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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

REGULATORY POLICIES AND PRACTICES SUBCOMMITTEE

+ + + + +

TUESDAY

FEBRUARY 2, 2016

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ROCKVILLE, MARYLAND

+ + + + +

The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:35 a.m., John W. Stetkar, Chairman, presiding.

COMMITTEE MEMBERS:

JOHN W. STETKAR, Chairman

DENNIS C. BLEY, Member

RONALD G. BALLINGER, Member

MICHAEL L. CORRADINI, Member

JOY L. REMPE, Member

GORDON R. SKILLMAN, Member

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ACRS CONSULTANT:

WILLIAM SHACK

DESIGNATED FEDERAL OFFICIAL:

HOSSEIN P. NOURBAKHS

ALSO PRESENT:

NATHAN BIXLER, Sandia National Laboratories

MICHAEL CASE, RES

MATTHEW DENMAN, Sandia National Laboratories*

HOSSEIN ESMAILI, RES

EDWARD FULLER, RES

TINA GHOSH, RES

ERICA GRAY, Public Participant

EDWARD HACKETT, Director, ACRS

DONALD HELTON, RES

JOE JONES, Sandia National Laboratories

CHRISTIANA LUI, ACRS

KYLE ROSS, Sandia National Laboratories

PATRICIA SANTIAGO, RES

KC WAGNER, Dycoda

*Present via telephone

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P R O C E E D I N G S

8:35

a.m.

CHAIRMAN STETKAR: The meeting will now come to order. First of all, I'd like to wish you all a happy groundhog's day. I haven't seen the reports so I'm not sure what we're in for yet. Spring is coming. That's good news.

This is a meeting of the ACRS Subcommittee on Regulatory Policy and Practices. I'm John Stetkar, chairman of the subcommittee meeting.

Members in attendance are Ron Ballinger, Dick Skillman, Mike Corradini, Joy Rempe. We will be joined, I'm told, soon by Dennis Bley and also in attendance is our consultant, Bill Shack. In fact, Dennis Bley just walked in.

The purpose of this meeting is to discuss the draft report State of the Art Reactor Consequence Analysis Project on certainty analysis of the unmitigated short-term station blackout of the Surry Power Station.

The subcommittee will gather information, analyze relevant issues and facts and formulate proposed positions and actions as appropriate for

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1 deliberation by the full committee.

2 Dr. Hossein Nourbakhsh is the designated
3 federal official for this meeting. The entire
4 meeting is open to the public. Rules for the
5 conduct of and participation in the meeting have
6 been published in the Federal Register as part of
7 the notice for this meeting.

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

11 It is requested that speakers first
12 identify themselves and speak with sufficient
13 clarity and volume so that they can be readily
14 heard and I'll remind everyone to please check your
15 little communications devices and turn them off.

16 We have received no written comments or
17 requests for time to make all statement from
18 members of the public regarding today's meeting.

19 However, I understand that there may be
20 folks on the bridge line who are listening in on
21 the proceedings and we'll open the bridge line at
22 the end of the meeting to check to see if anyone
23 has comments.

24 It's been a while since we've had a
25 meeting on SOARCA. I think November 2013, if my

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1 recollection is correct, was the last one when we
2 heard about Peach Bottom.

3 Changes have been made. Improvements
4 have been made and we're interested in hearing
5 about them. So we'll now proceed with the meeting
6 and I'll call upon Pat Santiago, the Office of
7 Nuclear Regulatory Research, to open the
8 presentations.

9 MS. SANTIAGO: Thank you. My name is Pat
10 Santiago and I'm the branch chief for accident
11 analysis branch in the division of systems
12 analysis, Office of Nuclear Regulatory Research.

13 And I know Dr. Stetkar said he's been
14 excited for at least 17 minutes with regard to this
15 new presentation on SOARCA.

16 He's correct. The last time we briefed
17 was in 2013 on the Peach Bottom uncertainty
18 analysis and over the last two years we've been
19 working on the Surry uncertainty analysis.

20 And we did take back several
21 recommendations from our past briefs to the
22 subcommittee as well as the full committee with
23 regard to our analysis.

24 So today we are talking about the Surry
25 uncertainty analysis and we better document the

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1 parameter development process, as you had
2 recommended in the past.

3 We also look at the effects of key input
4 parameter uncertainties and that unmitigated short-
5 term station blackout accident scenario.

6 Another recommendation that you had made
7 to us is to conduct the uncertainty analysis in
8 parallel from the beginning of the project, which
9 we are doing for the SOARCA Sequoyah analysis and
10 we hope to bring that presentation to you sometime
11 this spring.

12 The SOARCA project and uncertainty
13 analysis touch on many different disciplines and
14 are relevant to the severe accident consequence
15 model.

16 This multi-disciplinary project was
17 conducted with numerous colleagues at NRC, Sandia
18 National Laboratory and other contact
19 organizations.

20 Today, three team members will make
21 presentations - Dr. Tina Ghosh of my staff, KC
22 Wagner, who is Dycoda but formerly of Sandia
23 National Laboratories and worked with us on the
24 prior SOARCA consequence analyses.

25 He's replacing Dr. Randy Gauntt, who has

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1 been our MELCOR expert and has not been able to
2 attend today. Hopefully, he may be on the bridge
3 line to help answer questions later on. And Dr.
4 Nathan Bixler, also of Sandia National
5 Laboratories.

6 Other team members are in the audience -
7 Trey Hathaway of my branch and other members of
8 Sandia National Laboratories are Joe Jones, Kyle
9 Ross and Dusty Thompson.

10 And with that, I'll turn the presentation
11 over to Dr. Ghosh.

12 MS. GHOSH: Okay. Thank you.

13 The first slide I have here, just to
14 continue on what Pat was just talking about, this
15 was very much a team effort and we have a subset of
16 the team here and we just wanted to recognize every
17 who's helped out with the project on this slide.

18 Most of the people directly contributed
19 to the report. We also had several internal
20 reviews of parameters in the draft report itself.

21 CHAIRMAN STETKAR: Pull that - pull that
22 closer. I'm not sure he can hear you.

23 MS. GHOSH: Oh, are you having trouble
24 hearing? Yes? Okay.

25 Is that better? Yes. Okay. Great. We

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1 also had some fellow NRC staff review our
2 parameters during the development process as well
3 as reviewing the draft report and we really
4 appreciate everyone's support.

5 Unfortunately, a couple of the primary
6 authors of this work have left Sandia since the
7 work was completed. But they're still listed as
8 Sandia because that's where they were at the time
9 that the work was done.

10 And anyway, so this is a more full
11 listing. So just thanks to everyone who's
12 contributed to this project.

13 So what we'll talk about this morning we
14 expect to go over what were the objectives at this
15 Surry uncertainty analysis and give an overview of
16 what we did and what the overall conclusions were.

17 This time around, unlike with the Peach
18 Bottom uncertainty analysis, we did implement some
19 MELCOR model enhancements and updates and we'll
20 just give an overview of that.

21 Then we'll talk about our parameter
22 development process. As Pat mentioned, we had to
23 take these - the lessons of feedback on the Peach
24 Bottom uncertainty analysis and document better how
25 we chose which parameters to vary, which parameters

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1 we considered but we didn't and including the
2 certainty analysis and what the basis was for the
3 distributions that we chose.

4 Then we'll go into what were the set of
5 MELCOR parameters that we looked at. We'll give
6 you the whole list and talk about a subset of them.

7 Then we'll go into the MACCS parameters
8 that were chosen. Same thing - give you the whole
9 list and talk about a subset of them.

10 Then we'll go through the MELCOR analysis
11 results, the MACCS consequence analysis results and
12 wrap up with a quick summary.

13 So this time around the objectives of
14 this uncertainty analysis were similar to the
15 objectives of the Peach Bottom uncertainty analysis
16 with a little bit of an addition.

17 We know from past studies that you can
18 have a lot of uncertainty in these complex system
19 models that we have but not all of the
20 uncertainties evenly contribute to the uncertainty
21 and the results.

22 So we wanted to develop some insight into
23 what are the model inputs that the results that we
24 care about are actually most sensitive to it.

25 We wanted to identify the most

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1 influential input parameters for all the phases of
2 the modeling project.

3 So, basically, what contributes to the
4 most interesting variations in the accident
5 progressions and so differences in source term
6 timing and magnitude and then in the offsite
7 consequence results that we looked at and in this
8 case we kept the offsite consequence results that
9 we were looking at still to the individual latent
10 cancer fatality risk and individual early fatality
11 risk.

12 And this time around we - one of - an
13 additional goal was to also complement and support
14 the NRC's ongoing site level three barrier project
15 as well as some of the post-Fukushima regulatory
16 activities that are continuing.

17 And I quoted those words straight out of
18 the commission's SRM, or staff requirements
19 memorandum, that came back to us to make sure that
20 we conducted the study in a way that would
21 complement and support these other projects.

22 MEMBER BLEY: Tina, you highlighted that
23 you - this time around you've changed the
24 documentation and expanded it some and also made
25 some changes in - was it MELCOR?

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1 MS. GHOSH: Yes, we - right. We changed
2 -

3 MEMBER BLEY: Were there any other
4 changes besides those two and how you did this
5 study compared to the first one?

6 MS. GHOSH: I think - yes, there were
7 some additional studies. I think as we go through
8 this morning as I describe what we did and when we
9 talk about some of the parameters you'll notice
10 that there were some additional changes.

11 So I guess just to give you an example,
12 you know, with Peach Bottom we showed our
13 regression analysis results. Sometimes it was very
14 hard to process all the information because we had
15 four methods for the consequence - you know,
16 offsite consequences alone we were looking at five
17 circular -

18 MEMBER BLEY: Right.

19 MS. GHOSH: It was just a tremendous
20 amount of information to process. So we tried to
21 come up with a better way to both summarize the
22 insights that we're getting from the four methods
23 taken together.

24 So we changed the presentation of the
25 material slightly and also added a couple of

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1 intermediate steps to try to help that information
2 processing step. That's one example.

3 With a couple of the MACCS parameters,
4 the MACCS parameter's set was the same but we
5 updated our distributions and I think Nate will
6 talk about a couple of those when he gives his
7 presentation.

8 MEMBER BLEY: Okay. Good.

9 MS. GHOSH: So that's just a couple of
10 examples. You know, it had been a few years and we
11 continue to learn and progress our thinking so
12 there are some additional changes.

13 MEMBER BLEY: One change I thought was
14 you didn't use Latin hypercube sampling this time.

15 MS. GHOSH: Thank you. Yes, you're
16 right. We didn't.

17 MEMBER BLEY: Did you have - it didn't
18 seem to me that you made the sample sizes any
19 larger and I've been wondering how you covered the
20 parameter or you -

21 MS. GHOSH: Yes. So - right, so -

22 MEMBER BLEY: You did seem to cover the
23 parameters well when you looked at your
24 clarification but how did you know that ahead of
25 time?

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1 MS. GHOSH: You know, I think actually we
2 relied heavily on the extensive work we did for
3 Peach Bottom with the different sampling schemes to
4 convince ourselves that with 1,003 successful
5 realizations that having the simple random sampling
6 is just - essentially just as good as Latin
7 hypercube sample.

8 Maybe at the very tails we could have
9 achieved a little bit more, you know, with the
10 Latin hypercube sampling but it's almost in the
11 noise at that point when we get to 1,003.

12 But, you know, it is something to
13 consider for future projects. You know, if we
14 don't want to expend the computational resources
15 every time to do a thousand or so realizations, you
16 know. You know, Latin hypercube sampling is still
17 a good thing but for this - for the purposes of
18 this project we were very comfortable that the
19 simple random sampling was certainly good enough
20 with the number of samples that we had.

21 MEMBER CORRADINI: But that was just
22 judgment. It wasn't anything provable. That's
23 what I -

24 MS. GHOSH: In this - yes.

25 MEMBER CORRADINI: - I don't understand

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1 about the difference. I know the Latin hypercube
2 you slice it into bins to make sure you cover the
3 bins.

4 MS. GHOSH: Right. Right.

5 MEMBER CORRADINI: But just because it's
6 a thousand it just -and just by kind of just
7 inspection it looks about the same?

8 MS. GHOSH: Well, with Peach Bottom we
9 had the quantitative proof of how well the results
10 were converged to each other. In this case again
11 we were relying on the Peach Bottom results to be a
12 similar enough system that we were comfortable.
13 But in this case if we had theoretically done it
14 both ways it would have been similar.

15 DR. SHACK: But you did the
16 bootstrapping, which sort of gave you some
17 confidence on how robust the sampling was.

18 MS. GHOSH: Right. Right. And the
19 bootstrap -yes, and the bootstrapping is, you know,
20 better done with a simple random sample because
21 there you don't have the, you know, dependence
22 issues that you do with the Latin hypercube.

23 CHAIRMAN STETKAR: The fact of the matter
24 is most of the distributions are not very broad.
25 They did a lot of work - they had initial broad

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1 distributions and they did a lot of work to narrow
2 them down.

3 So if you have very narrow distributions
4 it works. If you have quite broad and skewed
5 distributions, which they actively tried to stay
6 away from, doesn't look so good.

7 MS. GHOSH: That's a fair look at the -
8 for the parameters that matter though the most,
9 yes.

10 So the scenario - so this time again we
11 did the uncertainty analysis on one of the SOARCA
12 scenarios and the one we chose was the unmitigated
13 short-term station blackout.

14 For Peach Bottom we had done the long-
15 term solution blackout but here again it's the
16 unmitigated versions. So you're not crediting the
17 SAMGs and the - any of the new flux strategies and
18 so on.

19 And the focus was on the epistemic or the
20 state of knowledge uncertainty and the input - the
21 model input parameter's value. So we weren't
22 explicitly looking at other kinds of epistemic
23 uncertainty. And we handled - we looked at some
24 aspects of aleatory uncertainty.

25 We used the same approach for the

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1 aleatory uncertainty that comes from the fact that
2 you just don't know when an accident might happen
3 in the future.

4 So you don't know what the weather is
5 going to be at the time that the accident happens.
6 We used the same approach. We looked at Peach
7 Bottom and the standard approach pretty much for
8 all our MACCS analyses these days.

