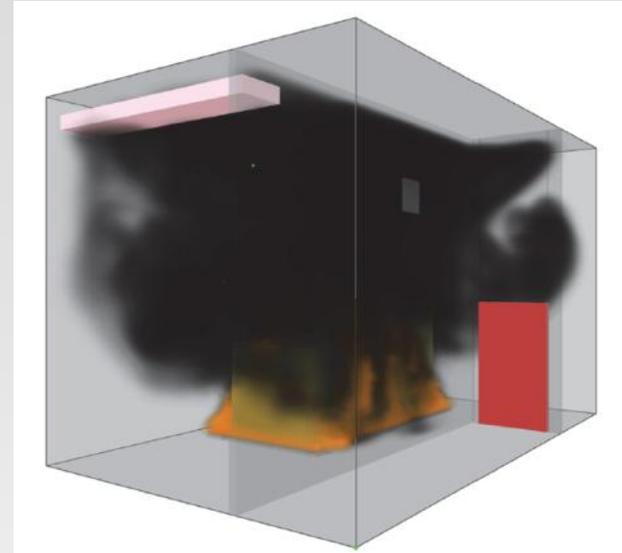
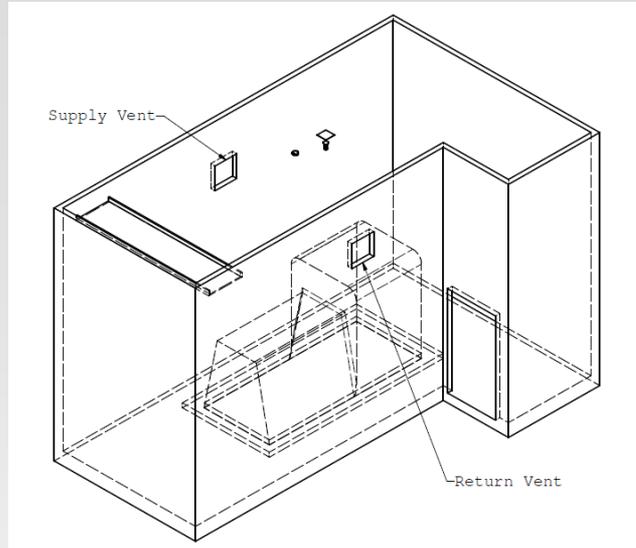
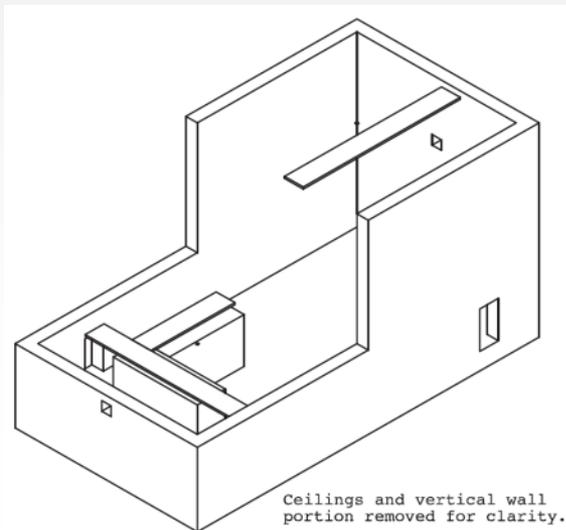


Figure B-10. FDS/Smokeview rendering of the switchgear room.

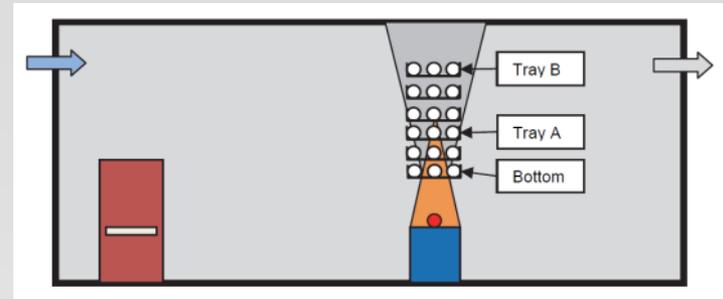
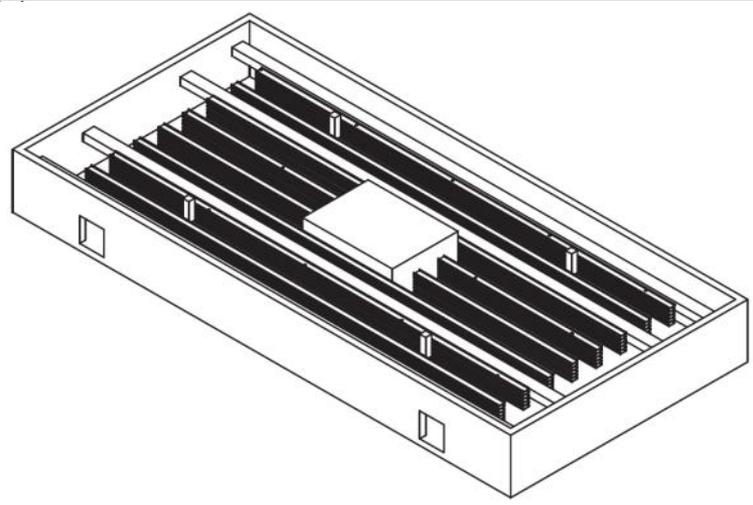
C. Lube Oil Fire in a Pump Room



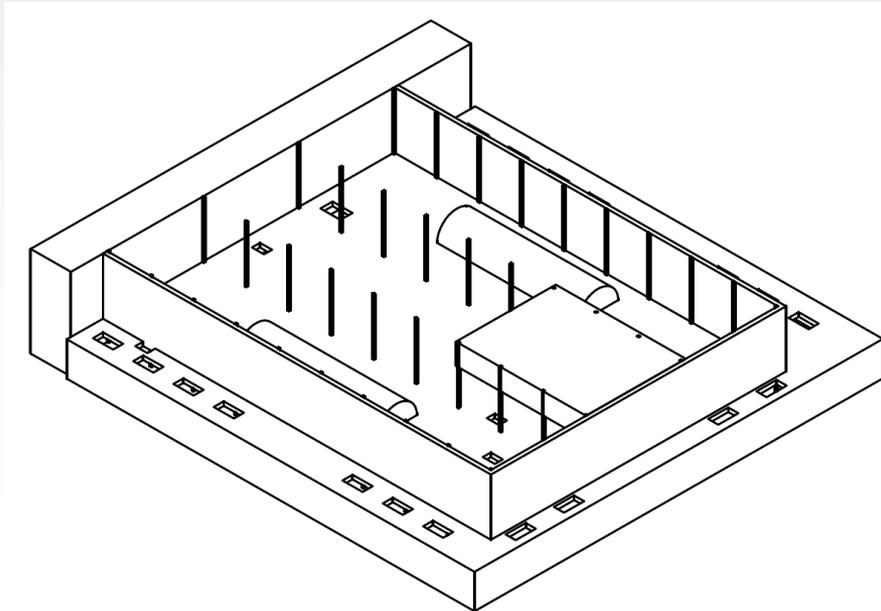
D. Motor Control Fire in a Switchgear Room



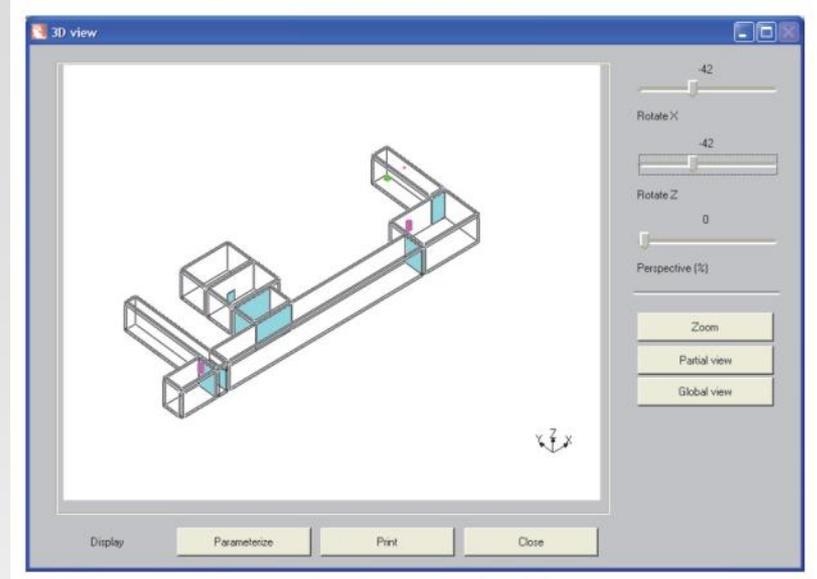
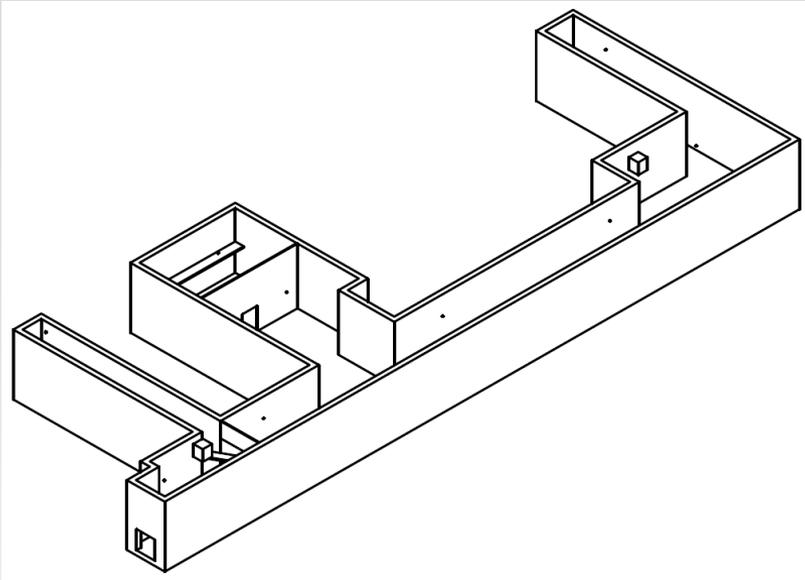
E. Transient Fire in a Cable Spreading Room



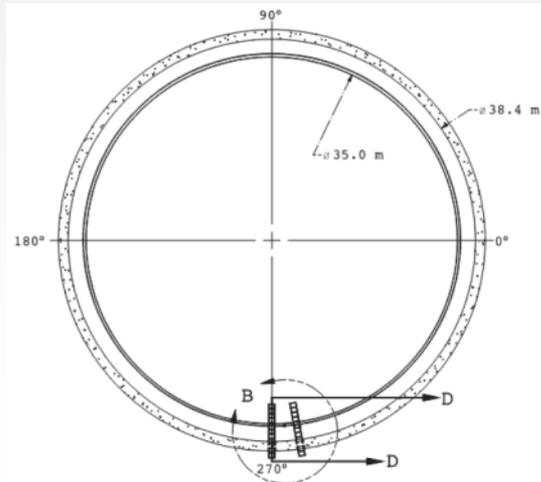
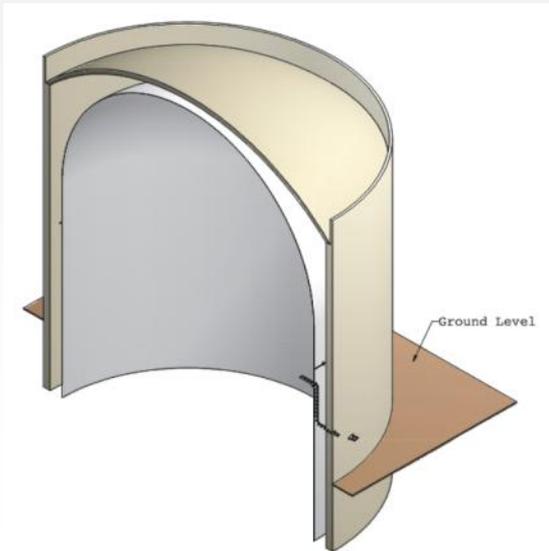
F. Lube Oil Fire in a Turbine Building



G. Transient Fire in a Multi-Compartment Corridor



H. Cable Tray Fire in the Annulus



28



Example: Fire in the Main Control Room

A.1 Modeling Objective

A.2 Description of the Fire Scenario

A.3 Selection and Evaluation of Fire Models

A.4 Estimation of Fire-Generated Conditions

A.5 Evaluation of Results

A.6 Conclusion

A.7 References

A.8 Attachments

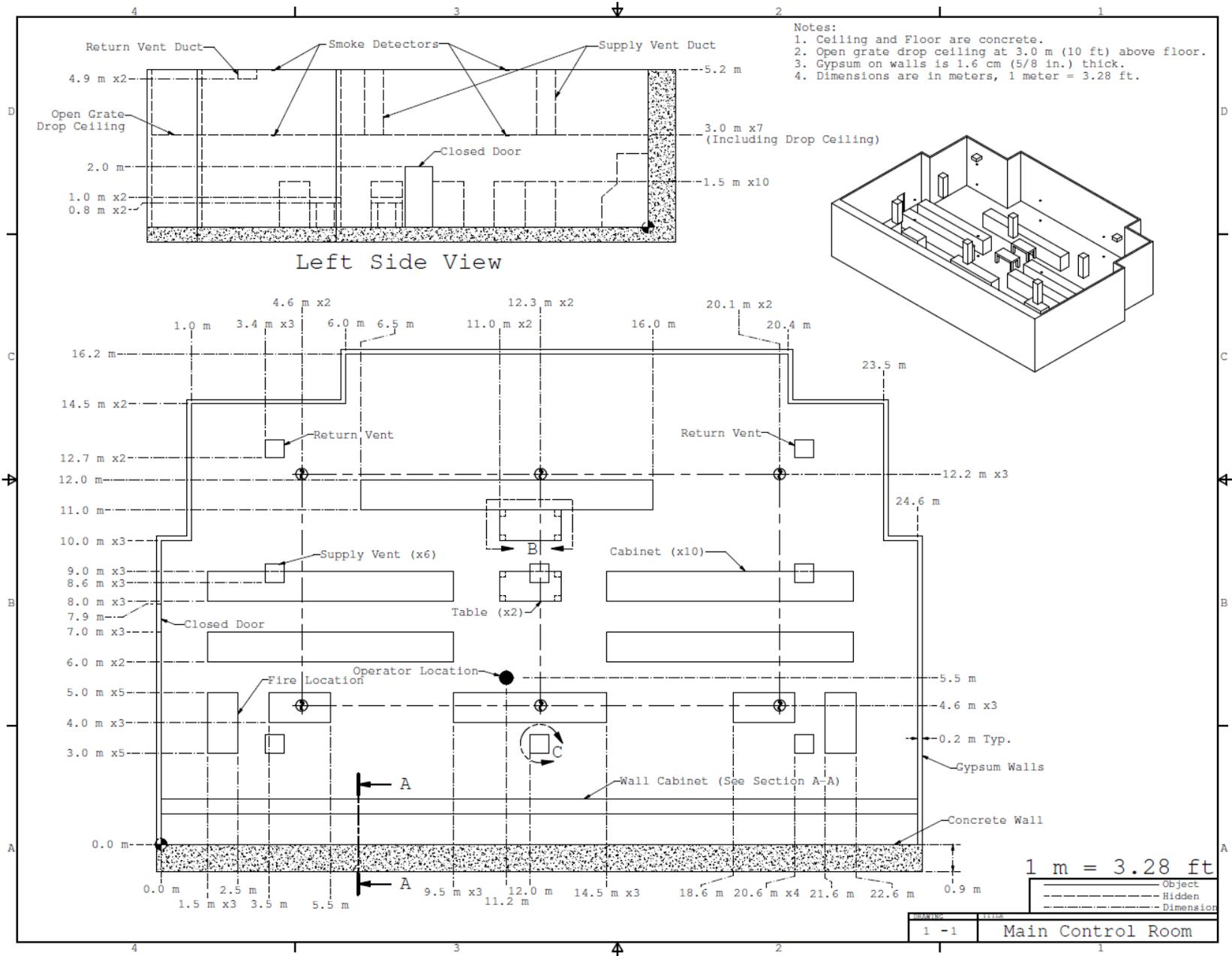
A.1 Modeling Objective

The purpose of the calculations described in this appendix is to determine the length of time that the main control room (MCR) remains habitable after the start of a fire within a low-voltage control cabinet. These calculations follow the guidance provided in NUREG/CR-6850 (EPRI 1011989), Volume 2, Chapter 11, “Detailed Fire Modeling (Task 11).” MCR fire scenarios are treated differently than fires within other compartments, mainly because of the necessity to consider and evaluate forced abandonment in addition to equipment damage.

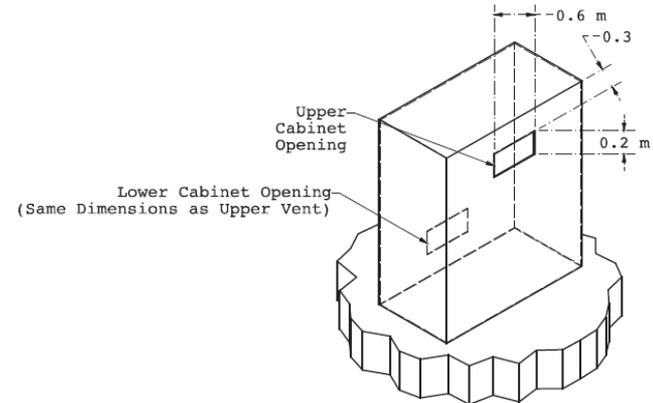
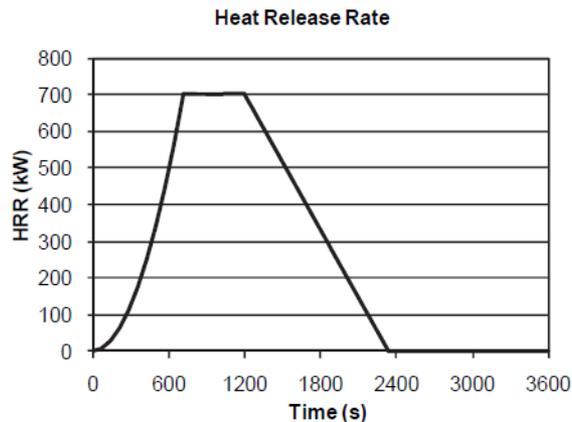
Habitability: The MCR is manned 24 hours per day during normal plant operations. To assess habitability of the compartment, the operator position indicated in Figure A-1 is used. According to NUREG/CR-6850 (EPRI 1011989), Volume 2, Chapter 11, “Detailed Fire Modeling,” a space is considered uninhabitable if at least one of the following occurs:

1. The incident heat flux at 1.8 m (6 ft) exceeds 1 kW/m^2 . A smoke layer temperature of approximately $95 \text{ }^\circ\text{C}$ ($200 \text{ }^\circ\text{F}$) generates this level of heat flux.
2. The smoke layer descends below 1.8 m (6 ft) from the floor, and the optical density of the smoke is greater⁹ than 3 m^{-1} .

A.2 Description of Fire Scenario



A.2 (cont.) Description of Fire Scenario



DETAIL D, ISO VIEW
(Fire Origin Cabinet)

Figure A-5. Time history of the HRR used by all models in the MCR scenario.

Table A-1. Data for MCR fire based on XPE/neoprene electrical cable.

Parameter	Value	Source
Effective Fuel Formula	$C_3H_{4.5}Cl_{0.5}$	Combination of polyethylene and neoprene
Peak HRR	702 kW	NUREG/CR-6850 (EPRI 1011989), App. G
Time to reach peak HRR	720 s	NUREG/CR-6850 (EPRI 1011989), App. G
Heat of Combustion	10,300 kJ/kg	SFPE Handbook, 4th ed., Table 3-4.16
CO ₂ Yield	0.63 kg/kg	SFPE Handbook, 4th ed., Table 3-4.16
Soot Yield	0.175 kg/kg	SFPE Handbook, 4th ed., Table 3-4.16
CO Yield	0.082 kg/kg	SFPE Handbook, 4th ed., Table 3-4.16
Radiative Fraction	0.53	SFPE Handbook, 4th ed., Table 3-4.16
Mass Extinction Coefficient	8700 m ² /kg	Mulholland and Croarkin (2000)

A.3 Selection and Evaluation of Fire Models

Table A-2. Normalized parameter calculations for the MCR fire scenario. See Table 2-5 for further details.

Quantity	Normalized Parameter Calculation	Validation Range	In Range?
Fire Froude Number	$\dot{Q}^* = \frac{\dot{Q}}{\rho_{\infty} c_p T_{\infty} D^{2.5} \sqrt{g}}$ $= \frac{702 \text{ kW}}{(1.2 \text{ kg/m}^3)(1.0 \text{ kJ/kg/K})(293 \text{ K})(0.4^{2.5} \text{ m}^{2.5})\sqrt{9.8 \text{ m/s}^2}} \cong 6.2$	0.4 – 2.4	No
Fire Height, $H_f + L_f$, relative to the Ceiling Height, H	$\frac{H_f + L_f}{H} = \frac{2.1 \text{ m} + 2.7 \text{ m}}{5.2 \text{ m}} \cong 0.9$ $L_f = D \left(3.7 \dot{Q}^{*2/5} - 1.02 \right) = 0.4 \text{ m} (3.7 \times 6.2^{0.4} - 1.02) \cong 2.7 \text{ m}$	0.2 – 1.0	Yes
Ceiling Jet Radial Distance, r_{cj} , relative to the Ceiling Height, H	N/A – Ceiling jet targets are not included in simulation.	1.2 – 1.7	N/A
Equivalence Ratio, ϕ , of the Room, based on Forced Ventilation of Purge Mode	$\phi = \frac{\dot{Q}}{\Delta H_{O_2} \dot{m}_{O_2}} = \frac{702 \text{ kW}}{13,100 \text{ kJ/kg} \times 3.7 \text{ kg/s}} \cong 0.014$ $\dot{m}_{O_2} = Y_{O_2} \rho_{\infty} \dot{V} = 0.23 \times 1.2 \text{ kg/m}^3 \times 13.4 \text{ m}^3/\text{s} \cong 3.7 \text{ kg/s}$	0.04 – 0.6	No
Compartment Aspect Ratio	$\frac{L}{H} = \frac{24.6 \text{ m}}{5.2 \text{ m}} \cong 4.7$ $\frac{W}{H} = \frac{16.2 \text{ m}}{5.2 \text{ m}} \cong 3.1$	0.6 – 5.7	Yes
Target Distance, r , relative to the Fire Diameter, D	$\frac{r}{D} = \frac{8.8 \text{ m}}{0.4 \text{ m}} \cong 22$	2.2 – 5.7	No



Require Justification

Notes:

- (1) The effective diameter of the base of the fire, D , is calculated using $D = \sqrt{4A/\pi}$, where A is the area of the cabinet vent.
- (2) The Fire Height, $H_f + L_f$, is the sum of the height of the fire off the floor plus the fire's flame length.

A.3 (cont.) Selection and Evaluation of Fire Models

Justifying use of the model when the application falls outside of the validation range

For the scenario with no ventilation, the classic definition of the Equivalence Ratio does not apply because there is no supply of oxygen in the room. However, it can be shown that there is sufficient oxygen in the room to sustain the specified fire. The total mass of oxygen in the room is the product of the density of air, ρ , the volume of the room, V , and the mass fraction of oxygen in the air, Y_{O_2} :

$$m_{O_2, \text{tot}} = \rho V Y_{O_2} = 1.2 \text{ kg/m}^3 \times 1945 \text{ m}^3 \times 0.23 \cong 537 \text{ kg} \quad (\text{A-1})$$

The mass of oxygen required to sustain the fire is equal to the total energy produced by the fire divided by the energy released per unit mass oxygen consumed:

$$m_{O_2, \text{req}} = \frac{Q}{\Delta H_{O_2}} \cong \frac{702 \text{ kW} \times 60 \text{ s/min} \times \left(\frac{12}{3} + 8 + \frac{19}{2} \right) \text{ min}}{13,100 \text{ kJ/kg}} \cong 69 \text{ kg} \quad (\text{A-2})$$

These calculations show that the quantity of oxygen in the room would be able to sustain the specified cabinet fire.

- The ratio of the Target Distance relative to the Fire Diameter, r/D , exceeds the range of the validation study. However, this parameter is only relevant to the point source radiation heat flux calculation, which is by definition more accurate, as the target moves further from the source. Thus, although the parameter is outside the validation range, it is not outside of the methodology's range of validity.

A.4 Estimation of Fire-Generated Conditions

Start with empirical models first

(Foote, Pagni, Alvarez Correlation for Closed, Ventilated Compartment)

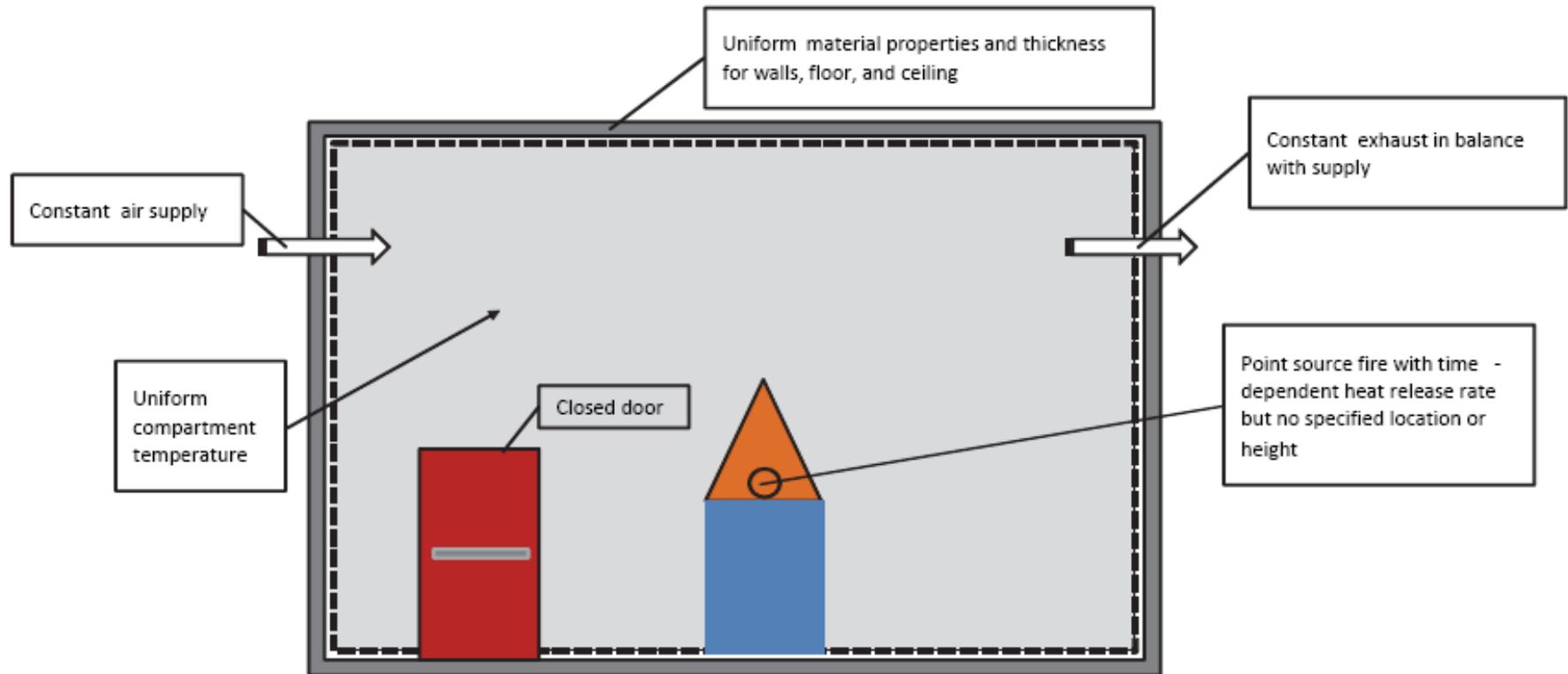
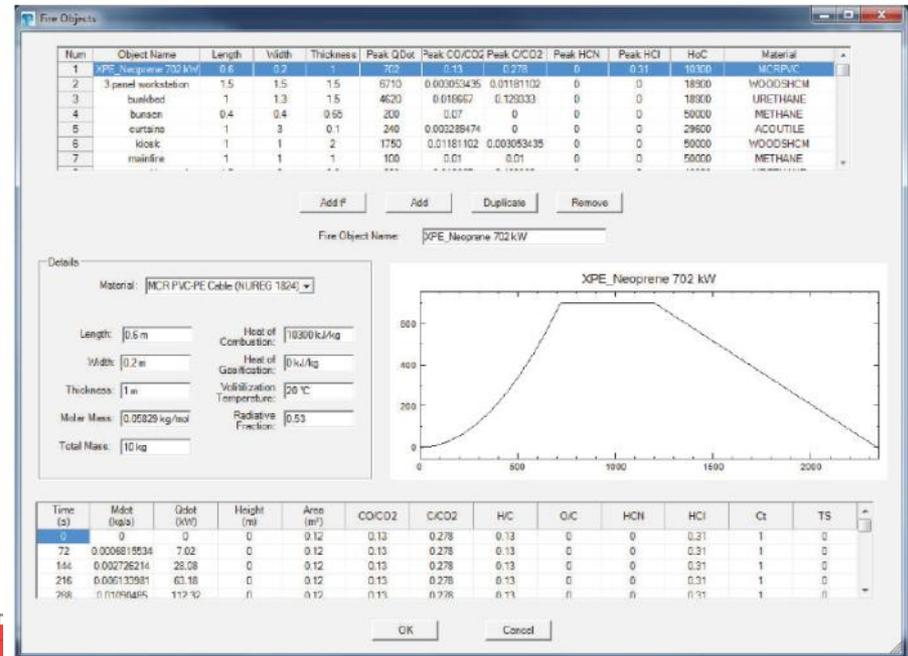
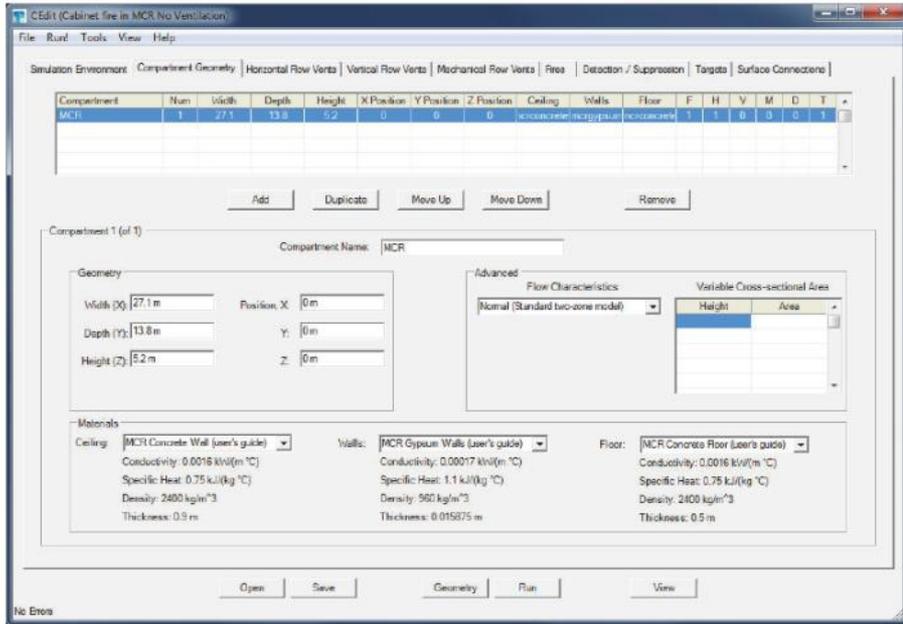