9 MEMBER CORRADINI: Just one
10 clarification. So the only difference that I
11 remember from a station short-term to a long-term
12 is that batteries aren't available and therefore
13 the aux feed water system doesn't function.

14 MS. GHOSH: That's exactly right, yes.

15 MEMBER CORRADINI: The operator action to
16 be pressurized still, you know, as many times. I'm
17 just trying to remember the difference.

18 MS. GHOSH: There's no operator action.
19 There's actually no operator actions because
20 there's no -

21 MEMBER CORRADINI: So there's not even
22 the depressurization?

23 MS. GHOSH: There's nothing, yes. We
24 have do DC, no AC power so -

25 CHAIRMAN STETKAR: Tina, is that - I want

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1 to make sure that I understand that. This -
2 because the description of the scenario said aux
3 feed water fails because seismic failure of the
4 emergency condensate storage tank. It did not say
5 that DC power was not available. So is DC power
6 available or is it not available?

7 MS. GHOSH: Yes. Actually that's a good
8 point. In this case, because we don't credit
9 anything it doesn't matter. I think the -

10 MEMBER CORRADINI: You do credit things
11 because you credit level two use of instrumentation
12 and notification of offsite resources and
13 instrumentation in the control room and
14 communications. You don't - I mean, it's not
15 explicit but -

16 MS. GHOSH: Yes.

17 MEMBER CORRADINI: And if DC power is
18 available relief valves will work and -

19 MS. GHOSH: Yes, thank you. I apologize.
20 You're right.

21 MEMBER CORRADINI: So -

22 MS. GHOSH: I think - yes.

23 MEMBER CORRADINI: - I'm really confused
24 about what's available in the scenario and that's
25 important for me to understand because I don't know

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1 whether the analysis is conservative or optimistic.
2 My sense is it may be optimistic.

3 MS. GHOSH: Okay. You're right. I
4 should be more careful about how it describe
5 things. Thank you. But we assume there are -
6 there is no battery power and aux feed is not
7 working.

8 But that's the - those are the main
9 things. The safety relief valves are working. We
10 don't - we're not crediting any power operator.

11 MEMBER CORRADINI: But the - well, you
12 have to be careful. The spring-loaded safety
13 valves are working. The atmospheric relief valves
14 are assumed to not open on the steam generators and
15 the pressurizer power-operated relief valves -

16 MS. GHOSH: Exactly.

17 MEMBER CORRADINI: - are assumed to not
18 open. So therefore they cannot open and stick
19 open, which is an optimism for both of them, which
20 they could possibly with DC power but I don't know
21 how Surry is designed.

22 MS. GHOSH: Okay. You're saying that
23 instead of the SRV sticking open that some other
24 valves could stick open.

25 MEMBER CORRADINI: Yes.

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1 MS. GHOSH: That is not considered.

2 MEMBER CORRADINI: So the likelihood of
3 getting stuck open valve scenarios could be a lot
4 higher.

5 CHAIRMAN STETKAR: Other valves that
6 would open sooner.

7 MEMBER CORRADINI: Other valves that
8 would open sooner and cycle more quickly, for
9 example, and might not be designed for water
10 relief, for example, as well as the safety valves.

11 So it's really important to understand
12 whether DC power is available and nowhere could I
13 find in the - the only thing I could find in the
14 description of the scenario was the statement that
15 it is a short-term station blackout because seismic
16 failure of the emergency condensate storage tank
17 disables auxiliary feed water. That was explicitly
18 stated. There was no statement about DC power.

19 MEMBER CORRADINI: He's much more precise
20 than I am. The only reason I asked my question was
21 is that I'm trying to understand if I went to long-
22 term DC is available.

23 Potentially, feed water works and you'd
24 then tell the operators that they can depressurize
25 and I assume when you said short-term all three of

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1 those things were off the table.

2 MS. GHOSH: Right. Right.

3 CHAIRMAN STETKAR: That's right. The
4 difference between long-term and short-term is
5 whether aux feed water works for some period of
6 time until the batteries -

7 MEMBER CORRADINI: But with the DC power
8 then the operators can depressurize based on some
9 operator action and here that's not the case. You
10 just rely on the safety valves to pop when they
11 should pop.

12 MEMBER BLEY: But it's not just a matter
13 of precision. John's pointing out that supposedly
14 a conservative assumption - no DC power - actually
15 precludes failure modes that might happen in the
16 real world.

17 MEMBER CORRADINI: Sure.

18 MEMBER BLEY: So it might not be as - so
19 it might not be conservative.

20 CHAIRMAN STETKAR: It is a scenario that
21 is a scenario but it's important when you describe
22 that scenario to tell people what it - what is
23 available and what is not available and why it's
24 not available because this might not be -

25 Okay. Because in the main body of the

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1 report it doesn't say that.

2 DR. SHACK: No, it doesn't say it
3 anywhere.

4 CHAIRMAN STETKAR: In fact, it explicitly
5 describes why it's a short-term station blackout
6 because of the seismic failure of the condensate
7 storage container.

8 DR. SHACK: I think in the later report
9 they - you're never quite sure which part you're
10 reading but I think the later report also has the
11 DC power. But in the NUREG it's only in the
12 appendix.

13 MS. GHOSH: Yes, and we should probably
14 put that in the body of the report. You know, one
15 of the things is we keep relying on the NUREG 7110
16 volume two as well.

17 But that's probably worth repeating in
18 the body of the UA report. Thank you for the
19 comment.

20 CHAIRMAN STETKAR: But anyway, the - from
21 my understanding the basic assumption is that DC
22 power is not available.

23 MS. GHOSH: Yes. KC, did you want to add
24 something?

25 MR. WAGNER: Yes. So I don't believe we

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1 credit any instrumentation unless you found
2 evidence of that in the report. We didn't have any
3 DC power, AC power so -

4 CHAIRMAN STETKAR: But you don't - when
5 you say credit you think explicit branch points
6 being event trees and fault trees.

7 I think of event response and how people
8 in the control room know what's going on and how
9 they interact with the outside world and how they
10 communicate with emergency responders and how the
11 technical support center doesn't exist because it
12 doesn't have any information, you know, that sort
13 of stuff.

14 That is not explicit branch points in any
15 event tree or fault tree that you've developed.
16 However, it is implicit that all of those things
17 work fine because all of the emergency response
18 stuff works fine.

19 MS. GHOSH: Yes. So Joe, I don't know if
20 you can - Joe Jones is one of the EP experts.

21 I believe if you lose all AC and DC power
22 you have a very precise triggering point for
23 declaring the emergency. But Joe, you can speak to
24 that.

25 MR. JONES: This is Joe Jones. Exactly.

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1 You know you're in a short-term station blackout
2 fairly quickly.

3 The on-site resident inspectors have
4 satellite phones to make off-site contact with the
5 NRC headquarters operation center so they can make
6 their contacts and then the on-site ERO has
7 redundant systems to run to contact their folks -
8 ERO, the emergency response organization.

9 So that's why we don't have any delays in
10 the off-site is because we know at the very least
11 we have on-site resident inspectors with satellite
12 phones for direct communication off site.

13 DR. SHACK: It is interesting in the
14 later report from Sandia there's a statement no DC
15 power considered. Sandia will ensure this is
16 stated in the document as a boundary condition that
17 affects the sequence.

18 MS. GHOSH: Yes. Yes. Thank you.

19 DR. SHACK: We know where to stick it
20 now.

21 MS. GHOSH: We very much appreciate your
22 thorough review. You know, we always make our
23 documentation better after we come to the ACRS. So
24 thanks for - thank you for that.

25 CHAIRMAN STETKAR: Well, the only reason

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1 I wanted to make sure that I understood I thought
2 that was the case.

3 MS. GHOSH: Yes.

4 CHAIRMAN STETKAR: But I wanted to make
5 sure because as Dennis mentioned there - if DC
6 power were available it would not change any of
7 your MACCS type stuff - the emergency response -
8 because of the assumptions that have been made that
9 it's all perfect.

10 Everybody knows exactly what they have to
11 do and all communications work despite the fact
12 that this was a bigger earthquake than anybody
13 could ever imagine, which we'll get into later.

14 If DC power were available then the
15 scenario progression could be substantially
16 different than what is modeled because you could
17 get pressurizer PORs cycling open and closed.

18 I don't know the Surry design. I don't
19 know whether they're DC operating pilots. I don't
20 know whether they're solenoid valves. I don't know
21 how the block valves work.

22 I don't know whether they're pneumatic or
23 hydraulic. I don't know anything about them. The
24 same is true for the atmospheric relief valves on
25 the steam generators in terms of cycling and

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1 possibly sticking open.

2 So the scenario progression and the
3 timing of events could be different from a MELCOR
4 respect if DC power were available and the
5 assumptions are that you only rely on cycling of
6 the spring-loaded safeties.

7 MS. GHOSH: Right. Right. Yes,
8 absolutely. This is a very scenario-specific
9 analysis where a lot of it is prescribed up front.

10 CHAIRMAN STETKAR: Well, we'll get into
11 the scenario-specific earthquake part of it later
12 when we talk about evacuation and assumptions about
13 emergency planning.

14 MS. GHOSH: Right. Okay. So the other
15 thing I wanted to point out is that actually one of
16 the other differences from the Peach Bottom UA was
17 that we considered some additional aleatory aspects
18 of the modeling this time around and specifically
19 we looked at the effect of when in the burn up
20 cycle you might be at the time of the accident.

21 So we actually sampled the time at cycle
22 instead of just using a single point in the time at
23 cycle to see how the importance of that compared
24 with the other uncertainties we were looking at.

25 And in terms of the safety relief valve

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1 behavior, we also investigated some aleatory
2 aspects of that - of the safety valve behavior.

3 So in addition to the epistemic
4 uncertainty in the failure rate of the valves we
5 also looked at - we imposed in addition some
6 aleatory modeling in terms of given the failure
7 rate how many times it may cycle before a failure.
8 So we added those aleatory aspects to otherwise
9 epistemic uncertain parameters.

10 MEMBER REMPE: Tina, with respect to
11 looking at the time at cycle, it's my understanding
12 that maybe things have changed that MELCOR does not
13 consider thermal conductivity degradation as a
14 function of burn up.

15 So you are considering within a cycle
16 whether it's beginning of cycle or end of cycle.
17 But you don't ever consider other effects that
18 occur with the fuel with respect to time that might
19 be important. Is that a true statement still?

20 MS. GHOSH: I don't know if KC can
21 understand - can explain. I'm not sure I
22 understood your question.

23 MEMBER REMPE: Well, thermal connectivity
24 with other fuel decreases significantly with
25 respect to burn-up. Well, it would be something

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1 that would be time dependently changing and I don't
2 think the code does consider that effect. So what
3 I'm trying to get at - because there's a lot of
4 uncertainty still that's not captured in today's
5 model. Is that true?

6 MR. WAGNER: Yes, that's true. So we
7 don't vary the gap connectivity as a function of
8 time. There is - you know, half of the fuel is
9 from a batch before so it's a little bit older.

10 I mean, there's - it would be fresh fuel.
11 We don't - we didn't adjust the gap connectivity.

12 MEMBER BALLINGER: But this - you're only
13 considering the source term effects, right?

14 MEMBER REMPE: Yes, but the heat transfer
15 and just the way the thing would regress.

16 MEMBER BALLINGER: Isn't that already
17 built in?

18 MEMBER REMPE: In some codes for design
19 or for, like, a LOCA analysis, yes, they do
20 consider it. But a sever accident code like MELCOR
21 does not consider that at this time is what I'm
22 trying to get at.

23 MS. GHOSH: Then as I mentioned before we
24 updated our MELCOR model and we'll talk a little
25 bit about that. And the main reasons were it had

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1 been several years since the original model was
2 created. We've moved to a new MELCOR version and
3 we don't support the version that was originally -
4 the original model was built with anymore and -

5 MEMBER CORRADINI: So let me ask this
6 question and I'm looking so I admit that I may -
7 haven't found it in the 500 pages yet.

8 MEMBER BLEY: 495.

9 MEMBER CORRADINI: Thank you. Is there a
10 comparison calculation that shows that when you
11 redo it you actually get the same result?

12 MS. GHOSH: Well, it shows you the new
13 result that you get. So it -

14 MEMBER CORRADINI: Oh, okay. That's not
15 what I'm asking. What I'm asking is - I mean, I'm
16 back to a hand calculation. If I - if I change my
17 mode and I do a hand calculation and I get a
18 different result I ought to know why my result is
19 different. Where would I look for that?

20 MS. GHOSH: So in Appendix A we've
21 actually documented fairly extensively all the step
22 changes from the old model to the new model and we
23 explained the reasons.

24 So MELCOR 2.1 has the new modeling in it
25 that is based on our updated understanding that

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1 didn't exist in 1.86. There are enough changes
2 even in the code version that it makes sense that
3 some things change a little and then we also
4 updated our - the MELCOR model itself and KC's
5 coming up to elaborate.

6 MEMBER BLEY: But to Mike's point, I
7 think it also said somewhere I saw that you do get
8 differences but you don't know why because there
9 are so many changes.

10 MEMBER CORRADINI: That was in the
11 executive summary. That part I read.

12 MEMBER BLEY: Okay.

13 MS. GHOSH: Yes. I think it's difficult
14 to pinpoint, you know, every specific - to map all
15 of the changes onto the very specific effect.

16 But we tried to give you the cumulative
17 differences for various intermediate steps in the
18 process. But KC, yes, whatever -

19 MR. WAGNER: So what was done in Appendix
20 A and that's where I direct you to is we had the
21 1.86 calculation, the vintage 2007.

22 We did a straight conversion of that
23 input deck using SNAP to 2.1 and with the code
24 version that was being used for the current
25 calculations we just compared 1.86 to 2.1 and I

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1 would judge that comparison was very close - the
2 timing and it's spelled out.

3 Then to go from there to the UA model
4 there was a set of corrections to the model and
5 we'll talk about those today, and then there was
6 enhancements to support the UA and we'll talk about
7 those today also.

8 And then so the 2.1 calculation that was
9 the straight conversion of the 2007 calculation was
10 compared to the new UA and that response was
11 substantially different and we talk about the
12 reasons for those differences in there and why they
13 make sense.

14 MEMBER BLEY: Thank you.

15 MEMBER REMPE: But just out of curiosity
16 is there something that you can point to that will
17 say man, that, we think, makes the most
18 difference? Because I couldn't follow that and I
19 will admit that by the time I got to Appendix A it
20 was pretty late.

21 You know, but was it, like, the steam
22 generator utilization or is there something that
23 really made more of a difference in the changes?

24 MS. GHOSH: Yes, I'll let you - I'll let
25 you take the first one.

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1 MR. WAGNER: For as long as I've been
2 involved in Surry and that started in the '80s at
3 NEL we thought that there was limestone concrete in
4 the Surry containment.

5 In reality, it's basaltic and that makes
6 a huge difference. And so that the kind of got
7 you.

8 MEMBER REMPE: Okay. But I can remember
9 for some other work I did that it seemed to be that
10 the nodalization was pointed out as - the timing
11 even before you got X vessel that things started
12 extending out and, like, I think you quote some
13 values in Appendix A. But, you know, 50 hours
14 longer before something occurs is before -

15 MR. WAGNER: Little bit of that. When we
16 did the original SOARCA we didn't have - we didn't
17 do new arching calculations and at the time there
18 was a Hyberna program going on at NRC Research.

19 And so we used the decayed heat from that
20 model because it's the best thing that we had
21 available at the time in lieu of doing, for lack of
22 a better word, best guesstimate origin type
23 calculations for decay heat. So decay heat was
24 maybe skewed a little bit high in the original
25 SOARCA but we -

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1 MEMBER REMPE: Okay.

2 MR. WAGNER: - felt like that was, you
3 know, it was better than what was built in MELCOR
4 and it was the best that we had at the time.

5 MEMBER REMPE: Okay. Thanks.

6 MEMBER SKILLMAN: Before you exit, and
7 building on Dr. Rempe's question, it seems that
8 there's an ah-ha in the failure of the lower
9 support plate timing. There's almost an hour shift
10 between the original calc and the revised calc and
11 there is a - there is a sequence there.

12 The first failure of the support plate -
13 lower support plate - lower plant dry out, then
14 lower head failure. Those times are shifted by
15 approximately an hour in the new calc. Why is
16 that, please?

17 I understand the limestone versus
18 basaltic concrete issue. But I'm wondering why
19 there is such a time difference laid in the
20 sequence. This is seven hours, seven and a half
21 hours.

22 MR. WAGNER: Can you point me to which
23 two calculations you're talking about? Are these
24 the 2.1 calculations?

25 MEMBER SKILLMAN: I'm looking at 2.1 -

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1 1.8 versus 2.1.

2 MR. WAGNER: Okay. So -

3 MEMBER SKILLMAN: And the area of
4 interest that I'm pointing to is the approximate
5 hour shift laid in the scenario.

6 The first failure of the lower support
7 plate goes from 6:36 - six hours and 36 minutes -
8 and the newer calc is 7:33 - seven hours and 33
9 minutes - almost an hour later. Lower plant dry
10 out goes from hour 6:39 to hour 7:35 in the new
11 calc. Approximately an hour.

12 MR. WAGNER: So the dry out is usually a
13 function of when the debris gets there. We have to
14 get some down there in that. So the changing of
15 the core plates will change the timing of the dry
16 out.

17 Why there was the changing of the dry out
18 of the core plate we have about eight years of co-
19 development and so I think the models did change a
20 little bit and improve. I can't point to anything
21 specifically.

22 MEMBER SKILLMAN: Well, it's the same
23 hardware - same machine, same reactor vessels, same
24 internals.

25 MR. WAGNER: That's not - their model is

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1 nowhere close to it.

2 MEMBER SKILLMAN: Let me finish. And so
3 obviously what's occurred here is we had the
4 conservatism in their earlier version and that
5 might have been so sobering that as the
6 conservatism is released we see the greater time.

7 MR. WAGNER: I mean, one hour in the
8 timing of the core plate failure is - the timing to
9 the start of release and the failure of the
10 containment I think was pretty similar.

11 There was some differences in the vessel
12 accident progression. We judge those relatively
13 close.

14 MEMBER SKILLMAN: Thank you.

15 MS. GHOSH: Okay. So getting back to the
16 overview of what we did, we looked at the
17 uncertainty in key model input.

18 So the first step was to come to a set of
19 what are the key uncertain input parameters that we
20 - when varied and then we propagated those
21 uncertainties in a two-step Monte Carlo simulation
22 we first generated a source of - a set of source
23 terms using the MELCOR model and then we combined
24 the source terms with a set of MACCS realizations
25 that sampled all of the MACCS' uncertain parameters

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1 to get a distribution of consequence results.

2 And we ended up with 1,003 successful
3 MELCOR realizations that completed to 48 hours and
4 each of those were coupled with a successful MACCS
5 realization and because the question sometimes
6 comes up, just so you know of the ones - the MELCOR
7 realizations that didn't complete we didn't analyze
8 the reason that those didn't complete and we also
9 looked for -we did a regression analysis on the
10 incomplete realizations to make sure that there
11 weren't areas in our sample space that were
12 consistently failing the runs and we did determine
13 that we had sufficient - that the failures happened
14 randomly in the parameter sample space.

15 So we had a sufficient - the set of runs
16 that we had sufficiently covered the entire sample
17 space and all dimensions. So we were comfortable
18 with -

19 MEMBER CORRADINI: So since I kind of do
20 these calculations once in a blue moon -

21 MS. GHOSH: Yes.

22 MEMBER CORRADINI: - these are - these
23 are - the reasons they - that the calculation dies
24 should tell you something. So was there some
25 attribute about all these failures that told you

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1 something about the calculation?

2 In other words, were they all failing in
3 a certain subroutine? Were they all failing
4 because of time step - we couldn't restart? There
5 is just some model that froze up every time you
6 access it? I mean, these sorts of things.

7 MS. GHOSH: Right. So that's exactly the
8 kind of analysis that was done so we categorized
9 all the failures by which subroutine - you know,
10 what was the problems.

11 MEMBER CORRADINI: So where is that?

12 MS. GHOSH: Do we have that in the - we
13 have that. Oh, it's not in the report. I think we
14 just summarized -

15 MEMBER CORRADINI: Failure at - you learn
16 more from failure than success.

17 MEMBER BLEY: But kind of - what kind of
18 things were there? I mean, divide by zero -
19 whatever you get, somewhere something's going wrong
20 and that - one would think would lead you to decide
21 if it's a problem in the way the code was written,
22 if it's a modeling problem and -

23 MS. GHOSH: Right. Right. Yes.

24 MEMBER BLEY: - and since, you know, it
25 ought to be -

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1 MS. GHOSH: So let me - let me -

2 MEMBER BLEY: You ought to understand it
3 and fix it because it might be something important.

4 MS. GHOSH: Yes. KC is coming up. I
5 think he - KC has a summary. We have a table of
6 summarizing what the reasons were. But if we could
7 back up a step.

8 With all of these large projects we've
9 done we have found things in the code that we were
10 - that we saw where we were able to improve maybe a
11 small bug or just some improvement that could be
12 made which got our success rate up to a thousand
13 out of, you know, 1,200.

14 And the reason that I say that we're
15 comfortable with the stuff that we ended up with is
16 that when we analyzed the reasons for the
17 incomplete realizations we were able to convince
18 ourselves that they don't affect the validity of
19 the results that we get.

20 There's no correlation in terms of if
21 these three parameters come together in this way it
22 always fails the code. There is nothing like that
23 that came up.

24 They are - the failures are just randomly
25 distributed in this end dimensional sample space.

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1 So we're comfortable with the results that we ended
2 up with. That's from my side in terms of the
3 overall uncertainty analysis.

4 From the MELCOR side, they also did look
5 at the specific reasons and it's not the same
6 reason every time. There's a set of reasons and I
7 don't know if, KC, if you want to elaborate on
8 that.

9 But there are various, you know,
10 subroutines and reasons but they're not - it's not
11 pointing to any failure that's always going to
12 happen when things converge in a certain way with
13 the model.

14 But yes, go ahead, KC.

15 MR. WAGNER: Yes. I guess as a long time
16 user there are problem areas that crop up often
17 where I would say probably we have to co-develop or
18 look at them and see whether they could be fixed.

19 They usually ended in the code saying you
20 couldn't converge anymore and so it stops because
21 it can't get a satisfactory convergence and the
22 routines are in the cavity package and one of the
23 debris temperature calculations in the lower head.

24 MEMBER CORRADINI: Exclusively or
25 primarily?

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1 MR. WAGNER: Primarily.

2 MEMBER CORRADINI: So the cavity package
3 is three, right?

4 MR. WAGNER: Right.

5 MEMBER CORRADINI: So it's dying there
6 most of the time of the 200?

7 MR. WAGNER: In Sequoyah, which we aren't
8 talking about today, yes. In Surry it was more
9 often in the core package.

10 MEMBER CORRADINI: Oh.

11 MR. WAGNER: So it was evaluating a
12 debris temperature in the lower head. We asked the
13 developer to take a look at it.

14 He looked at quite a few of them and -

15 MEMBER CORRADINI: Okay. So -

16 MR. WAGNER: Did have - did have a patch
17 in the time frame for this project.

18 MEMBER CORRADINI: That's fine. I mean,
19 I appreciate how hard this is so I'm not - it's not
20 meant for as a criticism, just trying to learn.

21 So you're saying in the Surry case it was
22 - I'll just use the word primarily in the core
23 package and primarily in the lower - the lower head
24 calculation?

25 MR. WAGNER: Yes.

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1 MEMBER CORRADINI: Okay. So in the phase
2 one of the crosswalk since that I'm familiar with,
3 between DoE and NRC, MAP and MELCOR has
4 substantially different models in the lower plenum.

5 So and I know this is the case because
6 the Sandia team with the, I'll just say, EPRI team
7 have been talking about this.

8 So it - so as you're - what I hear you
9 saying is they think they understand where it is
10 but in the time frame of the study it got - didn't
11 get fixed. Is that -

12 MR. WAGNER: Yes.

13 MEMBER CORRADINI: - is that a fair
14 characterization?

15 MR. WAGNER: That is correct.

16 MEMBER BALLINGER: So but there's a flip
17 side to this, which is kind of insidious, and that
18 is your runs that didn't finish and so you've got
19 an analysis and it says so in the document.

20 But have you verified that some of the
21 runs that did finish are not fortuitously finishing
22 because you've got - because of the same problem?

23 Maybe I'm not saying it right. Last time
24 I wrote code they were using Wang computers and
25 stuff. But they - what we used - we used to stick

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1 in things where if something failed we knew exactly
2 what statement it failed on and the system stopped,
3 right.

4 So presumably you can do that, right?
5 But are you sure that you're not getting yourself
6 comfortable because ah-ha, we have 1,003 successful
7 runs?

8 They were successful because they
9 converged or they're successful because - is
10 convergence tantamount to saying everything went
11 fine and the answers are fine or are you - is there
12 a potential for deceiving yourself into thinking
13 that they're fine when they're not fine because of
14 some fortuitous other errors that suddenly make a
15 thing work okay or converge.

16 I don't even mean work okay. I just mean
17 converge. I mean, so in other words, if you track
18 - if you track down every single case where it
19 didn't converge or whatever the - whatever
20 constituted failure to find out that A, it was a
21 model that was out of its range or something
22 happening other than just divide by zero and other
23 kinds of things those are really insidious errors
24 because you can divide by zero someplace and have
25 the thing keep running. So am I stating this -

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1 MS. GHOSH: Okay. So let me - it is an
2 interesting - I think it's a very deep question.

3 I can give you maybe a higher level
4 answer. I'm not a micro coder or analyst or, you
5 know, any of those things. I think at the end of
6 the day - so the purposes of this study what we're
7 - what we're trying to do is to get some
8 distribution on the results, understand what the
9 variations can be and how the system behavior may
10 progress and be able to identify what - in terms of
11 everything we've put in the pod what are the most
12 influential parameters for the results that we care
13 about.

14 We feel that with the set of things that
15 we did and the way that we analyzed the results
16 that those insights are reliable. I think when
17 you go down a couple of levels deeper and ask
18 questions for every single of the 1,003, you know,
19 realizations, you know, how confident are we.

20 You know, it's very hard to answer that
21 question but I think that we have reasons to be
22 confident and then kind of the sum total of what
23 we've done because we've sliced and diced the
24 numbers.

25 We took a statistical approach with a

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1 stability analysis to see, you know, how stable the
2 results are.

3 With the regression analyses we don't
4 rely just on the regression analysis results in
5 terms of the regression numbers that come up but we
6 look at individual realizations of interest that
7 exhibit a variety of behavior - a different
8 behavior to see what we can explain what happened
9 in those particular realizations. So taking all of
10 those together, you know, we have a comfort level.

11 MEMBER BALLINGER: Sometimes getting the
12 right answer is - you fool yourself because it's an
13 answer you're expecting, right, and that's even
14 sometimes worse than getting an answer which you
15 know to be wrong.

16 MEMBER REMPE: To kind of - even though
17 what was it, like, you said 90 percent of the non-
18 steam generator to rupture realizations or 90
19 percent of the time you didn't get a steam
20 generator to rupture but then 10 percent of the
21 time dominated the released.

22 Well, were all these failures - is there
23 the potential that they might have change that
24 conclusion is what - to try and put it physically
25 is what I would do and maybe you or KC has an idea

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1 and say oh no, those were cases that aren't going
2 to give you a big release even though they failed.

3 MEMBER BALLINGER: Because the creep
4 parameters are very sensitive.

5 CHAIRMAN STETKAR: Since it's 16 percent
6 of the wrongs or something like that. I did the
7 math right. Yes, 200 over 1,200 didn't go.

8 MS. GHOSH: But if I could - if I could -
9 I'll repeat what I already said just to emphasize.
10 We did a regression analysis so, you know, we
11 varied.