Figure A-6. Schematic diagram of the FPA calculation for the MCR smoke purge scenario.

A.4 (cont.) Estimation of Fire-Generated Conditions

Move to next level of complexity (zone models) if empirical correlations cannot address all of the failure criteria.



Note: Values for "Total Mass," "Heat of Gasification," and "Volatilization Temperature" are set at default values.

Figure A-10. Snapshot of the CFAST simulation of the MCR fire with mechanical ventilation.

A.4 (cont.) Estimation of Fire-Generated Conditions

Move to next level of complexity (CFD model) if there is a need for a “second opinion”.

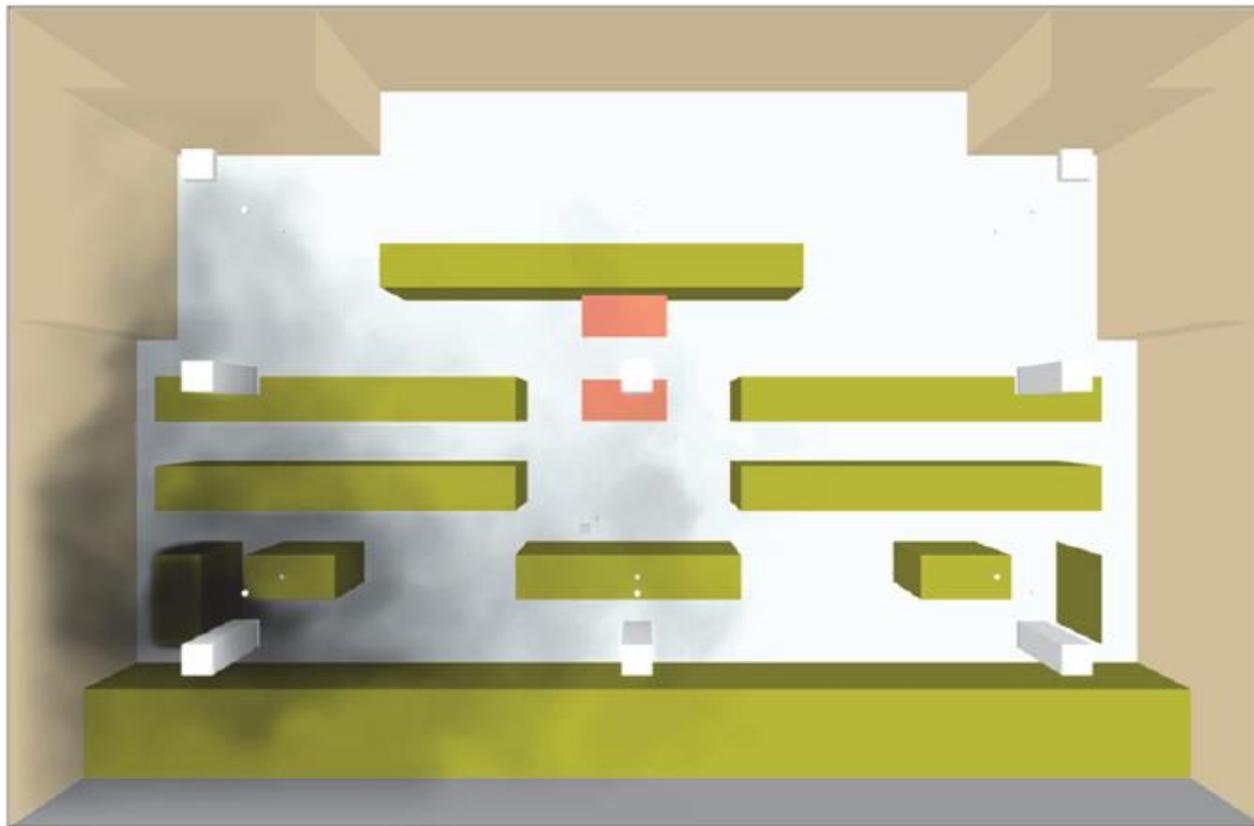


Figure A-11. FDS/Smokeview rendering of the MCR, as viewed from above.

A.5 Evaluation of Results

Table A-4. Summary of the model predictions of the MCR scenario.

Model	Bias Factor, δ	Standard Deviation, $\tilde{\sigma}_M$	Ventilation	Predicted Value	Critical Value	Probability of Exceeding
Temperature (°C), Initial Value = 20 °C						
FIVE (FPA)	1.56	0.32	Purge	70	95	0.000
CFAST	1.06	0.12		60	95	0.000
FDS	1.03	0.07		48	95	0.000
CFAST	1.06	0.12	No Vent.	82	95	0.009
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Optical Density (m⁻¹)						
CFAST	2.65	0.63	Purge	6.5	3	0.362
FDS	2.7	0.55		0.5	3	0.000
CFAST	2.65	0.63	No Vent.	47	3	0.906
FDS	2.7	0.55		31	3	0.909

A.5 (cont.) Evaluation of Results

Focus in on the phenomenon that is most likely to be a cause for concern.

Optical Density near Operator

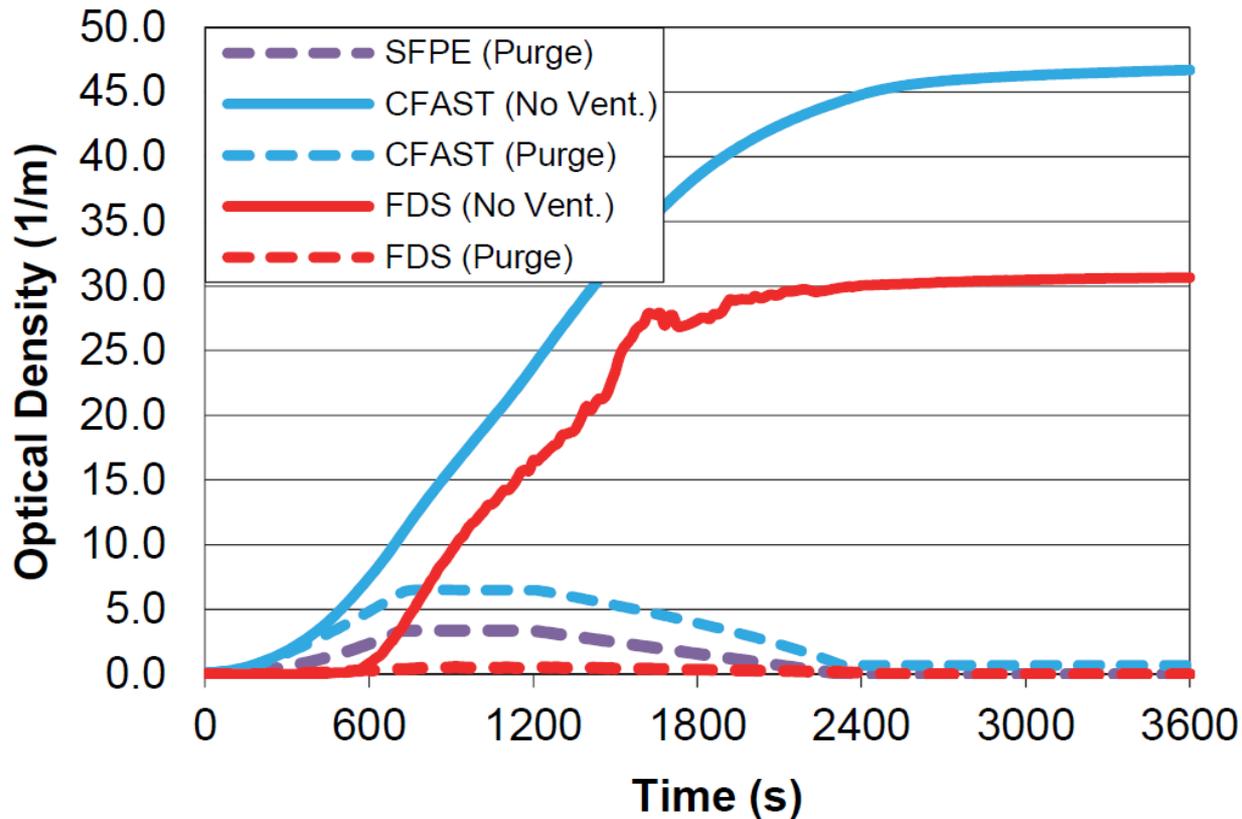


Figure A-14. Optical density predictions for the MCR scenario.

A.6 Conclusion

A fire modeling analysis has been performed to assess the habitability of the MCR in the event of a fire within an isolated electrical cabinet. The fire is not expected to spread to other cabinets. Of the three MCR abandonment criteria, it is most likely that the operators would be forced to abandon the MCR because the optical density would surpass 3 m^{-1} approximately 12 minutes after the fire ignites if the smoke purge system is not activated before this time, according to the FDS analysis. A simple analytical method and the zone model CFAST indicate that the optical density would exceed the critical value with the smoke purge system on and with the ventilation system turned off. However, these analyses are based on several important assumptions. For the smoke purge case, the analytical method assumes that the smoke fills the entire compartment uniformly, even though the FDS analysis shows that the supply vents maintain visibility in the vicinity of the operator location. CFAST reports the optical density of the upper layer, but does not predict that the upper layer would descend to the level of the operator in either the purge or no ventilation scenario based on the specified assumptions.

A.7 References

1. NUREG-1805, *Fire Dynamics Tools*, 2004.
2. NUREG/CR-6850 (EPRI 1011989), *Fire PRA Methodology for Nuclear Power Facilities*, 2005.
3. NUREG-1824 (EPRI 1011999), *Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications*, 2007.
4. *SFPE Handbook of Fire Protection Engineering*, 4th edition, 2008.
5. NIST SP 1018-5, *Fire Dynamics Simulator (Version 5), Technical Reference Guide, Vol. 3, Experimental Validation*.
6. NIST SP 1030. *CFAST: An Engineering Tool for Estimating Fire Growth and Smoke Transport, Version 5 - Technical Reference Guide*, National Institute of Standards and Technology, Gaithersburg, Maryland, 2004.
7. G.W. Mulholland and C. Croarkin. "Specific Extinction Coefficient of Flame Generated Smoke." *Fire and Materials*, 24:227–230, 2000.



U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

**596th Meeting of the Advisory
Committee on Reactor Safeguards**

**St. Lucie, Unit 1
Extended Power Uprate**

July 11, 2012



Opening Remarks

Michele G. Evans

Division Director

Division of Operating Reactor Licensing

Office of Nuclear Reactor Regulation



Introduction

Tracy J. Orf

Project Manager

Division of Operating Reactor Licensing

Office of Nuclear Reactor Regulation

Topics for Discussion

- EPU Overview
- Training
- LOCA PCT Inputs
- TCD – License Condition and FRAPCON analysis
- Steam Generators



St. Lucie Unit 2 Extended Power Uprate (EPU) ACRS Full Committee

July 11, 2012

Agenda

- ➔ **Introduction Joe Jensen**
- **EPU Overview Jack Hoffman**
- **Discussion Topics from ACRS Subcommittee**
 - Acceptability of Single Simulator..... Dave Brown
 - LOCA Peak Cladding Temperature Rackup..... Jay Kabadi
 - Steam Generators (Proprietary) Rudy Gil
- **Acronyms**

St. Lucie

- **FPL appreciates the opportunity to discuss the EPU License Amendment Request for St. Lucie Unit 2 with the ACRS**
- **Since the ACRS Subcommittee meeting, FPL and NRC Staff worked diligently to address actions from the Subcommittee members**
- **FPL recognizes and appreciates the importance of the Subcommittee's questions, particularly those on Steam Generator performance**
- **FPL's top priority is safety; we continue to proceed with caution through the remaining steps of the EPU**
- **FPL looks forward to answering any remaining questions**

St. Lucie Unit 2

- **Located on Hutchinson Island, southeast of Fort Pierce, Florida**
- **Pressurized Water Reactor (PWR)**
- **Combustion Engineering Nuclear Steam Supply System (NSSS)**
- **Westinghouse Turbine Generator**
- **Architect Engineer – Ebasco**
- **Fuel supplier - Westinghouse**
- **Unit output 907 MWe gross**



St. Lucie

- **Original operating license issued in 1983**
- **Renewed operating license issued in 2003**
- **Installation of a new single-failure proof crane to support spent fuel dry storage operations in 2003**
- **Steam Generators (SGs) replaced in 2007**
- **Reactor Vessel Head was replaced in 2007**
- **Replaced 2 of 4 Reactor Coolant Pump motors in 2007 and 2011**
 - The remaining motor replacements planned for 2012 and 2014

Agenda

- Introduction Joe Jensen
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 - Steam Generators (Proprietary) Rudy Gil
- **Acronyms**

- **Licensed Core Power**

- Original Licensed Core Power 2560 MWt
- Current Licensed Core Power 2700 MWt
 - 5.5 % Stretch Uprate (1985)
- EPU Core Power 3020 MWt
 - 10% Power Uprate
 - 1.7% Measurement Uncertainty Recapture
 - $(2700 \times 1.10) \times 1.017 \sim 3020$ MWt

- **Grid stability studies have been completed and approved for the EPU full power output**
- **Final modifications to support EPU operation are being implemented in 2012**

EPU License Amendment Request (LAR) was prepared utilizing the guidance of *RS-001, Review Standard for Extended Power Uprates*

- **Addressed lessons learned from previous PWR EPU reviews**
- **Evaluations consistent with the St. Lucie Unit 2 Current Licensing Basis (CLB) per RS-001**
- **License Renewal evaluated in each License Report section consistent with RS-001 requirements**
- **Measurement Uncertainty Recapture evaluated the proposed Leading Edge Flow Meter (LEFM) system using the Staff's criteria contained in *RIS 2002-03, Guidance on the Content of Measurement Uncertainty Recapture Uprate Applications***

Agenda

- Introduction Joe Jensen
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- **Acronyms**

A single control room simulator for St. Lucie Unit 1 and 2 is acceptable for licensed operator training

- **A single control room simulator is typical for dual unit sites**
- **St. Lucie Operator Training Programs are accredited by the Institute of Nuclear Plant Operations (INPO) National Academy for Nuclear Training**
 - St. Lucie's methods of training, including the use of a single simulator, determined to be acceptable
- **Operators are licensed and qualified on both units, and routinely operate both units**
- **Differences between the two units are emphasized in both classroom and simulator training**
- **EPU modifications will reduce the number of differences between the units**

Agenda

- Introduction Joe Jensen
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 - Steam Generators (Proprietary) Rudy Gil
- **Acronyms**

Large Break LOCA analysis Peak Cladding Temperature (PCT) of 2087°F meets 10 CFR 50.46 requirements

Large Break LOCA PCT Rackup Deltas from Pre-EPU to EPU

Input Parameter Changes	Penalties (°F)	Benefits (°F)
Increase in core power	+ 54	--
Flattening of power around peak rod	+ 19	--
Decrease in maximum integrated radial peaking factor, Fr	--	- 53
Increase in RCS flow rate	--	- 17
Increase in Containment Spray flow rate	+ 23	--
Increase in ECCS Flow Rate	+ 9	--
Conservative containment passive heat sink	+ 3	--
Reduction in discretionary conservatism 1. Decrease in third reflood rate 2. Increase in two-phase mixture level	--	- 60
Total	+ 108	- 130

Integrated impact is 17°F benefit



Small Break LOCA analysis PCT of 1903°F meets 10 CFR 50.46 requirements

Small Break LOCA PCT Rackup Deltas from Pre-EPU to EPU

Input Parameter Changes	Penalties (°F)	Benefits (°F)
Increase in core power	+ 335	--
Change in axial power consistent with blanketed fuel	--	- 81
Implementation of replacement steam generators with 10% SGTP (from OSGs with 30% SGTP)	--	- 100
Change in ECCS flow rates (Includes crediting Charging Flow)	--	- 169
Total	+ 335	- 350

Integrated impact is 40°F benefit

Agenda

- Introduction Joe Jensen
- EPU Overview Jack Hoffman
- Discussion Topics from ACRS Subcommittee
 - Acceptability of Single Simulator..... Dave Brown
 - LOCA Peak Cladding Temperature Rackup..... Jay Kabadi
 - Steam Generators (Proprietary) Rudy Gil

Acronyms

Acronyms

ACAD	National Academy for Nuclear Training Guideline	MDNBR	Minimum Departure From Nucleate Boiling
AOO	Anticipated Operational Occurrences	MSLB	Main Steam Line Break
AVB	Anti-Vibration Bar	MSR	Moisture Separator Reheater
BAMT	Boric Acid Makeup Tank	MSS	Main Steam System
BOP	Balance of plant	MWe	Megawatts electric
CHF	Critical Heat Flux	MWt	Megawatts thermal
CLB	Current Licensing Basis	NPSH	Net Positive Suction Head
COLR	Core Operating Limits Report	NSSS	Nuclear Steam Supply System
CVCS	Chemical and Volume Control System	OSG	Original Steam Generator
DNB	Departure From Nucleate Boiling	PCT	Peak Cladding Temperature
ECCS	Emergency Core Cooling System	PLHR	Peak Linear Heat Rate
EHC	Electro Hydraulic Control	PORV	Power Operated Relief Valve
EPU	Extended Power Uprate	PPM	Parts per Million
EQ	Environmental Qualification	PSIA	Pounds per square inch - absolute
F	Fahrenheit	PWR	Pressurized Water Reactor
F_r^T	Total Radial Peaking Factor	PZR	Pressurizer
ft	Feet	RCS	Reactor Coolant System
FW	Feed Water	RIS	Regulatory Issue Summary
HFP	Hot Full Power	RPS	Reactor Protection System
HTP	High Thermal Performance	RTP	Rated Thermal Power
HZP	Hot Zero Power	RWT	Refueling Water Tank
IC	Inside Containment	SB	Small Break
INPO	Institute of Nuclear Plant Operations	SGTP	Steam Generator Tubes Plugged
Keff	K-effective	SIT	Safety Injection Tank
lb/hr	Pounds per hour	SDM	Shutdown Margin
LAR	License Amendment Request	Sec	Second
LB	Large Break	SLB	Steam Line Break
LEFM	Leading Edge Flow Meter	SG	Steam Generator
LHGR	Linear Heat Generation Rate	V	Velocity
LOCA	Loss of Coolant Accident	ρ	Density

Extended Used Fuel Storage and Transportation Safety Basis

Industry Perspectives

NRC Advisory Committee on Reactor Safeguards

July 11, 2012

Rod McCullum



NUCLEAR
ENERGY
INSTITUTE

Extended Storage Safety Basis

- **Dry Casks are robust systems with no moving parts**
- **Extensive Operating Experience – over 1,700 casks**
- **72.42 rulemaking – license/renewal terms up to 40 yrs.**
 - “This increase is consistent with the NRC staff’s findings regarding the safety of spent fuel storage as documented in the renewal exemptions issued to the Surry and H.B. Robinson ISFSIs” 76 Fed. Reg. 8874 2/16/2011
- **Waste Confidence rulemaking**
 - “studies performed to date have not identified any major issues with long-term use of dry storage” 75 Fed. Reg. 81072, 12/23/2010
- **EPRI and NRC Dry Storage PRAs conducted in 2007**
 - Annual cancer risk between 1.8E-12 and 3.2E-14 *
- **Opportunities to further verify performance being pursued**

Performance Verification

- **INL Dry Storage Characterization Project opened cask stored from 1985 to 1999 and verified “long-term storage has not caused detectable degradation of the spent fuel cladding or the release of gaseous fission products”**
- **Industry working with DOE to develop a similar demonstration program for additional data (including higher burn up fuel)**
- **EPRI is conducting inspections to verify canister performance in chloride rich atmospheres**

Extended Storage in an Integrated System

- **An integrated system must, at a minimum, connect the following elements***
 - **Storage at reactor sites**
 - **Transportation**
 - **Storage at consolidated sites**
 - **Transportation (?)**
 - **Disposal**
- **Integration must be built on the system we have, not the one we wish we had**
- **Integration must be supported by a more efficient regulatory framework**

*The deployment of recycling technologies will not completely eliminate the need for direct disposal of at least some portion of the used fuel inventory

Conclusion

- **There is a strong basis to support safe used fuel storage for extended time periods**
- **Industry is working pro-actively to address future challenges regarding extended storage**
- **Extended storage should be addressed in the context of the integrated system in which it exists**
- **Regulatory framework improvements will enhance our ability to address extended storage**

Regulation of Future Extended Storage and Transportation Technical Information Needs

James Rubenstone

Office of Nuclear Material Safety and Safeguards

U.S. Nuclear Regulatory Commission

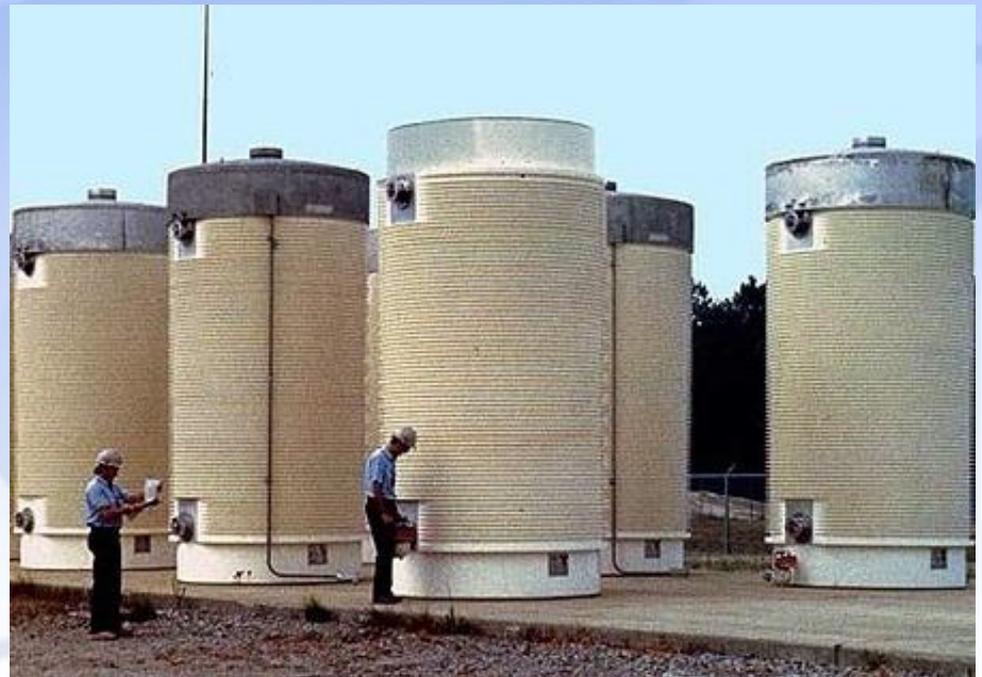
Advisory Committee on Reactor Safeguards

July 11, 2012



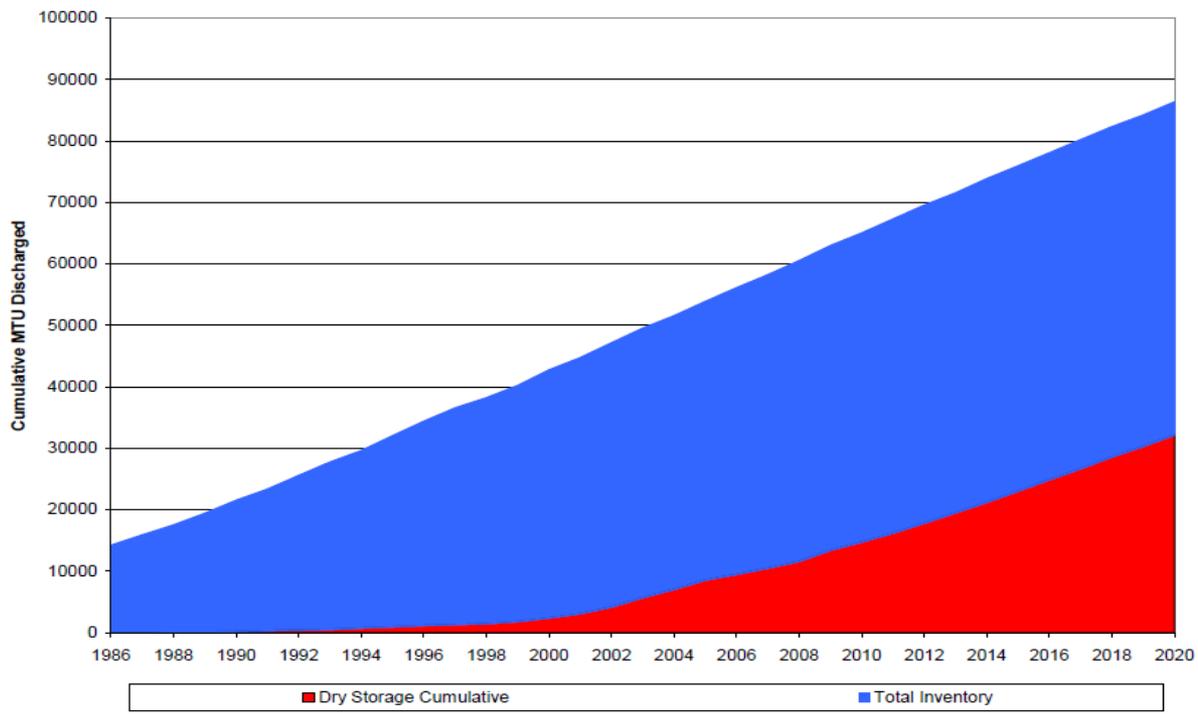
Overview

- Changing policy environment
- Regulatory framework—current and future
- Extended storage and transportation—technical information needs
- Next steps