12 In total there's 24 - 23 MELCOR parameter
13 groups that we varied that covered the span of all
14 the aspects that we were modeling and we did a
15 regression analysis on what part of the sample
16 space was covered by the failed runs versus the
17 successful runs and if there were some combination
18 of things coming together that would every time
19 fail the MELCOR run and therefore leave us with a
20 set of successful realizations that weren't
21 successful we would have expected some of that to
22 show up in the regressions to say that you have
23 some part of the sample space that's failing your
24 runs every time.

25 Our regressions show that those failures

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1 were completely - were randomly distributed. There
2 was no correlation between what was sampled in the
3 - all the parameters that we sampled and which runs
4 were successful or incomplete.

5 So that gives us a lot of confidence that
6 there isn't some - you know, some, you know, the
7 stars aligning in a certain way every time is going
8 to fail your MELCOR, you know, run and therefore we
9 missed some part of the -

10 MEMBER REMPE: Well, I heard you say that
11 but then I heard KC say oh, no, that it's always in
12 the core package. And so that's what's puzzling me
13 is there's a disconnect that -

14 MEMBER CORRADINI: I guess - can I ask
15 Joy's question a little differently and then we can
16 stop torturing her for a while. The way I
17 interpret this is - the way I interpret this is
18 there's got to be something to be learned from the
19 200 failures about the model.

20 Whether or not it affects your
21 uncertainty I don't think it does because you've
22 already proven that it's the boundary conditions
23 and initial conditions that drive your uncertainty.

24 It's not how the stuff models once you
25 hit the go button and things start going to hell in

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1 a handbasket.

2 So it seems to me this model set of - if
3 it really is occurring primarily in the core
4 package and primarily in lower plenum that's
5 interesting to learn what you can do to improve it.
6 But I'm not sure it affects the uncertainty
7 analysis. That's what I heard you saying.

8 MS. GHOSH: And that - and that's a very
9 good point and I think we will continue to work on
10 making sure that some of these are code issues and
11 improved in the future.

12 And in the process of the project we did
13 fix a number of issues that, you know, running
14 MELCOR this many times in the same model you do it
15 - it's a model validation exercise or a core
16 validation. You do uncover things and I think
17 that's fair and we would continue to kind of track
18 those down.

19 As KC mentioned, on the time frame that
20 we had we got to a point where we felt it was good
21 enough and you kind of have to stop there.

22 MEMBER BALLINGER: Okay. Let me ask one
23 more dumb question. For these runs that fail, did
24 you pick one run that failed and then run the same
25 exact run a number of times to see if it failed at

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1 the same place every time?

2 I mean, that's another one of these
3 techniques that people use.

4 MS. GHOSH: Yes, you know, Ron, I think
5 when we - in the past after we fixed a bug we've
6 done that to make sure that it's fixed but this
7 time I don't think we did that particular step for
8 - but yes. Go ahead. Sorry. Go ahead.

9 MR. WAGNER: I guess I'll just add I
10 understood your question perfectly and that was a
11 good one.

12 And we didn't individually look at each
13 run other than to the extent that we test on -
14 well, we test them on to the developer and he
15 looked for common themes in subroutines where we
16 did have convergence problems.

17 But I would add that the code does have
18 energy checks and when it does converge we do trust
19 it because of the energy balance checks and the
20 things that are done to assure convergence, you
21 know, conservation in energy, mass and volume.

22 The code has been validated in volume
23 three of the - the user's guide came out with the
24 validation cases. But we didn't get into each one
25 of those to see or we - I wouldn't characterize -

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1 we didn't feel like we were lucky.

2 We felt like if it converged in the code
3 it satisfied the criteria to move on to the next
4 time step. We were comfortable with that run.

5 MS. GHOSH: Thanks, KC. Okay. So moving
6 on to the next slide. The figures of merit that we
7 looked at were the cesium and iodine released to
8 the environment by 48 hours.

9 The in-vessel hydrogen production, the
10 timing of the initial fission product released to
11 the environment, which we defined as 1 percent of
12 noble gases, and in terms of the offsite
13 consequences as I mentioned before we kept the same
14 metrics as the original SOARCA study of the
15 individual early fatality risk and individual
16 latent cancer fatality risks.

17 And we used the same four regression
18 methods to analyze the results that we used in the
19 Peach Bottom UA.

20 We also used scatter plots and also,
21 again, we did phenomenological investigation into
22 selected individual realizations to make sure that
23 we understood the regression results and
24 specifically differences in the behavior of the
25 system.

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1 So this is just an overview. It's a
2 little bit - just a reminder. In the original
3 SOARCA calculation we did what's depicted on the
4 left. Basically, the weather uncertainty was
5 reported as a mean, which is shown as the age on
6 the X axis - the red age on the X axis in the
7 figure.

8 So when we now do the uncertainty
9 analysis we are varying a set of inputs into the
10 MELCOR model as well as a set of inputs into the
11 MACCS model but continuing to keep the - what we
12 call the inner loop for the weather.

13 So I think eventually in the report we're
14 going to add some figures that look like the family
15 of figures on the right, which will show both the
16 uncertainty due to weather in addition to some
17 example of the spread of individual curves from the
18 epistemic uncertainty.

19 But right now whenever you see the curves
20 in the report or the tables what we're reporting is
21 the distribution on the mean consequence from the
22 set of weather trials, given one set of epistemic
23 inputs from both the MACCS and the MELCOR sides of
24 the equation.

25 So it's the distribution of the ages -

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1 the ages and the double bars.

2 So the regression techniques that we used
3 were the linear rank regression. It's the simplest
4 method and historically the one that's been used
5 most often in past studies like NUREG 1150, and
6 then we used the same three we added for Peach
7 Bottom, which was the quadratic regression,
8 recursive partitioning and MARS.

9 And these methods are more advanced in
10 that they create regression models that can also
11 capture interaction effects amongst the variables
12 as well as capturing nonmonotonic effects and those
13 two things are not possible with just the linear
14 rank regression modeled by itself.

15 And we used multiple approaches to pulse
16 process the set of Monte Carlo results that we got
17 and we think it provided better explanatory power
18 with regard to identifying which input parameters
19 were the most influential with respect to results
20 and this was demonstrated previously in the Peach
21 Bottom UA.

22 The overall conclusions from this Surry
23 uncertainty is that it continues to corroborate the
24 SOARCA study conclusions, that in an absolute sense
25 the public health consequences in terms of the

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1 matrix we looked at, which are individuals, early
2 fatality risk and individual latent cancer fatality
3 risk are smaller than previously calculated and in
4 the original SOARCA study we were - we did a
5 comparison with the siting study - the Sandia
6 siting study from 1982, and the delayed releases we
7 find continue to provide time for emergency
8 response actions and the long-term ends up
9 dominating the offsite health effect risks and we
10 continued to compute essentially early fatality
11 risk.

12 We did have a handful of nonzero numbers
13 but they were extremely small, which is why we use
14 this essentially zero terminology. And a major
15 determinant this time around of the source term
16 magnitude is whether or not the accident progresses
17 to a steam generator two rupture and then you get
18 order of magnitude roughly more release in that
19 case.

20 And the mean individual - the mean - this
21 is mean over the weather variation - individual
22 latent cancer fatality risks assuming at linear
23 known threshold, the dose response model
24 conditional on the accident actually happening is
25 still less than needed to be very small.

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1 For reasons that we explain in the report
2 they're lower than the risk that was evaluated in
3 the original SOARCA study, both within ten miles,
4 and the ten-mile risk in this case is the highest
5 population at risk and that risk decreases at
6 longer distances.

7 CHAIRMAN STETKAR: Tina, just for the
8 record - I don't want to dwell on this - everything
9 you state here is very carefully stated within the
10 context of the particular scenario that was
11 evaluated.

12 A footnote here notes that the frequency
13 of that is on the order of about 10 to minus six
14 per year for that particular seismic acceleration.

15 Full scope seismic PRAs have typically
16 shown that seismic-related station blackout occurs
17 more frequently because of seismic events that are
18 perhaps not as strong as this seismic event but
19 include hardware failures of the emergency diesel
20 generators, which was one of the reasons why I
21 asked about the ability to receive power.

22 This assumes that the event is so strong
23 that it destroys all of the safety-related AC and
24 DC stuff inside the plant, which is a really big
25 earthquake.

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1 We'll get back to that later. I just
2 want to make that for the record.

3 So making conclusions about absolute
4 frequencies here in terms of how they relate to
5 offsite health consequences is very dangerous.

6 It is true within the context of a
7 specific scenario with the assumptions -

8 MS. GHOSH: Yes

9 CHAIRMAN STETKAR: - that were modeled
10 here and those assumptions aren't necessarily
11 always conservative.

12 MS. GHOSH: Yes, I know. That's fair and
13 we did no work on the frequency side of the
14 equation. So yes, that's fair. Thank you.

15 CHAIRMAN STETKAR: Well, you did no work
16 on the frequency but you do allude to it in these
17 types of presentations -

18 MS. GHOSH: We do alluded to it, yes.
19 It's -

20 CHAIRMAN STETKAR: - about why things are
21 really, really small.

22 MS. GHOSH: Right. Yes, it's always a
23 struggle because everything we calculated was
24 conditional on the set of assumptions leading up to
25 it and we're trying to provide context. It's

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1 always a struggle how to provide the context.

2 CHAIRMAN STETKAR: Yes, we've had this -
3 you know -

4 MS. GHOSH: Yes, I know. Okay.

5 CHAIRMAN STETKAR: - we don't need to -
6 we've had the discussion before.

7 MS. GHOSH: Yes.

8 CHAIRMAN STETKAR: Don't try to oversell
9 the results in terms of -

10 MEMBER BLEY: It's being generalized.

11 CHAIRMAN STETKAR: Yes, in terms of
12 generalized. This report has done a much better
13 job of not doing that than the previous report.

14 MS. GHOSH: We took your advice into
15 consideration.

16 MEMBER REMPE: So as you do that to this
17 report, even though it does say you've used updated
18 EOPs and things like that, it doesn't mention the
19 fact that flux isn't out there and so there might
20 be a need to put a caveat like that in the
21 document. I mean -

22 MS. GHOSH: Yes. Okay. And that's a -
23 that's a good feedback - you're right - because at
24 the time of the original SOARCA there was no flags.
25 Yes.

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1 MEMBER TEMPE: Targets. Yes.

2 MS. GHOSH: And we just - we're going
3 back to the original scenario specifications. But
4 you're right, this is published in 2016. There may
5 be an expectation to explain how it relates or
6 doesn't. Thanks.

7 Okay. So the next section we'll just
8 quickly go through what were the model enhancements
9 and actually we started some of this discussion
10 already.

11 We updated the model to MELCOR 2.1 and
12 then between, you know, about 2007 and when we
13 started this study in earnest we realized that
14 there were some errors and unintended things in the
15 model that we figured if we're enhancing the model
16 anyway we should just go ahead and update all of
17 those.

18 And I'll just go through a quick listing
19 of what those were and, again, this is documented
20 in detail in Appendix A and summarized in Chapter
21 5, I believe.

22 So the model enhancements - the main
23 ones included enabling the molten core of concrete
24 interactions to take advantage of recent code
25 enhancements and corrections that are thought to

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1 add realism. We increased the steam generator
2 nodalization that we have a picture on a subsequent
3 slide.

4 MEMBER CORRADINI: We're going to get
5 back to these by later, right? This is just a
6 summary.

7 MS. GHOSH: This is a - yes, this is a
8 summary. We included the hot tube modeling in the
9 SGTR logic and we redefined the admission criteria
10 and extended the hot leg nozzle modeling to
11 consider the stainless steel cladding.

12 MEMBER REMPE: Tina, before you lift that
13 slide even though this is just a summary, if I -
14 what exactly is in the hot leg nozzle at this time?

15 Because I was looking at Page 57 out of -
16 which is like three three in your report. Is it
17 carbon steel with stainless steel cladding or is it
18 later at the bottom of the page where it says the
19 hot leg nozzle was not on the original Surry
20 analysis of stainless steel but was found to be
21 Inconel. What exactly was modeled or -

22 MS. GHOSH: Yes, I think we need to
23 correct that in the report. If I understand
24 correctly, what we added, and KC or Kyle, correct
25 me if I'm wrong - I believe we originally had

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1 carbon steel and we added the stainless steel
2 cladding next time.

3 MEMBER REMPE: Okay. But what was that
4 last - that's what the top of that page says but
5 then the bottom of the page has Inconel.

6 MS. GHOSH: Yes.

7 MEMBER REMPE: Is that just a typo that
8 needs to be fixed?

9 MS. GHOSH: I think we had a- right. We
10 had an error in the report.

11 MEMBER REMPE: Okay. That's fine. Okay.
12 I just was -

13 MEMBER BALLINGER: Typically, what
14 happens is it is a carbon steel nozzle line with
15 stainless steel but the weld between the nozzle and
16 the pipe has got an Inconel or some filler metal
17 which is equivalent to Inconel in between to match
18 thermal expansion. So it's a lot more complicated
19 than just saying it's Inconel.

20 MEMBER REMPE: I'm surprised they have
21 that level of detail. They're doing a weld in
22 MELCOR. Can someone - so that's just totally a
23 wrong sentence at the bottom of that page?

24 MS. GHOSH: Yes, we need to fix it.

25 MEMBER BALLINGER: Because it definitely

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1 was not an Inconel nozzle.

2 MEMBER REMPE: Okay. I was curious.

3 MEMBER BALLINGER: Okay.

4 MEMBER REMPE: That's the way it's
5 reading, okay?

6 MEMBER BALLINGER: That's a first.

7 MR. WAGNER: That is a typo and the tubes
8 or models is Inconel. In the original SOARCA it's
9 just modeled as carbon steel and here we tried to
10 represent a stainless steel cladding underneath,
11 you know, before the carbon steel nozzle. And I
12 guess we were influenced by how tough it was to
13 hold up with just the stainless steel cladding.

14 MS. GHOSH: And there were some
15 corrections that we also identified that we
16 implemented. There were some errant vapor pressure
17 coefficients for control rod materials that were
18 corrected and KC already mentioned that the
19 original analysis assumed a limestone aggregate for
20 the containment concrete.