Spent Fuel Storage: Historical and Projected Spent Fuel Discharges



Source: *Impacts Associated with Transfer of Spent Nuclear Fuel from Spent Fuel Storage Pools to Dry Storage After Five Years of Cooling*, Electric Power Research Institute, 2010

- About 18,000 MTU commercial SNF currently in dry storage
- About 1,500 casks currently loaded



Extended Spent Fuel Storage and Transportation: Needs

- **Potential changes to regulations and guidance to accommodate extended storage and transportation of long-stored spent fuel**
- **Technical information to inform potential regulatory changes and support future licensing reviews**
 - **Identify technical issues associated with long-term storage**
 - **Perform focused research on technical issues of regulatory significance**



Extended Spent Fuel Storage and Transportation: Technical Needs

- Focus on potential degradation phenomena for dry storage systems, structures, and components
- Consider impact on performance of safety functions for storage and transportation
- Consider understanding necessary for regulatory review



Draft Report for Comment

**Identification and Prioritization of the
Technical Information Needs Affecting
Potential Regulation of Extended Storage
and Transportation of Spent Nuclear Fuel**

May 2012



Extended Spent Fuel Storage and Transportation: Methodology

- **Used previous studies of technical gaps**
 - **NRC – Savannah River National Laboratory**
 - **Department of Energy**
 - **Nuclear Waste Technical Review Board**
 - **Electric Power Research Institute**
- **Level of knowledge for degradation processes**
 - **Time and conditions of initiation**
 - **Rate of progression**
 - **End state**
- **Impact on meeting regulatory criteria**



Extended Spent Fuel Storage and Transportation: Criteria

- **Design criteria – Safety functions**
 - **Confinement**
 - **Criticality control**
 - **Radiation shielding**
 - **Structural integrity**
 - **Thermal control**
- **Ability to retrieve stored fuel by normal means**
- **Possible impacts for transportation of long-stored spent fuel**



Extended Spent Fuel Storage and Transportation: Technical Needs

- **High priority degradation areas:**
 - Stress corrosion cracking of stainless steel canister body and welds in marine atmosphere
 - Degradation of cask bolts
 - Effects of fuel pellet swelling and fuel rod pressurization on cladding stress
- **High-priority cross-cutting areas:**
 - More realistic thermal model calculations
 - Effects of residual moisture after canister drying
 - In-service monitoring methods for dry storage systems



Extended Spent Fuel Storage and Transportation: Technical Needs

- **Other (nearly as) high priority degradation areas:**
 - **Propagation of cladding flaws, cladding fatigue, and low temperature creep (stress dependent)**
 - **Fuel assembly hardware corrosion and fatigue embrittlement**
 - **Neutron absorber degradation**
 - **Microbially influenced corrosion**
 - **Concrete degradation in unexposed areas**



Extended Spent Fuel Storage and Transportation: Active Work Areas

- **Stress corrosion cracking of stainless steel canister body and welds in marine atmosphere**
- **Effects of residual moisture**
- **Improved thermal models**
- **Potential non-destructive methods for inspection and monitoring**



Extended Spent Fuel Storage and Transportation: Current SCC Work

- **Prior scoping investigation (NUREG/CR-7030)**
 - Limited control of quantity of salt deposited on surface; tests used higher relative humidity than expected for facilities
 - Results showed SCC could occur at lower temperatures where salt could deliquesce
- **Current NRC-sponsored investigation**
 - More realistically bound conditions where SCC can occur
 - Preliminary results indicate that SCC can occur even with relatively low quantity of deposited salt, for likely temperature and relative humidity
- **Industry efforts**
 - Currently focusing on canister conditions, including surface temperature, relative humidity, and deposited material



Extended Spent Fuel Storage and Transportation: Regulatory Areas

- Long term cladding integrity and retrievability
- Long-term financial assurance
- Decommissioned sites
- Physical security
- Risk informed regulations
- Integration of storage, transportation, and disposal regulations
- Coordination with current licensing process improvements



Extended Spent Fuel Storage and Transportation: Next Steps

- Finalize report on *Technical Information Needs Affecting Potential Regulation of Extended Storage and Transportation* after public comments
- Complete research plan for technical investigations
- Assess potential regulatory issues
- Continue technical investigations in selected high-priority areas
- Engage industry and other stakeholders
- Monitor outside technical work



Spent Fuel Storage and Transportation: BRC

Blue Ribbon Commission proposed a national nuclear waste management strategy with eight key elements, including:

- A new, consent-based approach to siting future nuclear waste management facilities**
- Prompt efforts to develop one or more consolidated storage facilities**
- Prompt efforts to prepare for the eventual large-scale transport of spent nuclear fuel and high-level waste to consolidated storage and disposal facilities when such facilities become available**



Conclusions

- **NRC is continuing to perform its mission while preparing for potential policy changes**
- **Initial NRC staff efforts have defined tasks and developed plans and schedules**
- **Draft report for technical needs been issued for public comment**
- **Staff is completing technical work plans, examining regulatory areas, and has begun some technical work**
- **Staff is continuing interaction with public, industry, and other stakeholders**



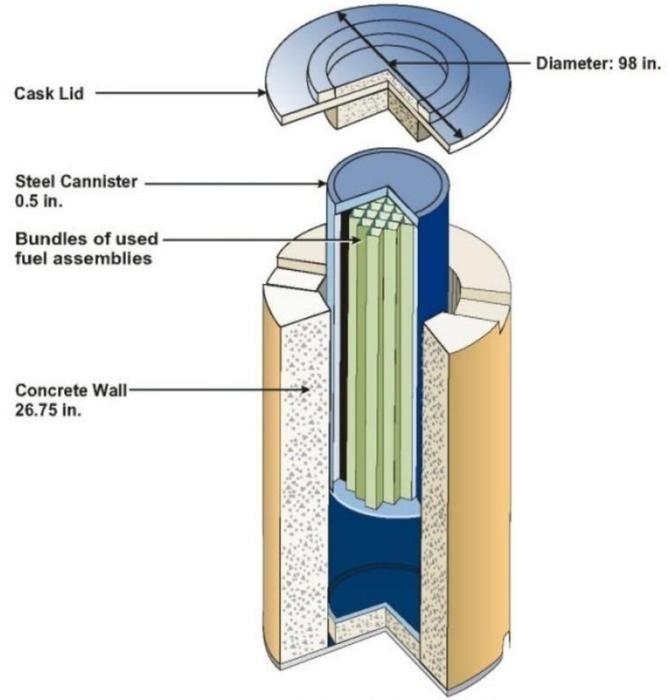
Backup Slides





Spent Fuel Storage: Dual Purpose Systems

Dual Purpose Storage Cask*

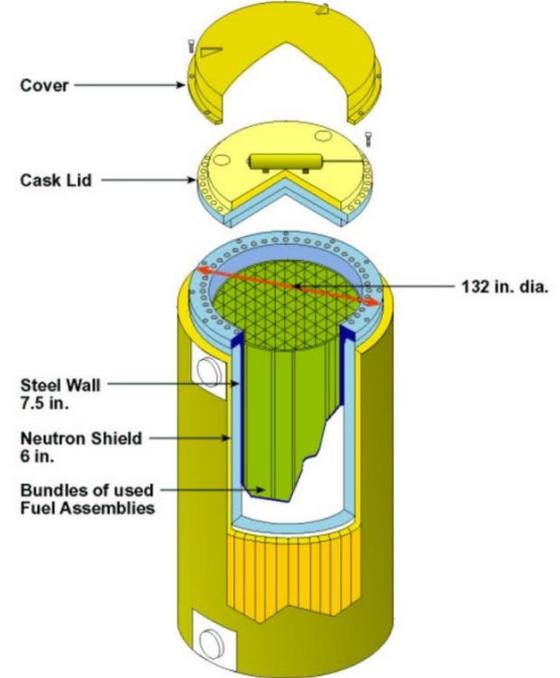


(Holtec International
HI-STORM 100)

Overall Length: 197 to 225 in.
Loaded Weight: 360,000 lbs.
Typical Payload: 24 PWR Bundles

* Storage and Transportation

Dual Purpose Cask*

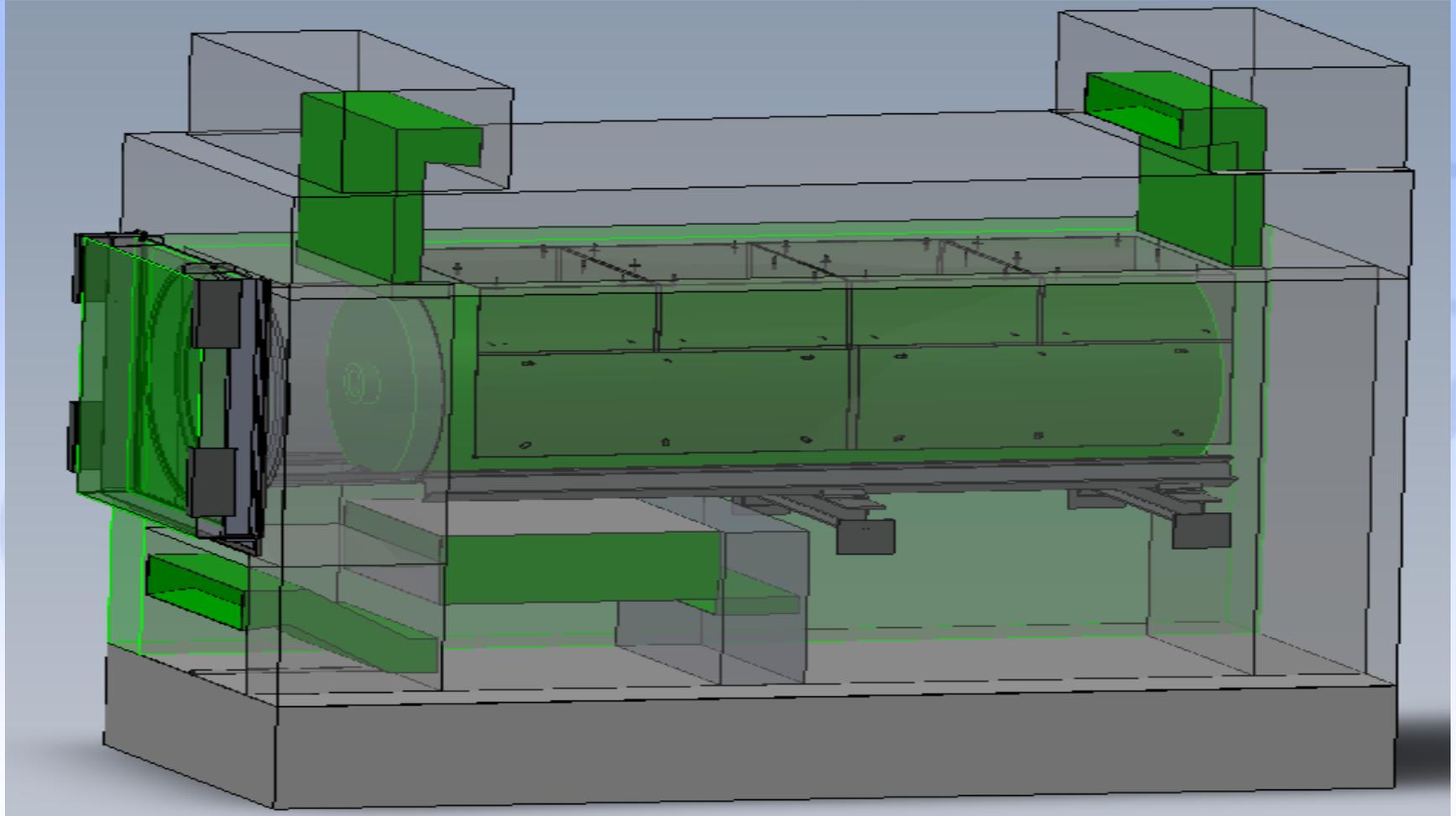


(Transnuclear TN-68)

Overall Length: 178 in.
Loaded Weight: 240,000 lbs.
Typical Payload: 68 BWR Bundles



Spent Fuel Storage: NUHOMS Canister System





Extended Storage Technical Issues

John Kessler

Manager, Used Fuel and HLW Management Program

Advisory Committee on Reactor Safeguards

11 July 2012

Extended Storage – an International Issue

- Most “nuclear” countries face extended storage
 - No reprocessing
 - No disposal
 - Centralized (consolidated) storage is still storage
- Major need to share data and collaborate

“Extended Storage Collaboration Program” (ESCP) Launched in 2009

Bring together US and international organizations engaged with active or planned R&D

- Storage and transportation system vendors
- Regulators and their R&D contractors (includes NRC)
- National waste management organizations
- R&D organizations (includes DOE, EPRI)
- Industry (utilities/cask vendors)

EPRI Extended Storage Collaboration Program (ESCP)

- Purpose: “Provide the technical bases to ensure continued safe, long-term used fuel storage and future transportability”
- ✓ Phase 1: Review current technical bases and conduct gap analysis for storage systems
- Phase 2: Conduct experiments, field studies, and additional analyses to address gaps
- Phase 3: Long-term performance confirmation

Gap Analyses*: Highest Priority Items

- **Welded SS canisters SCC**
- **High burnup cladding:** hydride effects (reorientation, embrittlement)
- **Bolted casks:**
 - Corrosion of bolts
 - Embrittlement and mechanical degradation of bolts
- Fuel pellet swelling

*NWTRB, DOE, NRC, EPRI

Cross-Cutting Needs

- **Improved thermal modeling**
- **Degradation monitoring systems**
- Stress profiles
- Adequacy of drying
- Sub-criticality: burnup credit
- Examine casks at INL (DOE)
- Retrievability: fuel transfer options

EPRI Plans for In Situ Inspection of SS Canisters

SCC of Welded Canisters – What Do We Know?

For stress corrosion cracking you need:

- Susceptible material (austenitic stainless steels; e.g. 304, 316)
- Tensile stress (residual weld stress)
- Corrosive environment
 - Salts in the air
 - Deliquescence
 - Surface temperature
 - Humidity

Studies have shown SCC can occur on canister materials *under lab conditions*

What we don't know ...