21 But during research for the UA we found
22 out that the aggregate was actually basaltic and
23 the main steam line was found not to be isolating.
24 So those were fixed.

25 And then we developed a current Surry

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1 core inventory to facilitate the time at cycle
2 sampling. And just for reference, the Surry SOARCA
3 have implemented a high burnout core inventory.

4 So this is a - just a picture of the
5 difference in the nodalization. On the - on the
6 left is the original nodalization. On the right is
7 the increased nodalization for the UA implemented
8 in part because we wanted to study more of the
9 steam generator to ruptured variation of the short-
10 term station blackout.

11 MEMBER CORRADINI: So you had - so you
12 had more control volumes in the tube sheet? I'm
13 just trying to look at the difference. I only see
14 more control lines in the tube sheet. Is that
15 correct?

16 MS. GHOSH: Yes, the tube -

17 MEMBER CORRADINI: Tube bundles though?

18 MR. WAGNER: Yes, the descending side of
19 the tube bundle.

20 MEMBER CORRADINI: The descending side.
21 Exactly. Okay. Thank you.

22 MEMBER BALLINGER: Was there any attempt
23 to nodalize it with respect to where the support
24 plates are? That's a constraint.

25 MR. WAGNER: She mentioned that one of

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1 the new additions for this - these sets of
2 calculations was the hot tube modeling and so we
3 followed what had been done at INL before with
4 SCDAP/RELAP and that there's a site calculation
5 where we have a scope of the tool is representative
6 that I think was just six inches or a foot long.

7 And so and it's fed with boundary
8 conditions based on what the main calculation is
9 doing, and then the temperature is BIOS based on
10 the CFD work that Chris Boyd had done. We're going
11 to cover that a little bit later how that
12 calculation is done.

13 But there was a local or a hot tube
14 analysis that really focused close to the tube
15 sheet to make sure that we were able to capture the
16 hottest part of the flume entering the speed
17 generator.

18 MEMBER BALLINGER: So it's a thermal
19 model. Okay.

20 MS. GHOSH: And that's just a quick
21 summary of the MELCOR model enhancements. I'm
22 going to wrap up the overview section with the
23 parameter development process that we used.

24 And again, this was in an effort to
25 better document how we chose the parameters and why

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1 and then the basis for the distribution that we
2 had.

3 So we, of course, involved staff both
4 through Sandia and NRC with expertise in the MELCOR
5 MACCS modeling for SOARCA and we got involved a
6 wider group of subject matter experts to provide
7 reviews of the data and parameters.

8 And we started with a review of the
9 parameters that were used in Peach Bottom and then
10 we also performed a systematic review of the
11 phenomenological areas as relevant for Surry.

12 So, for example, in terms of the MELCOR
13 side, the sequence issues, the in-vessel and ex-
14 vessel accident progression, containment behavior
15 and the chemical form in aerosol disposition.

16 We - the group reviewed the
17 phenomenological topics covered in the MELCOR
18 reference manual just to make sure we didn't miss
19 anything and we also reviewed a comprehensive MACCS
20 parameter list.

21 On the MACCS side things were a little
22 bit simpler in that the change from a BWR to the
23 PWR doesn't matter as much in terms of offsite
24 parameters.

25 We did a thorough review but ended up

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1 with the same list of parameters that we had used
2 for Peach Bottom. We just reconfirmed that that
3 was the - a good set to vary.

4 So we developed an initial list of
5 candidate parameters and then we implemented what
6 we called a story board process where basically an
7 analyst kind of took the lead in documenting the
8 justification and the rationale for each parameter
9 and then we had a series of iterative discussions
10 and review meetings which involved others at Sandia
11 and NRC.

12 And the focus was on confirming that the
13 parameter representations appropriately captured
14 the key sources of uncertainty with respect to that
15 parameter and that the probability distributions we
16 ended up assigning to them were reasonable and had
17 a defensible technical basis.

18 During the - during the course of this
19 very iterative process we had repeated meetings on,
20 you know, logical groups of parameters. We decided
21 to omit some parameters from further considerations
22 and we added others along the way.

23 And some parameters, much like in Peach
24 Bottom, ended up being exploratory in the sense
25 that we didn't have a lot of basis for an

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1 uncertainty distribution. But we have the sense
2 that they are uncertain and we wanted to gain
3 insights into what variations in that parameter how
4 it might affect the results. So we -

5 CHAIRMAN STETKAR: Tina, help me - two
6 questions, one on parameters that were omitted and
7 the topic that you just mentioned -

8 MS. GHOSH: Yes.

9 CHAIRMAN STETKAR: - if you want to call
10 them exploratory uncertainty distributions. When
11 is it better to discuss those? When we get into
12 the actual MELCOR parameters presentation or now?

13 MS. GHOSH: Maybe either time. Do you
14 have a theoretical - an overview of discussion to
15 have or -

16 CHAIRMAN STETKAR: Well, I have one
17 question about a particular parameter. If you want
18 to - doesn't make any difference, I guess, when we
19 discuss it. But one parameter - bear with me while
20 I find my notes.

21 MS. GHOSH: Yes, sure.

22 CHAIRMAN STETKAR: I'm not very well
23 organized this morning. There's a statement that
24 said that you didn't consider a reactor pressure
25 vessel drain line because you couldn't find one,

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1 which, you know, is pretty much the case for
2 pressurized water reactors.

3 Pressurized - many pressurized water
4 reactors have a large number of in-core
5 instrumentation tubes around the bottom head that
6 could conceivably fail.

7 Did the models include those? Does Surry
8 have them, first of all, and if so did the models
9 include failures of those tubes?

10 MS. GHOSH: Yes. So I will let KC answer
11 the second part of the question. With respect to
12 the first part of the question, you know, it's kind
13 of funny with these projects.

14 There's a lot of cost dependence and that
15 statement came out of a review of our record on the
16 Peach Bottom UA to make sure that everything - you
17 had covered everything on the - on the with respect
18 to the drain line.

19 We haven't had a lot of discussion with
20 Peach Bottom so that - so that was, you know, the
21 reason that -

22 CHAIRMAN STETKAR: Yes, I'm aware of that
23 and also where the boiling water reactors have -
24 reactor water cleanup system drain lines off the
25 bottom of the vessel. I'm talking about a

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1 pressurized water reactor now.

2 MS. GHOSH: I understand. We should - we
3 should revise - we should revise that in the
4 report. But yes, that was just a packet dependence
5 thing because we were - we started with a boiling
6 water set and we were weeding out what we don't,
7 you know, need to consider. So that was a funny
8 result.

9 CHAIRMAN STETKAR: My more fundamental
10 question is does Surry have lower head penetrations
11 for in-core instrumentation with the guide tools
12 and if so were they included in the model.

13 That's the fundamental question. I don't
14 care about that part that it doesn't have a drain
15 line.

16 MS. GHOSH: We - so maybe KC can help me
17 with this but we don't model the instrument. We
18 should actually just let KC answer but just not
19 yet.

20 CHAIRMAN STETKAR: Well, but if you knew
21 pressurized water reactors you'd look for the in-
22 core instrumentation tubes so -

23 MR. WAGNER: Yes. Surry does have those.

24 CHAIRMAN STETKAR: They do? Good.

25 MR. WAGNER: We didn't model them.

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1 CHAIRMAN STETKAR: You did not?

2 MR. WAGNER: We did consider -

3 CHAIRMAN STETKAR: You did?

4 MR. WAGNER: We considered but we didn't
5 do it. Mark had done some work on the BWR for
6 Peach Bottom and then I guess in the original
7 SOARCA I remember listening to Bob Henry talk about
8 his modeling of TMI and, you know, release of maybe
9 some gases through the instrument lines and high
10 readings in certain parts of the containment.

11 So we didn't view it as a bypass
12 mechanism and we didn't really have the models
13 other than if we kind of did like what was done in
14 the Peach Bottom analysis to try and mock up
15 something.

16 But we didn't go to that level of detail
17 here because the conclusions from Peach Bottom was
18 that it wasn't terribly important. Our impression
19 from -

20 CHAIRMAN STETKAR: But again, Peach
21 Bottom is a boiling water reactor and I don't want
22 to talk about a boiling water. I want to talk
23 about Surry.

24 The statement is made in the report that
25 there are no high-pressure melt scenarios and one

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1 of the questions that I had is can you get a high
2 pressure ejection through failed instrument tubes
3 into the reactor cavity.

4 MR. WAGNER: I suspect that would be
5 possible under pressure.

6 CHAIRMAN STETKAR: Okay. And the
7 question is why then didn't you evaluate that?

8 MR. WAGNER: We have low pressure
9 accidents.

10 CHAIRMAN STETKAR: You do? And I guess
11 we'll understand later why they're all low
12 pressure. I would suspect that some - I don't know
13 anything about thermal hydraulics and I know less
14 about materials. But an early failure of a
15 instrument tube or several instrument tubes before
16 you get some sort of depressurization going on
17 through, like, a hot leg failure or a stuck open
18 cycling valve could in fact, I would think, lead to
19 a high pressure scenario.

20 How likely that is I have no idea because
21 I don't know the tubes and I don't know how to
22 modify the event scenario progresses.

23 MEMBER BLEY: It would seem the logic by
24 which you rolled it out ought to be here somewhere.
25 My memory is vague. Mike probably remembers

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1 better.

2 The TMI - a fair amount of corium went
3 down into those tubes, surprised people that it
4 didn't come out - that there was really good heat
5 transfer, I guess, on those tubes.

6 MEMBER REMPE: Actually, since I was
7 involved in this -

8 MEMBER BLEY: Yes.

9 MEMBER REMPE: - a long time ago, yes,
10 some of the corium went in but the post-accident
11 evaluations saw that the melt could never travel
12 enough below the lower head to cause that type of
13 failure.

14 Frankly, we never saw anything that
15 degraded those tubes enough to result in a high
16 pressure ejection and I believe that the folks from
17 Sandia should say but that's why the MELCOR does
18 not model that.

19 CHAIRMAN STETKAR: Even with the tube
20 thinning that a lot of plants have seen?

21 MEMBER REMPE: The tube thinning
22 instrumentation -

23 MEMBER BLEY: This is the guide tube -

24 CHAIRMAN STETKAR: The guide - the guide
25 tube thinning.

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1 MEMBER REMPE: I've never heard of people
2 seeing guide tube thinning. You've seen steam
3 generators tube thinning but -

4 CHAIRMAN STETKAR: No, no, no, no. Well
5 -

6 MEMBER REMPE: - guide tube thinning on
7 the left head?

8 CHAIRMAN STETKAR: Yes. Yes, look it up.
9 In-core instrumentation guide tube thinning. A lot
10 of people have replaced a lot of - plugged and
11 replaced a lot of guide tubes.

12 MEMBER REMPE: I have not heard of that
13 happening. I've heard of plugging of some
14 generators but not guide tubes. But -

15 CHAIRMAN STETKAR: I'll have to look up
16 the - I don't know, Dick, if you remember -

17 MEMBER SKILLMAN: I'd offer just two
18 comments. I was there with TMI tubes. They're one
19 in Schedule 160.

20 They're basically a gun barrel and
21 they're welded on tight and while there was corium
22 in the lower portion TMI tube had there was also
23 water there and so there was excellent heat
24 transfer.

25 There was some penetration. But

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1 remember, in the in-core too is an instrument
2 that's about three-eighths of an inch in diameter
3 and so the opening is really the annulus between
4 the ID of the tube and the instrument itself.

5 CHAIRMAN STETKAR: It depends on where
6 they park them. A lot of them park them back up at
7 the seal table.

8 MEMBER SKILL MAN: All 52 fully engaged
9 because those gave the burn-up from the iridium
10 detectors. But like Joyce said, it was excellent
11 heat transfer off the bottom.

12 MEMBER REMPE: Right. And in fact there
13 - you could see gaps between the relocated debris
14 and the nozzles because the debris shrinks when it
15 solidifies.

16 And so they just never saw - there was
17 damage where it cut across above where the stubs of
18 the tubes were left but they never saw a melt go
19 down below.

20 But I - they're not off the hook though
21 totally because one of the things that I think is
22 bizarre is that the way the MELCOR model - my
23 understanding of it is is when they have vessel
24 failure they assume some particular area and that
25 is based on engineering judgment, in my opinion.

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1 They can - but that's what they always
2 assume and to me it seems like the - why wasn't
3 that varied as a parameter that's uncertain because
4 there's no basis for assuming that other than
5 expert opinion and I didn't see it documented in
6 the story boards that that was considered something
7 worth jiggling around a bit and seeing if it's
8 important or not.

9 MEMBER BLEY: I'm going to go back to the
10 other one though. You told us about TMI.

11 MEMBER REMPE: Right.

12 MEMBER BLEY: But Dick just said that
13 they always kept the instruments in the core and at
14 least some years ago many of the plants that I had
15 looked at do just what John said and they put them
16 in to take measurements and they pull them back out
17 so that they're - so that there's an empty tube
18 down there, which is a different story than the one
19 you described.

20 MEMBER REMPE: Yes, that's some
21 information that they examine and replace some
22 flood vents.

23 MEMBER BLEY: I didn't know about the
24 thinning but I did know that they're empty much of
25 the time.

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1 MEMBER REMPE: But yes.

2 MEMBER BLEY: I mean, empty of
3 instruments.

4 MEMBER CORRADINI: So I just think - I
5 think at least the report ought to explain the
6 logic of why you ignored it because - or decided by
7 judgment that it wasn't - because I think Joy's
8 explanation is what I remember, which was you had
9 water always down there no matter how long you
10 tried to degrade the core.

11 And so you pretty much - and I guess I'd
12 - even if I had a thin tube I'm not going to blow
13 those as long as I've got water available.

14 But once the melt comes down now it's a
15 question of timing. I'm kind of curious and I
16 don't remember in all the various of your many,
17 many runs if you had the steam generator tube
18 ruptured that late in the game.

19 I thought it was occurring way before I'd
20 have slumping. So if I had it way before slumping
21 I'm not worried about it there. I'm worried about
22 it going somewhere else.