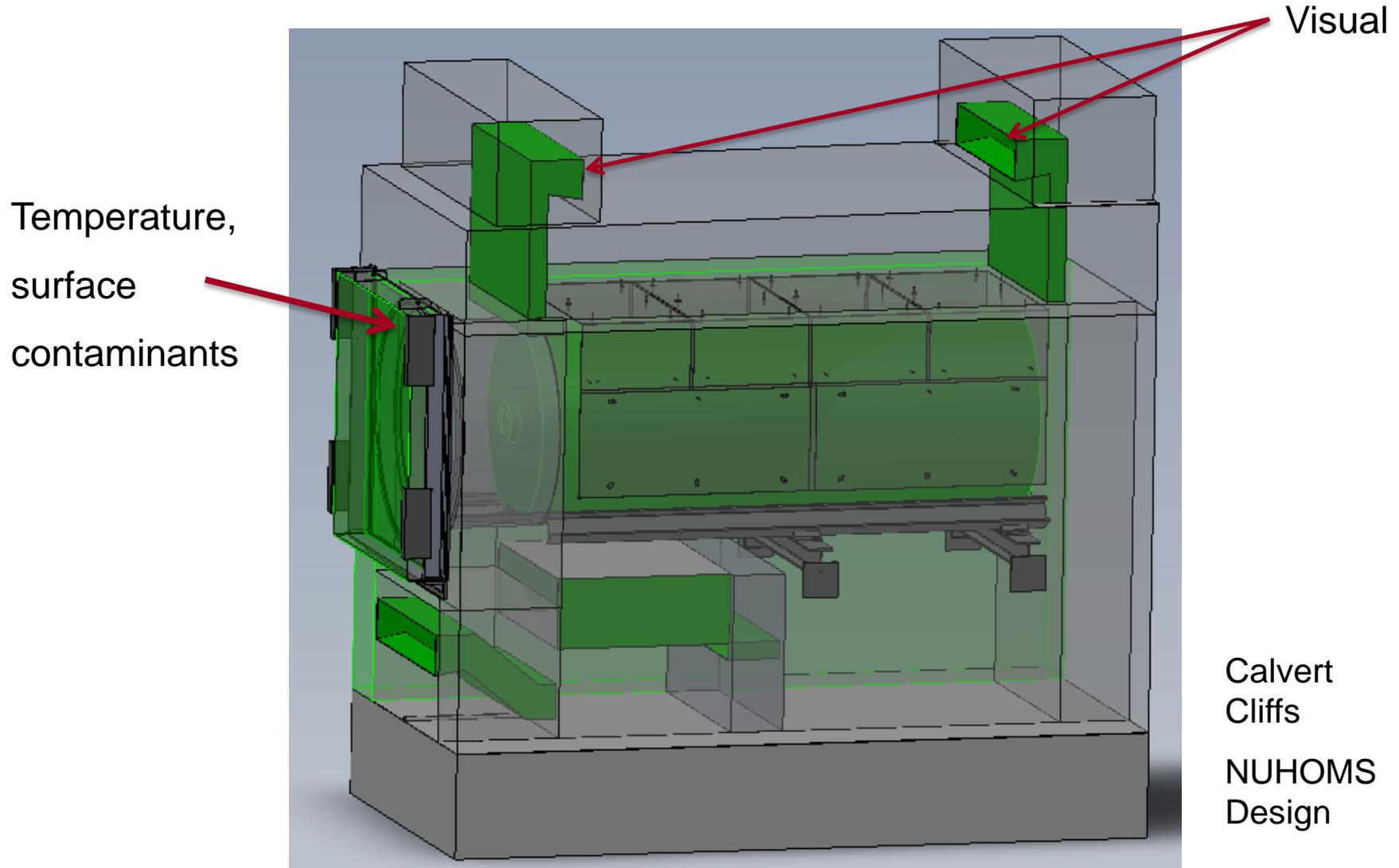
What are the conditions on actual canisters?

Inspection #1: Calvert Cliffs (June 27-28, 2012)

- ~ ½ mile from Chesapeake Bay
- Canisters in service for >15 years
- Two canisters were inspected
 - “HSM-15” visual inspection for license renewal
 - “HSM-1” (oldest, coldest): R&D data to evaluate SCC potential
- Constellation currently preparing report for NRC

More inspections to follow

Calvert Cliffs Inspection Entry Points



HSM-1 Temperature, Surface Contaminant Data Collection: Mock-Up Demonstration, Training



Photo courtesy of
Transnuclear

SaltSmart Deployment: Example from Mockup

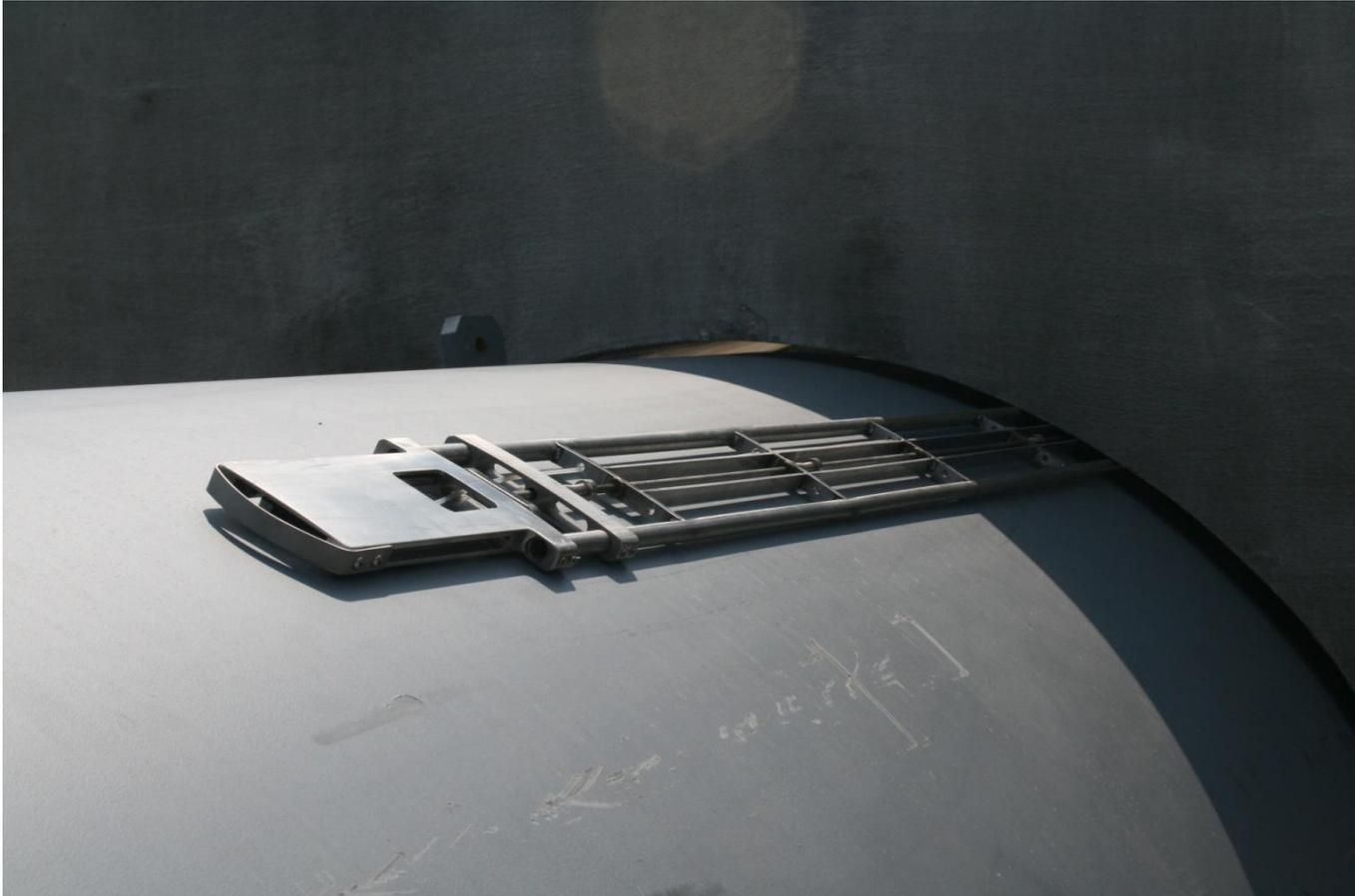


Photo courtesy of
Transnuclear

Surface Deposit Collector: Example from Mockup



Photo courtesy of
Transnuclear

Ultimate Goal: Industry-wide SS Canister Aging Management Plan

- Identify potentially susceptible canisters
 - Where?
 - When?
- Inspection plans
- Mitigation plans if required

Full-scale, Long-term, High Burnup Used Fuel Confirmatory Data Collection

(“high burnup demo”)

High Burnup Demo Needs

Confidence in understanding longer-term behavior of dry storage system requires:

1. Model development and benchmarking data
2. Small-scale “Separate effects testing”
- 3. Confirmatory testing under “prototypic” conditions**
 - Full scale
 - Representative dry storage conditions
 - Prefer multiple high BU fuel types (if possible)

Full-scale High Burnup Demo Activities

Industry need to keep
this short

- Obtain “t=0” data from sister rods
- Modify existing cask with a special lid that includes
 - Thermocouples
 - Gas sampling
 - Other?
- Load cask and emplace modified lid
- ***Data collection through lid begins immediately***
 - Capture temperature and gas evolution during drying
 - Continue temperature measurements and periodic gas sampling
- After X years (TBD), re-open, remove rods, visually inspect for degradation

High Burnup Demo Option that Keeps Startup Time Short

- Initiate the demo at a reactor site
 - Avoids up-front transportation to a national lab
 - Avoids having to wait for a full-scale hot cell to be funded and constructed
 - Keeps costs lower prior to test initiation
- Dominion-TN option(start test in 3-5 years)
 - Willing host (North Anna or Surry)
 - Multiple, high burnup fuel types
 - TN to supply cask(s) at lower cost
 - EPRI providing initial funding for instrumented lid design
 - Looking for co-funding

Together...Shaping the Future of Electricity

I) The total quantity of hydrogen that could be produced in a severe accident

A) In the Three Mile Island accident, it is generally estimated that a total of 500 kg of hydrogen was produced.¹

B) A 1988 Oak Ridge National Laboratory report states that:

It should be noted that in an unmitigated BWR severe accident the entire Zircaloy inventory of the reactor would eventually oxidize (either in the reactor vessel or on the drywell floor), generating as much as...2722 kg of hydrogen (plant specific value).²

C) In severe accidents, if the total amount of the zirconium in a typical PWR's core (3600 megawatts thermal), approximately 26,000 kg, were to oxidize, approximately 1150 kg of hydrogen would be produced and if the total amount of the zirconium in a typical BWR's core (3800 megawatts thermal), approximately 76,000 kg, were to oxidize, approximately 3360 kg of hydrogen would be produced.³ (In both of these cases, the total quantity of zirconium in the core is greater than that of 100 percent of the active fuel cladding length.)

D) In a BWR severe accident, between 100 kg and 400 kg of hydrogen could be produced from the oxidation of the boron carbide neutron absorber material.⁴ And in a severe accident, "[s]teel oxidation may contribute about 10% to 15% to the total [in-vessel] hydrogen production."⁵

II) Potential rates of hydrogen production in a severe accident

In a severe accident, hydrogen generation would occur at rates from 0.1 to 5.0 kg per second; during a reflooding of an overheated core up to 300 kg of hydrogen could be produced in one minute.⁶ One report states that between 5 and 10 kg of hydrogen could be produced per second, during the reflooding of an overheated core.⁷

III) The need for installing high-capacity filters at BWR Mark I and Mark IIs in addition to hardened vents:

A) The report “Filtered Venting Considerations in the United States,” states that “[f]iltered venting may have positive benefits for those sequences in which the rate of containment pressure rise is relatively slow. Filtered venting is less feasible for those sequences resulting in early over-temperature or over-pressure conditions. This is because the relatively early rapid increase in containment pressure requires large containment penetrations for successful venting.”⁸

B) In a December 2011 article, Saloman Levy⁹ stated that in the event of a U.S. BWR Mark I severe accident, “[e]arly venting [would be] preferred, when the containment pressure and hydrogen concentration are low and not prone to explosions and fires” and that in the Fukushima Dai-ichi accident, plant operators should have “[c]onsider[ed] early venting rather than waiting for containment pressure to reach or exceed design pressure.”¹⁰ Levy does not refer to high-capacity filters in his statements; however, it could be argued that implementing a policy of early venting would require installing a high-capacity filter to help protect the surrounding population, who would not have time to evacuate and prevent becoming exposed to radioactive releases.

C) The NRC should also consider that not all severe accidents would be like the Fukushima Dai-ichi accident: “slow-moving” station-blackout accidents caused by natural disasters. Fast-moving accidents could also occur; for example, a large break loss-of-coolant accident could rapidly transition into a severe accident—a meltdown could commence within 10 minutes after an accident initiated.¹¹ Early venting might be necessary in a fast-moving accident scenario: a high-capacity filter would help protect the surrounding population, who would not have time to evacuate and prevent becoming exposed to radioactive releases.

¹ Jae Sik Yoo, Kune Yull Suh, “Analysis of TMI-2 Benchmark Problem Using MAAP4.03 Code,” Nuclear Engineering and Technology, Vol. 41, No. 7, September 2009, p. 949.

² Sherrell R. Greene, Oak Ridge National Laboratory, “The Role of BWR Secondary Containments in Severe Accident Mitigation: Issues and Insights from Recent Analyses,” 1988.

³ International Atomic Energy Agency, “Mitigation of Hydrogen Hazards in Severe Accidents in Nuclear Power Plants,” IAEA-TECDOC-1661, July 2011, p. 10.

⁴ *Id.*, pp. 6, 15, 16.

⁵ Report by Nuclear Energy Agency Groups of Experts, OECD Nuclear Energy Agency, “In-Vessel and Ex-Vessel Hydrogen Sources,” NEA/CSNI/R(2001)15, October 1, 2001, Part I, B. Clément (IPSN), K. Trambauer (GRS), W. Scholtyssek (FZK), Working Group on the Analysis and Management of Accidents, “GAMA Perspective Statement on In-Vessel Hydrogen Sources,” p. 8.