23 MS. GHOSH: Right. So and let me ask the
24 author. This was a - this was actually a long
25 point of discussion, the instrument tubes. In the

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1 - from the original SOARCA peer review we had
2 discussions with Bob Henry and I believe we had
3 peer review comment and comment responses that are
4 documented.

5 Unfortunately, I can't remember all of
6 the details of the - what we have documented. But
7 as part of the original SOARCA study -

8 CHAIRMAN STETKAR: Original Surry SOARCA
9 or -

10 MS. GHOSH: The Surry - original Surry
11 SOARCA.

12 CHAIRMAN STETKAR: Okay.

13 MS. GHOSH: We have Bob Henry's comments
14 and our responses to the comments in the peer
15 review report that's publically available.

16 But I think it's a good comment that we
17 should repeat the logic here because of - it's a
18 natural question.

19 CHAIRMAN STETKAR: At least - yes, at
20 least clean up the documentation to provide the
21 rationale that indeed you thought about the
22 instrument tubes.

23 MS. GHOSH: Yes

24 CHAIRMAN STETKAR: Yes, in my opinion -
25 okay, you look for a drain line. It doesn't have a

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1 drain line but we know that it does have other
2 penetrations in the bottom head and there - the
3 report anyway is silent about them.

4 MR. FULLER: This is Ed Fuller. I just
5 want to provide a little perspective here. The MAP
6 code does model this instrument tube failure early
7 on and , of course, the model has Bob Henry's
8 official seal of approval on it.

9 But what happens in the MAP analysis is
10 that it happens very early, shortly after core
11 damage, and then as soon as material starts moving
12 consistent with what Dr. Rempe was saying before,
13 it indeed plugs up -the molten material plugs up
14 the tubes and freezes and essentially it stays
15 frozen through the whole melt progression.

16 What is important with these instrument
17 tubes is what happens when the core debris gets to
18 the lower plenum and if you model those tubes
19 properly you end up usually predicting with the MAP
20 calculation that they fail first or the - and it
21 would be not at the bottom of the vessel head but
22 on the side somewhere about where the hot spots
23 are.

24 So it's important but it's not important
25 early when all the zirc oxidation is going on in

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1 the core region.

2 CHAIRMAN STETKAR: Thanks, Ed.

3 MS. GHOSH: So I guess the last bullet on
4 the slide just denote that the parameters that we
5 considered but didn't include and we integrated
6 uncertainty analysis we listed in the report.

7 CHAIRMAN STETKAR: Tina, I got
8 sidetracked a little bit there. I was going to ask
9 about the - I think you characterized them as
10 exploratory -

11 MS. GHOSH: Yes.

12 CHAIRMAN STETKAR: - parameters.

13 MS. GHOSH: Right.

14 CHAIRMAN STETKAR: Is it appropriate to
15 ask about them now or are you -

16 MS. GHOSH: Yes. We may continue the
17 discussion. But you can ask your question now.

18 CHAIRMAN STETKAR: Let's bring up - I'm
19 trying to switch gears and look forward. There
20 were two that I had particular questions about and
21 I don't know if you're going to address them later.
22 You probably do. They had to do with the debris,
23 radial and -

24 MS. GHOSH: Yes. The -

25 CHAIRMAN STETKAR: - radial actual debris

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1 location. Are you going to talk about them later?

2 MS. GHOSH: We don't go - we don't talk
3 about them because we didn't learn anything new
4 since Peach Bottom. It's - it continues to be
5 something we don't know a lot about, which I
6 believe is why we characterize it as an exploratory
7 parameter because we want to know what the effect
8 of those are but we don't have a whole lot to go
9 on.

10 CHAIRMAN STETKAR: Well, but now I'll be
11 - I'll wax philosophical. I read the discussions
12 of those and they're much like what you just
13 briefly summarized orally.

14 They say, well, we don't know very much
15 about this - we're going to take a uniform
16 distribution over an order of magnitude range and I
17 think there's a statement that I hung up on that
18 said something like thus the inclusion of this
19 parameter is really to see what happens when it's
20 varied.

21 That's not an uncertainty analysis. That
22 is not an analysis. Every other parameter that I
23 read about in the whole study with the exception of
24 those two had technical justification for what is
25 the range of the parameter and what is the shape of

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1 the distribution.

2 One might disagree with that technical
3 justification but this just says well, we put a
4 uniform distribution in there and we kind of let it
5 vary.

6 Well, if you put a different distribution
7 in there might - maybe it would have been
8 important. A uniform distribution over an order of
9 magnitude is not going to get very many
10 realizations - many samples at extreme values.

11 If you believe those - I don't even know
12 if you believe the extreme values. So we just put
13 an order of magnitude in and look, it wasn't
14 important. Well, maybe it wasn't important because
15 your range or the distribution that you put in
16 there was absurd.

17 MS. GHOSH: Yes, and I guess it - you
18 know, it's always a struggle. You know -

19 CHAIRMAN STETKAR: Well, you have
20 experts.

21 MS. GHOSH: Right. But if the experts
22 agree that there is uncertainty around the plants
23 and for the most part everybody out there is using
24 point estimates.

25 But it's an uncertain quantity. You

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1 know, I guess there was a best attempt at assigning
2 some uncertainty to that but -

3 CHAIRMAN STETKAR: But it isn't in - and
4 my point is philosophically for those two
5 parameters - I read the stories about all of the
6 other parameters. I don't understand the stories
7 because I'm not an expert in every area.

8 But all of the others with the exception
9 of those two seem to have some reasoned arguments
10 about why we set the lower bound here, why we set
11 the upper bound here and why we ferret in some sort
12 of shape distribution for our uncertainty between
13 those bounds based on technical issues.

14 Those two parameters have nothing like
15 that. Said everybody uses point estimates,
16 everybody reasoned there's a lot of uncertainty.
17 We stuck in a flat distribution over a nominal
18 order of magnitude and to see what might happen and
19 that's not - I don't get it.

20 That's completely - philosophically it's
21 not consistent with the rest of what you're calling
22 an uncertainty analysis.

23 So if you have experts who understand
24 their uncertainty they ought to provide - be able
25 to provide some reasonable input on what the upper

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1 and lower bounds could be and there might be some
2 justification for what that is - technical
3 justification - and if they can't agree on a
4 particular shape of a distribution there could be
5 some technical justification of why it is a
6 uniform distribution between those bounds.

7 MS. GHOSH: Okay. I -

8 CHAIRMAN STETKAR: Those are the only two
9 exceptions that I could find.

10 MS. GHOSH: Yes. Well, I'm glad for
11 that.

12 CHAIRMAN STETKAR: Well, they're the only
13 one that I could find. Other people who are
14 smarter than I am might have -

15 MS. GHOSH: Okay. You know, I think
16 that's good feedback. We can work on what more we
17 could say about that to kind of bolster the
18 choices. Maybe not all of the expert thinking is
19 documented sufficiently at this point. I don't
20 know. I'm not an expert in that area.

21 CHAIRMAN STETKAR: I'm not either,
22 obviously. But it - but those two in particular
23 and you said - I think, you know, you used the term
24 exploratory parameters.

25 MS. GHOSH: Yes.

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1 CHAIRMAN STETKAR: I've forgotten what I
2 wrote in my notes. But from a philosophical
3 standpoint I'm more troubled about the philosophy
4 of saying well, we're going to do an uncertainty
5 analysis by throwing something in there that we
6 know we don't have any confidence in but just to
7 see what might happen.

8 That's not an uncertainty analysis that
9 you are later than relying on to draw conclusions
10 about offsite risk from - in the context of this
11 particular scenario.

12 MS. GHOSH: KC, did you want to add
13 something?

14 MR. WAGNER: I don't know if I'll be able
15 to shed much light on this. I guess I have two
16 comments. Do you see any benefit from having
17 exploratory parameters for guidance MELCOR severe
18 acts than analysis?

19 CHAIRMAN STETKAR: No, not in the context
20 of this analysis. This is supposed to be a - I'll
21 use the term scientifically-based uncertainty
22 analysis.

23 If you want to have - if you want to
24 explore MELCOR response to variations in parameter
25 values, do point estimate sensitivity calculations.

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1 Don't call them an uncertainty distribution.

2 If you want to see how the code responds
3 to extreme values of parameters without assigning a
4 probability to the occurrence of that extreme
5 value, put an extreme value in and see what
6 happens.

7 That's different from an uncertainty
8 analysis because every other part of this
9 uncertainty analysis has some technical
10 justification whether it's - whether it's data
11 related, experiment related, expert judgment
12 related on the range and the shape of the
13 distribution.

14 It's not in there to explore how the code
15 is going to respond. It's there to actually inform
16 quantitative results.

17 DR. SHACK: But isn't an order of
18 magnitude on a point estimate as sort of an expert
19 judgment that the expert - if he thinks the point
20 estimate is a reasonable value an order of
21 magnitude 3.3 either way?

22 MR. WAGNER: That's the origin of these -
23 the defaults in the code. They're - our scaled
24 experiments don't have the width to do this and so
25 we needed some sort of models so we didn't have

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1 stacks of things - stacks of fluid over here in one
2 area and none over here and so we needed some sort
3 of mechanism for relocation.

4 And expert judgment at the time the
5 models were developed gave us our defaults and we
6 felt it was -

7 DR. SHACK: I'll disagree with John. I
8 mean, it seems to me if you have no basis for a
9 better distribution I would at least like to see
10 some uncertainty range considered and they were
11 honest in the story board saying we don't have much
12 of a basis for this but, you know, this - there is
13 no real agreement on a thing, you know, and maybe
14 you can find more experts that we - you know, but
15 if the experts if that hard to come by I'm not sure
16 I believe their expert judgment is going to get
17 done.

18 MR. WAGNER: There's other parameters
19 where we did some of those sensitivity analysis and
20 these probably should have been more appropriately
21 put in there and in -

22 CHAIRMAN STETKAR: Well, again, I would
23 sort of like to see, you know, maybe both for those
24 kinds of parameters but it seems to me that an
25 uncertainty analysis that pretended there was no

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1 uncertainty in this parameter isn't an uncertainty
2 analysis either. Now, that's not - it's
3 certainly not what I'm advocating. I'm advocating
4 an uncertainty distribution that has a technical
5 basis.

6 We've told the experts, not just we
7 looked at things and experts said well, it's kind
8 of an order of magnitude.

9 The point estimates -

10 DR. SHACK: Well, but I'm assuming if
11 they're really going to do that they really did say
12 that the experts had no real basis for a thing.

13 I mean, yes, I agree. You know, you get
14 one guy in a room that says I don't know the answer
15 - pick an order of magnitude. No. But I'm
16 assuming that they did a - they argued for a while.

17 MEMBER CORRADINI: But I - but I think
18 that if these are the two that I remember there are
19 no experiments that are large enough that you have
20 a -

21 MS. GHOSH: That's what KC was just
22 saying, yes.

23 MEMBER CORRADINI: - that you have a way
24 of determining that.

25 The CORA experiments, the PHEBUS

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1 experiments are all very small bundles so MAP and
2 MELCOR did marvelously and got really good
3 agreement and then you expand the size of the core
4 and things tend to change. That's my memory. Am I
5 remembering correctly?

6 MR. WAGNER: Yes, I believe that's
7 written in there that we didn't have any large
8 scale and we measured some sort of model for it and
9 that's why it's in the code.

10 So we didn't have a strong experimental
11 defensible position that we could put in there. It
12 would have been polling of expert judgment, maybe
13 hand calculations or something of that sort.

14 MEMBER BLEY: There's a - you know, I saw
15 the story boards and I like that. Getting all the
16 things that could be uncertain down there to think
17 about is important.

18 There's a lot of experience with
19 eliciting expert judgment that shows if you start
20 at a median or a best estimate as your first
21 estimate you tend to just kind of mush the answers
22 around or you get locked to that if you're looking
23 at what was done before.

24 The way that generally works best is once
25 you identify the things that could be important you

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1 talk people through building the little model of
2 what could make it its worse highest value and what
3 could make it its lowest - estimating those and
4 then putting a best estimate in last rather than
5 first because that really anchors you and creates
6 one of the biggest biases and elicitation there is.

7 So I don't know how you guys did that
8 stuff. But even if you don't have experiments if
9 you got the parameters - the factors that could
10 make it worse and you try to say how bad could it
11 be and how could it be you tend to do much better
12 than the other way around.

13 MS. GHOSH: Right, and I think we need to
14 beef up our documentation because even if we - I
15 think there was more thinking that went in than
16 what is coming away - that the reader is coming
17 away with.

18 So I think we should better that in the
19 document.

20 MEMBER REMPE: In fairness to you guys,
21 at the end of Section 4.1.2.3 after talking about
22 PHEBUS and CORA they did have this one sentence in
23 there about well, we thought this order of
24 magnitude would take care of partially molten,
25 fully molten.

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1 So I don't know. I wasn't there for your
2 story board but that's what I took away was why
3 they picked that order of magnitude was that they
4 don't have a good basis for picking the value to
5 start off with but they thought that that would
6 take care of partially molten.

7 But I don't know. That's what I'm
8 reading.

9 CHAIRMAN STETKAR: Go on. There's
10 nothing more to talk about on that.

11 MS. GHOSH: This next slide is just the
12 information flow diagram. I'm not going to talk
13 about all of these boxes.

14 Basically, you have the MELCOR
15 uncertainty engine which takes all of the uncertain
16 inputs and creates the MELCOR input file.

17 We run MELCOR - that gets fed into
18 MELMACCS to create source terms for MACCS. MACCS
19 takes all of the source terms and matches up one
20 source term with one vector of uncertain MACCS
21 parameters to create the outputs.

22 This is more about the - how the MELCOR
23 uncertainty application works. I'm not sure that
24 we need to talk about this. It's an elaboration of
25 what was on the previous slide. Nobody has

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1 questions.

2 I think - yes, I think that was -

3 DR. SHACK: Well, I'll make one comment
4 on the report. To make sense out of that you
5 really have to go back to the Peach Bottom report.

6 CHAIRMAN STETKAR: Bill, turn it back on
7 again because you turned it off.

8 MS. GHOSH: Yes. But that's a fair
9 comment too. You know, we got a lot of complaints
10 about the size of the peach bottom document.

11 So we were trying to gain some efficiency
12 by - we were both trying to better document our
13 thinking on the - you know, the parameter
14 development and at the same time, you know, same
15 some pages where we could. If there are specific
16 things that you think we should re-import back
17 because I know we just refer - either refer back to
18 that report or have a very short summary.

19 We can add some pages and then we'll have
20 a record of why we're adding it back in. But yes,
21 I apologize. We have to make a judgment call on
22 how much to import into this document, too.

23 So for the complete story I think you
24 need both the 7110 volume of the original Surry
25 analysis and the Peach Bottom uncertainty analysis

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1 with this one. We tried to make it as standalone
2 as possible but you kind of need the back story in
3 there.

4 DR. SHACK: Well, I mean, you devoted
5 more space to the story board stuff which is, I
6 think, the important part.

7 I mean, you know, to understand the
8 mechanics you can go back to the Peach Bottom
9 thing. But, I mean, the real story here is how you
10 picked these parameters and you've done a much
11 better job this time, for all the complaints we're
12 going to have.

13 MS. GHOSH: Okay. So I think that was
14 the end of the overview section.

15 MEMBER BALLINGER: Can I have one more -

16 CHAIRMAN STETKAR: Absolutely, sir.

17 MEMBER BALLINGER: I mean, I've been
18 trying to follow this - because the steam generator
19 two rupture is so important I've been trying to
20 follow the logic through this on the steam
21 generator two rupture part.

22 And there's some places where there's a
23 pretty good explanation of, you know, why you chose
24 the hot tube and was there a difference between
25 where the hot tube was and where the failure was

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1 likely to occur and you say well, you did a
2 sensitivity analysis and there was no problem.

3 But then you say there's also adoption,
4 include a set of correlations to calculate the
5 direct stress multiplier in two cracking.

6 There's a strong basis for this method
7 and has been employed during NRC research in the
8 past. Okay, so that says okay, this is important.

9 However, the use of these correlations
10 will introduce a new set of multiples - uncertain
11 parameters - that would be much more difficult to
12 incorporate into the MELCOR model and was therefore
13 not included.

14 Okay. On the one hand it's important and
15 on the other hand well, it's too damn complicated
16 to put in there so to heck with it. We won't do
17 it.

18 But there's no - nothing in between that
19 says this is why - you know, there's a good reason
20 why we decided not to do something that we thought
21 was important before for the following reasons.

22 So there's - I couldn't find the
23 progression from one sentence to the next because
24 just because it isn't easy doesn't mean that it's
25 not worth doing.

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1 So was there something done in the
2 sensitivity analysis or something to say well, we
3 tried cracking here and it didn't make any
4 difference, sort of like the previous statement
5 with regard to the hot tube.

6 MS. GHOSH: Yes, I'll take the comment
7 that, again, we should beef up our documentation on
8 that but I don't know if anybody else wants to
9 offer anything at this point.

10 Or we can also talk about it more when we
11 talk about the MELCOR parameters in the next
12 session.

13 MEMBER BALLINGER: Yes, that was the next
14 place where it's brought up. Yes.

15 MS. GHOSH: Yes. Yes. That might be a
16 better time to discuss it more. But at a minimum I
17 think -

18 DR. SHACK: Yes, I have some comments on
19 that too so I think we need to get to that and can
20 discuss it -

21 MS. GHOSH: Okay. Yes.

22 CHAIRMAN STETKAR: Yes, let's table that
23 once we get to that.

24 MS. GHOSH: Okay.

25 CHAIRMAN STETKAR: I'm sure there'll be a

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1 lot of discussion.

2 MEMBER SKILLMAN: Tina, before we move on
3 I'd like to ask a question that's been bothering me
4 since we started this session.

5 Among the event description and the
6 initiated event is the SVO and its loss of all AC
7 and DC. I'm on Page 87, I think.

8 In the next line, which is almost
9 instantaneous, the MSIVs close. How do they get
10 closed? An MSIV is about as big as a Volkswagen.
11 They're normally powered by 120-volt vital AC.
12 They got a motor about so big. But these are
13 enormous valves.

14 CHAIRMAN STETKAR: Just for the record,
15 many many main steam isolation valves are
16 pneumatically or hydraulically powered, spring
17 opened - I'm sorry, spring closed hydraulics or
18 pneumatics to keep them open with DC solenoids. My
19 guess is they close on DC here.

20 MEMBER SKILLMAN: Could be. But it seems
21 to me that this is a very critical assumption.

22 CHAIRMAN STETKAR: That's my whole point
23 about -

24 MEMBER SKILLMAN: I got that.

25 CHAIRMAN STETKAR: - is DC available or

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1 not and what things depend on DC power.

2 MEMBER SKILLMAN: So it's really the
3 configuration of the plant.

4 CHAIRMAN STETKAR: Of the plant, and the
5 fundamental assumption of that loss of - if DC is
6 not lost it's not at all clear what the scenario
7 looks like in this plant, whether the MSIVs stay
8 open, whether the atmospheric reliefs on the steam
9 generator cycle, if the MSIVs are closed, whether
10 the condenser steam dumps are available. Probably
11 not, because they're typically nonsafety-related
12 AC.

13 MEMBER SKILLMAN: What I'm really getting
14 to here is that is a critical assumption in this
15 whole scenario. I spent a lot of time in
16 compartments that are 130 degrees Fahrenheit where
17 these valves are located. Some are electrical,
18 some are hydraulic, some are pneumatic.

19 But the assumption that these will close
20 is a critical assumption because if they don't
21 close then you've got your entire steam system out
22 there breathing with whatever is occurring from
23 this scenario.

24 MS. GHOSH: Yes, the - you know, that
25 scenario description dates back to the original

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1 SOARCA study and the plants reviewed all of that as
2 part of the plant fact check.

3 So that has been confirmed that that
4 would occur and loss of AC/DC power by the intent.
5 So that dates back to the original Surry SOARCA
6 analysis.

7 CHAIRMAN STETKAR: Thank you. Any other
8 questions for Tina? All I can say is you got off
9 pretty easy today so far. Let's -

10 MS. GHOSH: That was only the beginning.

11 CHAIRMAN STETKAR: Yes, that's right.
12 And I'll make the point I always make. None of us
13 have lives so we could be here at midnight.

14 DR. SHACK: Speak for yourself.

15 CHAIRMAN STETKAR: Let's take a break and
16 recess until 10:35.

17 (Whereupon, the above-entitled matter
18 went off the record at 10:18 a.m. and resumed at
19 10:39 a.m.)

20 CHAIRMAN STETKAR: We are back in session.
21 KC, just be careful of those mics, they're really
22 sensitive so they pick up rustling paper and all
23 that sort of stuff.

24 MR. WAGNER: My name is KC Wagner and I'm
25 going to talk about the MELCOR parameters.

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1 So here's the list of the MELCOR
2 uncertain parameters, and based on what we learned
3 at the Peach Bottom uncertainty analysis there was
4 a strong emphasis on looking at valve failures. So
5 on primary safety valves we had not only failed to
6 close but failed to open was considered. In
7 addition to that, similar to Peach Bottom, we
8 looked at high temperature failures of the safety
9 valves, and also due to passing water and so there
10 was really a complete look at both the valves that
11 were working for this scenario which are the safety
12 valves on the primary side and on the secondary.
13 Reactor coolant pump seal leakage, that was varied
14 to look at potential for normal leakage to multiple
15 seal failures. Then we touched on this a little bit
16 earlier; we had a hottest steam generator tube
17 model and that was one of the parameters that was
18 varied based on guidance from the CFD work that
19 Chris White had done. The tube thickness is where
20 we get our stress multiplier that we talked about
21 and you'll probably have some more comments on
22 that.

23 MEMBER SKILLMAN: KC, before you proceed
24 to the next comment let me ask you a question,
25 please.

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1 MR. WAGNER: Sure.

2 MEMBER SKILLMAN: I'm reading the text on
3 what is page 402, I think it's A3 or A4, is A4, and
4 here's the question. In the second paragraph on
5 page 402, the words that are presented are these
6 words: "The safety valves on the pressurizer begin
7 opening and closing to remove excess energy."
8 Operative word is safety valve, meaning spring, and
9 probably blow down rate, safety valve. Next
10 sentence: "The pressurizer relief valve flow causes
11 a steady decrease in the primary system's coolant
12 inventory." I believe the second sentence is really
13 clarifying the first sentence but instead of safety
14 valve what is written there is pressurizer relief
15 valve, and I would ask if that's what the author
16 really intended because those are different pieces
17 of hardware.

18 MR. WAGNER: Now we're talking about --

19 MEMBER SKILLMAN: Safety valves only.

20 MR. WAGNER: Same piece of hardware, and
21 Surry has some funny names for these things. We've
22 -- the first sentence would be correct, "spring
23 operated."

24 MEMBER SKILLMAN: Then I would suggest you
25 might want to take a look at this document and

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1 correct that.

2 MR. WAGNER: Yes.

3 MEMBER SKILLMAN: That was on page 402 in
4 the second paragraph from the top.

5 MS. GHOSH: Sorry, is that 402 in the PDF
6 file?

7 MEMBER SKILLMAN: Yes.

8 CHAIRMAN STETKAR: Make sure your thing is
9 on.

10 MS. GHOSH: Oh.

11 MEMBER SKILLMAN: It is on page Alpha 4,
12 it is the second --

13 MS. GHOSH: Okay, thank you.

14 MEMBER SKILLMAN: It is the second
15 paragraph from the top. And I make that comment
16 because the safety valves really are the large
17 spring valves, and a relief valve is commonly
18 actuated by some other medium. Right?

19 MR. WAGNER: It was sloppy.

20 MEMBER SKILLMAN: It's only the spring
21 valve that you're talking about.

22 MR. WAGNER: Yes.

23 MEMBER SKILLMAN: Okay, thank you.

24 MEMBER REMPE: So while you're being
25 interrupted, on the reactor coolant pump seal

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1 leakage in the write-up on page 4-23, I got
2 confused because some of this work was done a long
3 time ago that you cite before people went to like
4 the improved elastomers on the RCP, and did Surry,
5 did they go to the improved elastomers? Did you use
6 the appropriate data for quantifying reactor
7 coolant pump seal leakage is what I'm curious
8 about?

9 MR. WAGNER: We used the historical data.
10 They have gone to the new elastomers. They probably
11 are tougher than what is reflected but there was --
12 we did have good uncertainty guidance for the new
13 elastomers, so --

14 MEMBER REMPE: So basically you've used
15 data assuming that it leaks more than probably it
16 would leak, and your results are probably
17 conservative is what I should take away from this
18 question.

19 MR. WAGNER: Right.

20 MEMBER REMPE: Okay, thanks.

21 MR. WAGNER: I would note that it's
22 different modeling and the original SOARCA where we
23 had seal failures every -- when the system went
24 saturated near the pump seal we said that it
25 failed, and so that went to the 181 GPM, which was

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1 -- kind of changed the progression of transit. This
2 is improved because there's much lower likelihood
3 that you'd get the seal failure.

4 These are some of the in-vessel accident
5 progression models that are the parameters that
6 were being adjusted and the Zircaloy melt breakout
7 temperature, that's similar to what you'd seen with
8 Peach Bottom. The molten clad drainage rate is
9 another parameter so after the Zircaloy becomes
10 molten it could break through the Zircaloy oxide
11 crust, and how fast that flows out was an uncertain
12 variable.

13 Our two exploratory parameters which were
14 the radial solid and molten debris relocation. The
15 time at cycle was a huge undertaking and a big
16 change for -- and Surry I believe is the only UA
17 that will have done it. Peach Bottom didn't do it,
18 and Sequoyah isn't, but we looked at time of cycle
19 and so beginning of cycle, middle cycle, and end of
20 cycle.

21 MEMBER CORRADINI: So can I take you back
22 to the third -- on the right-hand side the third
23 and fourth bullet? You picked those because as we
24 had discussed previously is that there is no
25 experimental experience, and heuristically things

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1 ought to level out whether it's solid or liquid
2 between the various radial rings, so that's why you
3 picked it.

4 The crosswalk between MAAP and MELCOR
5 also identified the size of the debris and the
6 porosity factor in terms of how many gases come
7 through in hydrogen production. At least that's my
8 memory for the crosswalk, and yet those don't show
9 up here. It seems to me the debris size and the
10 porosity, the allowable porosities -- again, I'm
11 remembering. If I remember correctly, in MELCOR you
12 can never get down to no porosity, you can never
13 block a radial ring. You always can have some flow
14 through. Was those two thought about and just
15 thought not to be enough uncertainty to do it and
16 the values you guys default use because to me those
17 seem more uncertain and the crosswalk identified
18 them as two things that made MAAP and MELCOR evolve
19 differently. And maybe it's just timing of when you
20 chose this and did the analysis versus what the
21 crosswalk found out. Do you understand what I'm
22 asking?

23 MS. GHOSH: If I could just insert. I'll
24 let you answer, KC, but a lot of the same people --

25

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1 MEMBER CORRADINI: Oh, yes.

2 MS. GHOSH: -- working on this -- you
3 know, were also involved in the crosswalk so they
4 were very much aware of the findings from that
5 effort, as well. And I believe that, you know, the
6 outcome of which parameters we ended up with was a
7 result of the totality of their thinking which
8 would have included what they had been discovering
9 in, you know, the MAAP/MELCOR crosswalk
10 discussions. KC, if you want to elaborate on that.

11 MR. WAGNER: I don't have anything else to

12 -- MEMBER CORRADINI: So that was my polite
13 question. My impolite question is, I'm still
14 struggling since MAAP and MELCOR show dramatically
15 different results because of those two parameters,
16 I'd expect they'd be here. If they're not here, the
17 reason they're not here is?