⁶ E. Bachelierie, *et al.*, “Generic Approach for Designing and Implementing a Passive Autocatalytic Recombiner PAR-System in Nuclear Power Plant Containments,” Nuclear Engineering and Design, 221, 2003, p. 158.

⁷ J. Starflinger, “Assessment of In-Vessel Hydrogen Sources,” in “Projekt Nukleare Sicherheitsforschung: Jahresbericht 1999,” Forschungszentrum Karlsruhe, FZKA-6480, 2000.

⁸ R. Jack Dallman, *et al.*, “Filtered Venting Considerations in the United States,” May 17-18, 1988, CSNI Specialists Meeting on Filtered Vented Containment Systems, Paris France, p. 3.

⁹ “How Would U.S. Units Fare?” states that “Dr. Levy was the manager responsible for General Electric (GE) BWR heat transfer and fluid flow and the analyses and tests to support [GE’s] nuclear fuel cooling during normal, transient, and accident analyses from 1959 to 1977.” See Saloman Levy, “How Would U.S. Units Fare?,” Nuclear Engineering International, December 7, 2011.

¹⁰ Saloman Levy, “How Would U.S. Units Fare?,” Nuclear Engineering International, December 7, 2011. Levy makes the point that his observations are not intended to be criticisms of the actions of the Fukushima Dai-ichi plant operators.

¹¹ Peter Hofmann, “Current Knowledge on Core Degradation Phenomena, a Review,” Journal of Nuclear Materials, Vol. 270, 1999, p. 205.

Post-Fukushima Hardened Vents with High-Capacity Filters for BWR Mark Is and Mark IIs

By Mark Leyse, Nuclear Safety Consultant

A Project Completed for NRDC, July 2012

Acknowledgements: The author thanks David Lochbaum of Union of Concerned Scientists for reviewing this report.

I. Why Boiling Water Reactor Mark I Primary Containments have Been Backfitted with Hardened Vents

The U.S. Nuclear Regulatory Commission's (NRC) 2011 Near-Term Task Force report on insights from the Fukushima Dai-ichi accident states that NRC reports from 1975¹ and 1990² both concluded that in the event of a severe accident, boiling water reactor (BWR) Mark I primary containments have "a relatively high containment failure probability," because BWR Mark I primary containments have smaller volumes when compared to PWR containments³—about one-eighth the volume of PWR large dry containments. (BWR Mark I primary containments have a volume of approximately $0.28 \times 10^6 \text{ ft}^3$; pressurized water reactor (PWR) large dry containments have a volume of approximately $2.2 \times 10^6 \text{ ft}^3$.⁴) BWR Mark II primary containments also have relatively small volumes—about one-sixth the volume of PWR large dry containments. (BWR Mark II primary containments have a volume of approximately $0.4 \times 10^6 \text{ ft}^3$.⁵)

A BWR Mark I primary containment is comprised of a drywell, shaped like an inverted light bulb, and a wetwell (also termed "torus"), shaped like a doughnut. The

¹ NRC, "Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," NUREG-75-014, WASH-1400, October 1975.

² NRC, "Severe Accident Risks: An Assessment of Five U.S. Nuclear Power Plants," NUREG-1150, December 1990.

³ Charles Miller, *et al.*, NRC, "Recommendations for Enhancing Reactor Safety in the 21st Century: The Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," SECY-11-0093, July 12, 2011, available at: www.nrc.gov, NRC Library, ADAMS Documents, Accession Number: ML111861807, p. 39.

⁴ M. F. Hessheimer, *et al.*, Sandia National Laboratories, "Containment Integrity Research at Sandia National Laboratories: An Overview," NUREG/CR-6906, July 2006, available at: www.nrc.gov, NRC Library, ADAMS Documents, Accession Number: ML062440075, p. 24.

⁵ *Id.*

wetwell is half filled with water (typically over a million gallons⁶)—the suppression pool. A BWR Mark II primary containment also has a drywell and wetwell—both shaped differently than their BWR Mark I counterparts.

In a severe accident, the water pumped into the reactor core to cool the fuel rods would heat up and produce thousands of kilograms (kg) of steam, which would enter the primary containment. The water in the suppression pool is intended to condense the steam and help absorb the heat released by the accident to reduce the pressure in the primary containment. Without the condensation of the steam in the suppression pool, the relatively small primary containments of BWR Mark I and Mark IIs (often termed “pressure suppression containments”) would fail from becoming over-pressurized.

In a BWR severe accident, hundreds of kilograms of non-condensable hydrogen gas would also be produced (up to over 3000 kg⁷)—at rates as high as between 5.0 and 10.0 kg per second, if there were a reflooding of an overheated reactor core⁸—which would increase the internal pressure of the primary containment. If enough hydrogen were produced, the containment could fail from becoming over-pressurized. To help address this problem, in 1989, the NRC sent Generic Letter 89-16, “Installation of a Hardened Wetwell Vent” to all the owners of BWR Mark Is, *recommending*⁹ that hardened vents be installed in BWR Mark Is.¹⁰ Hardened wetwell vents are intended to depressurize and remove decay heat from BWR Mark I primary containments; and the water in the wetwell would help scrub the fission products (excluding noble gases) that had entered the containment.¹¹

⁶ David Lochbaum, “Fission Stories: Nuclear Power’s Secrets,” February 2000, p. 9.

⁷ International Atomic Energy Agency (IAEA), “Mitigation of Hydrogen Hazards in Severe Accidents in Nuclear Power Plants,” IAEA-TECDOC-1661, July 2011, p. 10.

⁸ J. Starflinger, “Assessment of In-Vessel Hydrogen Sources,” in “Projekt Nukleare Sicherheitsforschung: Jahresbericht 1999,” Forschungszentrum Karlsruhe, FZKA-6480, 2000.

⁹ Generic Letter 89-16 states that “the Commission has directed the [NRC] staff to approve installation of a hardened vent under the provisions of 10 CFR 50.59 [“Changes, Tests, and Experiments”] for licensees, who on their own initiative, elect to incorporate this plant improvement;” see NRC, “Installation of a Hardened Wetwell Vent,” Generic Letter 89-16, September 1, 1989, p. 1.

¹⁰ NRC, “Installation of a Hardened Wetwell Vent,” Generic Letter 89-16, September 1, 1989, p. 1.

¹¹ R. Jack Dallman, *et al.*, “Filtered Venting Considerations in the United States,” May 17-18, 1988, CSNI Specialists Meeting on Filtered Vented Containment Systems, Paris France, p. 5.

II. What Would Be the Features of Reliable Hardened Containment Vents with High-Capacity Filters?

It is widely known that in the Fukushima Dai-ichi accident, hardened vents did not prevent hydrogen from entering BWR Mark I secondary containments and detonating. In fact, hardened vents may have caused the Fukushima Dai-ichi accident to be worse than it would have been if such vents had not been used: “it is postulated that the hydrogen explosion in the Unit 4 reactor building was caused by hydrogen from Unit 3.”¹² Unit 3 and Unit 4’s containment vent exhaust piping was interconnected, so hydrogen may have been vented from Unit 3 to Unit 4’s secondary containment,¹³ where it detonated. Thus, one of the NRC’s requirements for a new design of a hardened vent is that it “shall include design features to minimize unintended cross flow of vented fluids within a unit and between units on site.”¹⁴

In a nuclear power plant (NPP) accident, venting BWR Mark I and Mark II primary containments could be beneficial; however, venting could also cause negative consequences. For example, a 1988 paper, “Filtered Venting Considerations in the United States” (hereinafter “Filtered Venting Considerations”), states that for some NPP accident scenarios, “venting has been postulated to increase the likelihood of core damage by causing pump cavitation¹⁵ and the eventual loss of injection to the reactor coolant system.”¹⁶

Given the vulnerabilities of BWR Mark I and Mark II primary containments—their relatively small volumes and dependence on suppression pools, which do not mitigate hydrogen—it is essential that a hardened containment vent be designed so that it

¹² Institute of Nuclear Power Operations, “Special Report on the Nuclear Accident at the Fukushima Dai-ichi Nuclear Power Station,” INPO 11-005, November 2011, p. 34.

¹³ *Id.*, pp. 33-34.

¹⁴ NRC, “Order Modifying Licenses with Regard to Reliable Hardened Containment Vents,” EA-12-050, March 12, 2012, available at: www.nrc.gov, NRC Library, ADAMS Documents, Accession Number: ML12054A694, Attachment 2, p. 1.

¹⁵ Cavitation is “[t]he formation of...vapor-filled cavities in liquids in motion when the pressure is reduced to a critical value while the ambient temperature remains constant. ... Cavitation causes “a restriction on the speed at which hydraulic machinery can be [operated] without noise, vibration...or loss of efficiency;” see “A Concise Dictionary of Physics,” Oxford University Press, 1990, p. 34.

¹⁶ R. Jack Dallman, *et al.*, “Filtered Venting Considerations in the United States,” p. 3.

would be reliable in a wide range of different severe accident scenarios. If such a vent cannot be developed,¹⁷ the NRC should perhaps consider either shutting down or not relicensing BWR Mark I and Mark IIs.

It could be difficult to design a hardened vent that would perform well in scenarios in which there were rapid containment-pressure increases. The report "Filtered Venting Considerations" discusses the importance of considering these scenarios: "[f]iltered venting may have positive benefits for those sequences in which the rate of containment pressure rise is relatively slow. Filtered venting is less feasible for those sequences resulting in early over-temperature or over-pressure conditions. This is because the relatively early rapid increase in containment pressure requires large containment penetrations for successful venting."¹⁸ This indicates that a reliable hardened vent's piping would possibly need a greater diameter and thickness than those of the hardened vents presently installed at U.S. BWR Mark Is.¹⁹

A 1993 OECD Nuclear Energy Agency paper, "Non-Condensable Gases in Boiling Water Reactors" (hereinafter "Non-Condensable Gases"), discusses severe accident scenarios in which there would be a rapid accumulation of steam in the drywell and non-condensable gas accumulation (nitrogen²⁰ and hydrogen) in the wetwell; in such scenarios, the primary containment's pressure could *rapidly* increase "up to the venting and failure levels."²¹ "Non-Condensable Gases" states that for a 3300 megawatt thermal BWR Mark I, in scenarios in which hydrogen would be produced from a zirconium-steam reaction of 40 percent, 70 percent, and 100 percent of all the zirconium in the reactor core,²² if the total quantity of non-condensable gases (including nitrogen) were to

¹⁷ It is noteworthy that a 1983 Sandia National Laboratories manual cautions that "it may be difficult to design vents that can handle the rapid transients involved [in a severe accident];" see Allen L. Camp, *et al.*, Sandia National Laboratories, "Light Water Reactor Hydrogen Manual," NUREG/CR-2726, August 1983, p. 2-66.

¹⁸ R. Jack Dallman, *et al.*, "Filtered Venting Considerations in the United States," p. 3.

¹⁹ The piping of hardened vents currently installed at U.S. BWR Mark Is is typically 8-inches in diameter.

²⁰ Nitrogen is used to inert BWR Mark I and Mark II primary containments.

²¹ T. Okkonen, Nuclear Energy Agency OECD, "Non-Condensable Gases in Boiling Water Reactors," NEA/CSNI/R(94)7, May 1993, pp. 4-5.

²² Equivalent to the quantity of hydrogen that would be produced from a zirconium-steam reaction of 72 percent, 126 percent, and 180 percent, respectively, of the active fuel cladding length.

accumulate in the wetwell, the primary containment's pressure would increase up to 107 pounds per square inch (psi), 161 psi, and 215 psi, respectively.²³

If a hardened vent were designed to have a rupture disk, the vent would work passively, ensuring that the venting of the primary containment commenced once its internal pressure reached the point at which the rupture disk was set to rupture. A reliable passive venting capability would satisfy two of the NRC's requirements for a new design of a hardened vent: 1) it "shall be designed to minimize the reliance on operator actions" and 2) it "shall include a means to prevent inadvertent actuation."²⁴ A reliable passive venting capability could also be advantageous in severe accident scenarios that had rapid containment pressure increases; however, there could always be other severe accident scenarios in which plant operators would want to vent the primary containment before the primary containment's internal pressure reached the point at which the vent's rupture disk was set to rupture.²⁵

In a December 2011 article, Saloman Levy²⁶ stated that in the event of a U.S. BWR Mark I severe accident, "[e]arly venting [would be] preferred, when the containment pressure and hydrogen concentration are low and not prone to explosions and fires" and that in the Fukushima Dai-ichi accident, plant operators should have "[c]onsider[ed] early venting rather than waiting for containment pressure to reach or exceed design pressure."²⁷ Levy does not refer to high-capacity filters in his statements; however, it could be argued that implementing a policy of early venting would require installing a high-capacity filter to help protect the surrounding population, who would not have time to evacuate and prevent becoming exposed to radioactive releases.

²³ T. Okkonen, "Non-Condensable Gases in Boiling Water Reactors," p. 6.

²⁴ NRC, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents," Attachment 2, p. 1.

²⁵ In a telephone conversation with the author on May 18, 2012, David Lochbaum of Union of Concerned Scientists said that there could be severe accident scenarios in which plant operators would want to vent the primary containment when the internal pressure was relatively low.

²⁶ "How Would U.S. Units Fare?" states that "Dr. Levy was the manager responsible for General Electric (GE) BWR heat transfer and fluid flow and the analyses and tests to support [GE's] nuclear fuel cooling during normal, transient, and accident analyses from 1959 to 1977." See Saloman Levy, "How Would U.S. Units Fare?," Nuclear Engineering International, December 7, 2011.

²⁷ Saloman Levy, "How Would U.S. Units Fare?," Nuclear Engineering International, December 7, 2011. Levy makes the point that his observations are not intended to be criticisms of the actions of the Fukushima Dai-ichi plant operators.

A high-capacity filter would also be needed for scenarios in which there was a reflooding of an overheated reactor core, which would rapidly generate hydrogen, thereby possibly threatening containment integrity and increasing the risk of radioactive fission product releases.²⁸ Additionally, a 1988 Oak Ridge National Laboratory (ORNL) paper suggests installing high-capacity filters at BWR Mark IIs because “[i]t is much more probable that operation of simple ‘hard’ venting systems in [Mark] II plants would result in the discharge of aerosols directly into the environment.”²⁹

“Filtered Venting Considerations” states that “[v]enting could be from the drywell or the wetwell, but wetwell venting is preferred to allow for fission product (excluding noble gases) scrubbing in the suppression pool.”³⁰ However, according to the same paper there could be a wide range in the effectiveness of suppression pools in scrubbing and retaining radionuclides in the event of a severe accident. The paper states that “[t]he decontamination factor³¹...associated with suppression pool scrubbing can range anywhere from one (no scrubbing) to well over 1000 (99.9 [percent] effective). This wide band is a function of the accident scenario and composition of the fission products, the pathway to the [suppression] pool (through spargers, downcomers, etc.), and the conditions in the [suppression] pool itself. Conservative [decontamination factor] values of five [80 percent removal] for scrubbing in Mark I suppression pools, and 10 [90 percent removal] for Mark II...suppression pools, have recently been proposed for licensing review purposes.”³² Clearly, a high-capacity filter would help protect the public from becoming exposed to radioactive releases if there were venting from either the drywell or wetwell (in cases in which the suppression pool was ineffective at scrubbing and retaining radionuclides).

²⁸ OECD Nuclear Energy Agency, “In-Vessel Core Degradation Code Validation Matrix: Update 1996-1999,” Report by an OECD NEA Group of Experts, October 2000, p. 13.

²⁹ Sherrell R. Greene, Oak Ridge National Laboratory, “The Role of BWR Secondary Containments in Severe Accident Mitigation: Issues and Insights from Recent Analyses,” 1988.

³⁰ R. Jack Dallman, *et al.*, “Filtered Venting Considerations in the United States,” p. 5.

³¹ The decontamination factor is “[t]he ratio of the initial amount of a nuclide in a [gaseous or liquid] stream (specified in terms of concentration or activity of radioactive materials) to the final amount of that nuclide in a stream following treatment by a given process;” see T. Chandrasekaran, *et al.*, NRC, “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors: PWR-GALE Code,” NUREG-0017, Rev. 1, March 1985, p. 1-4.

³² R. Jack Dallman, *et al.*, “Filtered Venting Considerations in the United States,” p. 4.

III. The Need for Installing High-Capacity Filters at BWR Mark I and Mark IIs in Addition to Hardened Vents

The nuclear industry and NRC staff appear generally to be in alignment on a variety of issues regarding the implementation of orders incorporating safety lessons from the agency's Fukushima task force, though some differences remain to be worked out.³³—Nuclear Energy Institute

In October 1985, the Swedish Barsebäck Power Plant completed the installation of a hardened venting system and high-capacity filter system (FILTRA),³⁴ a gravel filter with a volume of 10,000 cubic meters,³⁵ for its two BWRs, which were constructed by Asea-Atom.³⁶ Barsebäck's FILTRA system was "designed so that 99.9 [percent] of the core inventory of radioactivity, excluding noble gases, [would be] retained in the reactor containment and filter system in the event of containment venting" in a severe accident.³⁷ Interestingly, in the 1980s, the Long Island Lighting Company had plans to install a hardened venting system and high-capacity filter system, similar to the FILTRA system, at the Shoreham Plant, a BWR Mark II.^{38, 39}

The combined cost of Barsebäck's hardened venting and FILTRA systems for its two BWRs, was approximately 15 million dollars (1985 U.S. dollars).⁴⁰ In other words, Barsebäck's high-capacity filter system was not very expensive, considering that in the event of a severe accident it could significantly reduce the quantity of radioactive particulates discharged to the environment, which, in turn, reduces offsite contamination

³³ Nuclear Energy Institute, "NRC, Industry Discuss Details of Fukushima Response," April 12, 2012.

³⁴ R. Jack Dallman, *et al.*, "Filtered Venting Considerations in the United States," p. 6; and Sherrell R. Greene, "The Role of BWR Secondary Containments in Severe Accident Mitigation: Issues and Insights from Recent Analyses."

³⁵ OECD Nuclear Energy Agency, "Filtered Containment Venting Systems," Note on the Outcome of the May 1988 Specialists' Meeting on Filtered Containment Venting Systems, CSNI Report 156, 1988, p. 17.

³⁶ Barsebäck Power Plant Unit 1 and Unit 2 were permanently shutdown in November 1999 and May 2005, respectively.

³⁷ A. H. Persson, "The Filtered Venting System Under Construction at Barsebäck," *Nuclear Technology*, Vol. 70, No. 2, August 1985, Abstract.

³⁸ Sherrell R. Greene, "The Role of BWR Secondary Containments in Severe Accident Mitigation: Issues and Insights from Recent Analyses."

³⁹ The Shoreham Plant never operated.

⁴⁰ A. H. Persson, "The Filtered Venting System Under Construction at Barsebäck," Abstract.

and damage to economic activity. (Barsebäck is located in southern Sweden about 12 miles from Copenhagen, Denmark.)

By the end of 1988, all Swedish NPPs had high-capacity filter systems, intended to limit the contamination of the environment to 0.1 percent of the reactor core's inventory of radioactive material in the event of a severe accident. In Sweden, the FILTRA-MVSS (Multi Venturi Scrubber System) system—designed to handle flow rates of up to 12 kg per second—was installed in seven BWRs and three PWRs.⁴¹ An OECD Nuclear Energy Agency report states that Sweden's FILTRA-MVSS system cost less than five million dollars (1988 U.S. dollars) per reactor and opines that, because Sweden's high-capacity filter systems were inexpensive, "all criteria of the cost-benefit type are irrelevant."⁴²

A number of nuclear power plants in Europe currently operate with high-capacity filter systems, including designs other than the FILTRA-MVSS system. In France, hardened vents with high-capacity filter systems were installed in *all* French PWRs in the 1990s.⁴³ And in Germany, *all* of the BWRs have hardened vents with high-capacity filter systems.⁴⁴ Unfortunately, U.S. BWR Mark Is and Mark IIs are *not* presently operating with high-capacity filter systems. A 1988 ORNL paper reports that U.S. utilities believe that high-capacity filter systems have "unacceptably low cost-benefit ratios."⁴⁵ And a 2005 Nuclear Energy Institute (NEI) document on severe accident mitigation alternatives analysis states that the estimated cost of a filtered containment vent would be three million dollars and that the "upper bound estimate benefit" of installing a filtered vent would be zero dollars.⁴⁶ An April 30, 2012 *Huffington Post* article, which discusses the monetary values provided by the 2005 NEI document, states that a spokesperson for NEI

⁴¹ OECD Nuclear Energy Agency, "Filtered Containment Venting Systems," pp. 7, 8.

⁴² *Id.*, p. 4.

⁴³ E. Raimond, *et al.*, "Continued Efforts to Improve the Robustness of the French Gen II PWRs with Respect to the Risks of Severe Accidents: Safety Assessment and Research Activities," Eurosafe, 2011, p. 7.

⁴⁴ Martin Sonnenkalb, Manfred Mertins, "Severe Accident Mitigation in German NPP: Status and Future Activities," Eurosafe, 2011, p. 7.

⁴⁵ Sherrell R. Greene, "The Role of BWR Secondary Containments in Severe Accident Mitigation: Issues and Insights from Recent Analyses."

⁴⁶ NEI, "Severe Accident Mitigation Alternatives (SAMA) Analysis: Guidance Document," NEI 05-01 [Rev. A], November 2005, available at: www.nrc.gov, NRC Library, ADAMS Documents, Accession Number: ML060530203, p. 43.

said the estimated cost of three million dollars dated back to 1994 for a filtered vent, which would not have been “seismically designed;” the article also states that Dale Klein, a former NRC commissioner, estimates that a filtered vent might now cost about 15 million dollars.⁴⁷

When evaluating the cost of a filtered vent, it is pertinent that some U.S. BWR Mark Is and Mark IIs are located in proximity to areas with large populations. For example, the Limerick Nuclear Power Plant, which has two BWR Mark IIs, is located about 21 miles from Philadelphia. The potential impact of an unfiltered radioactive release in the event of a severe accident is quite large when considering the possible loss of agricultural economic activity and associated lands, the evacuation and suspension of industrial centers, and the cost of the decontamination of farmlands and city housing. However, even after the Fukushima Dai-ichi accident, the U.S. nuclear energy industry does not seem too keen on installing high-capacity filter systems,⁴⁸ in addition to the new hardened vents, which the NRC has required to be installed in BWR Mark Is and Mark IIs by December 31, 2016.⁴⁹

According to an April 12, 2012 NEI article “[i]ndustry participants [in a public meeting] said that other safety modifications could result in a level of safety benefit similar to that of filtered vents.”⁵⁰ And Maria Korsnick, Chief Nuclear Officer of Constellation Energy Nuclear Group, is quoted in the April 12, 2012 NEI article as stating that “[i]f you are managing a damaged core, managing containment, you are addressing the heart of the issue and there are modifications that are more beneficial than filtration.”⁵¹

Indeed, managing a damaged core and protecting the containment would be very important in a severe accident; however, the fact that severe accident computer safety models, instrumentation, and management procedures could be vastly improved is a separate safety issue than requiring that hardened venting systems have high-capacity

⁴⁷ Tom Zeller, “Nuclear Safety Advocates Accuse Industry and Regulators of Foot-Dragging on Basic Safety Measure,” *Huffington Post*, April 30, 2012.

⁴⁸ Jordan Weaver, NRDC, “Nuclear Safety Deferred: The U.S. Nuclear Regulatory Commission’s Inadequate Response to the Lessons of the Fukushima Dai-ichi Nuclear Accident,” March 2012, p. 12.

⁴⁹ NRC, “Order Modifying Licenses with Regard to Reliable Hardened Containment Vents.”

⁵⁰ NEI, “NRC, Industry Discuss Details of Fukushima Response.”

⁵¹ *Id.*

filters. The nuclear power industry's comments seem disingenuous: if the industry is confident that "there are modifications that are more beneficial than filtration," why did the industry not suggest implementing such modifications well before the Fukushima Dai-ichi accident occurred, in the 1980s and 1990s, when Europeans were installing hardened venting systems with high-capacity filters in NPPs?

The nuclear power industry's "modifications" for managing a damaged core seem to be predicated on at least three conditions: 1) computer safety models would accurately predict the progression of reactor core damage in different severe accident scenarios; 2) plant operators would know the condition of the core throughout the progression of a severe accident; and 3) there would not be circumstances in which plant operator error would make a severe accident far worse.

There is reason to doubt that these three conditions would be fulfilled in the event of another severe accident. Regarding the first condition: computer safety models under-predict the rates of hydrogen production that would occur in a severe accident, if there were a reflooding of an overheated reactor core.⁵² Regarding the second condition: given the fact plant operators did not know the condition of the reactor cores during the progression of the TMI-2 and Fukushima Dai-ichi accidents, there is reason to doubt that plant operators would know the condition of the core during the progression of another severe accident. (To help enable plant operators to accurately measure a wide range of in-core temperatures, under typical and accident conditions, NPPs need to operate with thermocouples (temperature measuring devices) placed at different elevations and radial positions throughout the reactor core.⁵³) Regarding the third condition: given the fact that plant operator errors made the TMI-2 and Chernobyl accidents far worse, there is reason

⁵² IAEA, "Mitigation of Hydrogen Hazards in Severe Accidents in Nuclear Power Plants," p. 14; and Report by Nuclear Energy Agency Groups of Experts, OECD Nuclear Energy Agency, "In-Vessel and Ex-Vessel Hydrogen Sources," NEA/CSNI/R(2001)15, October 1, 2001, Part I, B. Clément (IPSN), K. Trambauer (GRS), W. Scholtyssek (FZK), Working Group on the Analysis and Management of Accidents, "GAMA Perspective Statement on In-Vessel Hydrogen Sources," p. 9.

⁵³ In February 2012, the author of this report submitted a rulemaking petition (PRM-50-105) to the NRC requesting that the NRC require that NPPs operate with in-core thermocouples at different elevations and radial positions throughout the reactor core to enable NPP operators to accurately measure a large range of in-core temperatures under typical and accident conditions; see Mark Leyse, PRM-50-105, February 28, 2012, available at: www.nrc.gov, NRC Library, ADAMS Documents, Accession Number: ML12065A215.

to doubt that there would not be circumstances in which plant operator error would make another severe accident far worse.

The NRC is presently considering if it should require high-capacity filtration for hardened vents in order to reduce radioactive releases to the environment in the event of severe accidents. The NRC staff is scheduled to prepare a policy paper on this issue by July 2012.⁵⁴ NEI's April 12, 2012 article reports that Martin J. Virgilio, the NRC's Deputy Executive Director for Reactor and Preparedness Programs, "said that NRC staff also is working on a paper on the 'economic consequences of land contamination' from radioactive materials following a reactor accident" and "that cost-benefit analysis would be one of the tools used to analyze the land contamination issue."⁵⁵

The NRC should also consider that not all severe accidents would be like the Fukushima Dai-ichi accident: "slow-moving" station-blackout accidents caused by natural disasters. Fast-moving accidents could also occur; for example, a large break loss-of-coolant accident could rapidly transition into a severe accident—a meltdown could commence within 10 minutes after an accident initiated.⁵⁶ Early venting might be necessary in a fast-moving accident scenario: a high-capacity filter would help protect the surrounding population, who would not have time to evacuate and prevent becoming exposed to radioactive releases.

IV. Recommendations Regarding Hardened Vents with High-Capacity Filters for BWR Mark Is and Mark IIs

The author recommends that a hardened vent be designed so that it would perform well in scenarios in which there were rapid containment-pressure increases; for example, in scenarios in which there was a reflooding of an overheated reactor core. If such a vent cannot be developed, the NRC should perhaps consider either shutting down or not relicensing BWR Mark I and Mark IIs.

⁵⁴ NRC, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents," pp. 4-5.

⁵⁵ NEI, "NRC, Industry Discuss Details of Fukushima Response."

⁵⁶ Peter Hofmann, "Current Knowledge on Core Degradation Phenomena, a Review," *Journal of Nuclear Materials*, Vol. 270, 1999, p. 205.

The author also recommends that the NRC require that high-capacity filters be installed at BWR Mark Is and Mark IIs, in addition to hardened vents.

To uphold its congressional mandate to protect the lives, property, and environment of the people living within proximity to BWR Mark Is and Mark IIs, the NRC needs to require that hardened vents have high-capacity filtration systems, in order to reduce radioactive releases to the environment in the event of severe accidents. (Some BWR Mark Is and Mark IIs are located in proximity to areas with large populations. For example, the Limerick Nuclear Power Plant, which has two BWR Mark IIs, is located about 21 miles from Philadelphia.)