18 MS. GHOSH: One of the discussions we had
19 ongoing as a team is that with MELCOR often you can
20 use different parameters to get at the end effect
21 of a particular set of processes. And I don't know
22 the specific details of this one, but I know that
23 we went through the thinking of, you know, there
24 may be 10 parameters that you could actually vary
25 that would get at the same variation in a

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1 particular set of processes, and we end up varying
2 a subset of those just because it's simpler and we
3 think that we can get at the end effect of, you
4 know, that set of processes. So I think some of
5 that thinking went in this. I can't recollect the
6 specifics of the two parameters that you mention
7 and how it fits into this set, but --

8 MR. WAGNER: Yes, so maybe it has to do
9 with how the models work, also. We have -- we don't
10 have as much control over the porosity. We have a
11 size dimension that's kind of been selected to be
12 characteristic of E02 pellets for the oxide when it
13 drops down there, but when we have molten metals
14 they fill in the interstitial spaces and it will
15 fill up and reduce the porosity. I would assume
16 MAAP has a similar model.

17 MEMBER CORRADINI: MAAP can go to zero. As
18 far as I understand, MELCOR cannot go to zero.

19 MR. WAGNER: The only reason we don't go
20 to zero --

21 MEMBER CORRADINI: A block. I guess what
22 I'm trying to get at is -- so let me tell you the
23 observable.

24 MR. WAGNER: Okay, sure.

25 MEMBER CORRADINI: And then I'll --

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1 MR. WAGNER: Sure, that would help.

2 MEMBER CORRADINI: So the observer was a
3 great difference in hydrogen -- the amount of
4 hydrogen generated and a very large difference in
5 the melt temperature upon this stuff coming into
6 the lower plenum.

7 MR. WAGNER: After it's in the lower
8 plenum?

9 MEMBER CORRADINI: No, the initial
10 temperature that it enters the lower plenum is
11 quite different because of these -- potentially
12 these two parameters.

13 MR. WAGNER: Oh, so to be clear, are you
14 talking about the porosity in the lower plenum or
15 the porosity --

16 MEMBER CORRADINI: No.

17 MR. WAGNER: -- above the core plates?

18 MEMBER CORRADINI: Yes, the thinking at
19 least -- again, I had to go back to the crosswalk
20 report, but my understanding is in the crosswalk
21 report the estimate from the teams were that with
22 the presence of porosity I keep on producing a lot
23 of hydrogen because steam can still flow through in
24 the MELCOR simulation, and it keeps it cool enough
25 so then when things start slumping it slumps with

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1 lower temperatures and a lot of hydrogen. And MAAAP
2 is -- will just say 180 degrees opposite, which is
3 not very much hydrogen but very hot because it sits
4 there bottled up and then when it slumps it comes
5 down quickly and much hotter. So my question is,
6 that seems to be a big uncertainty and it wasn't
7 here.

8 MEMBER REMPE: But that was for a BWR in a
9 dry event. Right?

10 MEMBER CORRADINI: Well, this is a drill
11 down. This is a station blackout in both cases. So
12 I've asked my question.

13 MR. WAGNER: Yes. We looked at -- the
14 things that we looked at were prior to that
15 configuration as you can see. We looked at the Zirc
16 melt breakout temperature and the drainage rate. We
17 didn't -- we don't have that in there.

18 MEMBER CORRADINI: But my only guess was,
19 is that because, as Joy said, the BWR -- the
20 crosswalk was on a BWR and so the differences here
21 might have been smaller. So I guess maybe you did
22 some side calculations that said this is not a big
23 deal here because it's a PWR geometry.

24 MR. WAGNER: Yes.

25 MEMBER CORRADINI: That's the only

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1 justification I could guess that these don't show
2 up in your list, that's all. Am I making sense?

3 MR. WAGNER: Yes, you are.

4 MEMBER CORRADINI: Okay.

5 MEMBER REMPE: But it would be good to
6 document it, why some of these parameters are not
7 considered.

8 MR. WAGNER: Yes, there was a whole host
9 of ones that --

10 MEMBER CORRADINI: I'm sure, yes. I know
11 there's a lot of them.

12 MR. WAGNER: Yes, and that's certainly an
13 area that I know was thought about, but --

14 MS. GHOSH: Yes. Unfortunately, the person
15 who could probably best answer everything with
16 respect to that is in bed quite sick and I don't
17 know if he's listening on the phone. We may be able
18 to get you more details later today but whether --

19 MEMBER CORRADINI: That's good. I wanted
20 just to state it because you have in your thinking
21 process --

22 MS. GHOSH: Your mic.

23 MEMBER CORRADINI: I'm sorry, I'm off.
24 That you boil it down to like four or five classes
25 of uncertainties, and the in-vessel class is the

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1 one that has a lot of parameters, and it's hard to
2 tell which ones you pick and why you pick them as
3 to uncertainty. So I was just -- those two were
4 missing, and I just wanted to at least get a story
5 as to why they've been set aside.

6 MR. WAGNER: Maybe -- the one place it did
7 come in, so I guess I would add, is on the eutectic
8 temperature which is this --

9 MS. GHOSH: The last bullet there.

10 MR. WAGNER: Yes, the last bullet. At the
11 temperature that the Zirc and the EO2 form eutectic
12 and molten, and that changed the characteristic of
13 the core which would lead to much more blockage to
14 the extent that MELCOR is able to calculate that.
15 We have troubles when there's no volume, CVH can't
16 converge or it runs -- it causes numerical problems
17 as we approach, you know, completely filled cells.
18 But certainly that eutectic temperature changed the
19 characteristic of the melt that was going down to
20 the lower plenum.

21 You see that on a hydrogen generation.
22 You'll see some pretty low values and those were
23 with low eutectic temperatures where a big chunk of
24 the core is much more molten than say if that
25 eutectic temperature was higher. So probably that's

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1 -- recalling that that's probably the way we --
2 since that was such a big nod there, that was
3 probably how we were looking at, you know, a
4 variance in that.

5 MEMBER REMPE: A couple of questions
6 before you leave it. First of all, you said today
7 well, we're not doing the time in the fuel cycle
8 for Sequoyah. But as I recall, this report said
9 that was important so why is that not being done
10 for Sequoyah?

11 MR. WAGNER: I think I'll come back to
12 that, if you don't mind. But the MOC and the EOC
13 were not a whole lot different. Where we picked the
14 BOC was substantially different, but you -- and I
15 think we calculated in about 30 days your -- that
16 BOC is starting to look like an MOC, as far as --

17 MEMBER REMPE: With a transient this is
18 important.

19 MR. WAGNER: Yes.

20 MEMBER REMPE: Is the short-term answer.
21 The second thing is natural circulation. Why was
22 that decided that isn't -- to me there's limited
23 testing that people have for that, and I'm
24 surprised that wasn't something people decided to
25 use as an uncertainty parameter.

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1 MR. WAGNER: We addressed that in two
2 fashions. We -- from original SOARCA to the UA,
3 Chris Boyd's 1922, NUREG-1922 report came out, and
4 so he had much better guidance for us, so we
5 updated it based on that, so we are -- what his
6 recommended values were. And we -- rather than --
7 so we -- based on that we could have -- we looked
8 at his comments in the report and he varied a bunch
9 of boundary conditions in his CFD work, and the
10 conclusions were the recirculation ratio which is
11 the ratio between the flow in the hot leg and the
12 tubes didn't change very much. The Drake
13 coefficient that he calculated didn't change very
14 much. The size of the hot spot didn't change very
15 much, and so -- but there was a little bit of a
16 jumping around of the hottest tube, and that was my
17 impression, I was the one that wrote this one up.
18 There was the most uncertain variable, so it was a
19 strong effort because we're worried about
20 correlation to kind of pick maybe the key parameter
21 that was -- could capture the most things, and that
22 was our -- how hot is that hot plume that's
23 entering into there, so that was what we picked.
24 And then it was kind of geared towards looking for
25 SGTRs, and then the thinning of the tubes would

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1 have been the other parameter. So, we did give it
2 quite a bit of thought and we settled on we're just
3 going to vary that normalized temperature of the
4 hottest tube.

5 MEMBER REMPE: Okay, thank you.

6 MR. WAGNER: Ex-vessel accident
7 progression. We wanted to explore the possibility
8 of hydrogen burns after say hot leg failure or the
9 PRT fails on the pressurizer, the rupture disk
10 fails on the PRT, because in the original SOARCA we
11 got into steam inerted, and then we became oxygen
12 limited as the non-condensable gases from MCCI
13 pressurized the reactor, or the containment. So we
14 were looking for the lower flammability limit and
15 so that was selected as one of the parameters to
16 explore under the 10 percent which was used in the
17 original SOARCA to look at flammability at lower
18 levels, so that was an uncertain factor.

19 SGTR, we did the uncertainty of the
20 location because that affected the decontamination
21 of the aerosols in the secondary side, and so that
22 was another parameter.

23 On the containment behavior there was two
24 related to leakage and failure. One was the design
25 leakage, and I don't know if we talk about that one

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1 later but tech specs allow above the .1 percent per
2 day for certain periods of time under certain
3 situations, so we wanted to explore higher leakage
4 that could be allowed and see what its impact was.
5 And then there's an expert judgment process based
6 on scaled experiments to go to predict the
7 fragility code for the containment, and we wanted
8 to explore one of the parameters on when the
9 containment liner would rupture, and so that was an
10 uncertainty parameter.

11 The condensation which kind of fed into
12 whether there was a potential for a hydrogen burn,
13 the assessment primarily was contained in the DBA
14 work. They found out that the condensation
15 coefficient for inside the containment was low with
16 the correlation and MELCOR is using the same
17 correlation, so in contain based on their DBA work
18 they had increased that. So based on those insights
19 and some uncertainty and condensation heat transfer
20 that became an uncertain parameter which might
21 create conditions where hydrogen burns might be
22 possible, so we wanted to make sure that we
23 explored some of the parameters that might lead to
24 a containment failure.

25 The radionuclide part, the RN, I guess we

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1 didn't define that in the report. I need to fix
2 that, but that has to do with our radionuclide
3 transport. There was two parameters related to
4 iodine and cesium, and this was another kind of
5 ambitious undertaking because although it sounds
6 rather straightforward, it was a lot of code input
7 to implement these. But we looked at the amount of
8 iodine gas that was present and so that was an
9 uncertain variable, something that wasn't
10 considered in the original SOARCA. And then the
11 chemical form of cesium, and that's changed a lot
12 over the years based on insights from PHEBUS going
13 from I think some of the original Reg Guides, it
14 was primarily a cesium hydroxide, and now we agree
15 that it's more cesium molybdate based on evidence
16 from PHEBUS, but cesium hydroxide is another
17 possibility. Their vapor pressures are radically
18 different and their mobility, and so we wanted to
19 make sure that we explored some variability of the
20 compound makeup of the cesium.

21 And then finally, this was also in Peach
22 Bottom, and I think is going to be in Sequoyah, is
23 the dynamic shape factor, and that's the
24 aerodynamic shape factor for aerosols. So when the
25 aerosols form they make chains and they settle

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1 differently than the spheres which is the default
2 in MELCOR, and so that was explored as an
3 uncertainty parameter.

4 CHAIRMAN STETKAR: I'm trying to look
5 ahead. You don't have another slide on the chemical
6 forms, do you?

7 MS. GHOSH: I don't think --

8 CHAIRMAN STETKAR: You're not planning on
9 discussing that.

10 MS. GHOSH: Yes, sorry. We didn't include
11 that this time.

12 CHAIRMAN STETKAR: I'm going to -- I'll
13 telegraph. I'm going to beat you up an awful lot on
14 the valves which you do have slides on.

15 MS. GHOSH: Okay. But first you'll beat us
16 up on --

17 CHAIRMAN STETKAR: Unless you tell me to
18 wait until a later slide, and I haven't heard that.

19 MR. WAGNER: No, this would be the time to
20 talk about --

21 CHAIRMAN STETKAR: Oh, all right. Let me -
22 - I had a question. The -- I'm not a chemist. Dana
23 isn't here. You refer to the PHEBUS experiments as
24 evidence for the distribution that you used. That
25 distribution is -- in the study is capped at 3

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1 percent of the iodine inventory. I looked at the
2 figure, it's Figure 4-38 from the PHEBUS
3 experiments for low enriched fuel and it seems to
4 show quite a number of data points at higher than 3
5 percent for low enriched fuel at burnups around
6 higher than about 50,000 megawatt days per ton.
7 What's the current burnup at Surry?

8 MR. WAGNER: I think it's around 42 or so.

9 CHAIRMAN STETKAR: 42, so it's below that
10 50, okay. Because you made reference to Surry's
11 specific burnup information but you didn't cite
12 what it was, or at least not in the part that I
13 read. And that's the primary justification for
14 essentially disregarding those higher release
15 fractions?

16 MR. WAGNER: Yes.

17 CHAIRMAN STETKAR: Okay.

18 MR. WAGNER: So we did a fit to it and --

19 CHAIRMAN STETKAR: But it accounted for a
20 burnup lower than -- it's about 50,000 where you
21 start to see additional releases. Okay, thank you.
22 Okay, I'm done.

23 MEMBER CORRADINI: So you're done going
24 through the parameters. So now you took these
25 parameters, ran through Monte Carlo and came up

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1 with 1,200 samples. Did you -- I was going to use
2 the word "unscramble," but the character of the
3 parameters are different in the sense that they're
4 sequence parameters, they're in-vessel parameters,
5 they're -- so that it doesn't surprise me that
6 initial conditions and boundary conditions
7 dominate, so if I have the different initial
8 condition or boundary condition and I've got a tube
9 that breaks, that's really a big deal.

10 Is there a way to unwrap the 1,200 or
11 1,000 successful ones so that I ought to look at
12 what's important in in-vessel progression given a
13 sequence, or ex-vessel progression given a sequence
14 in in-vessel. You know what I'm asking? In some
15 sense, I was looking at your summary table and the
16 things that drive it don't surprise me, but yet all
17 the rest are kind of in the noise, so do I
18 interpret that everything is in the noise?

19 MS. GHOSH: We did try to do subsets of
20 results in the regressions.

21 MEMBER CORRADINI: Yes.

22 MS. GHOSH: Yes, the way -- actually,
23 there's a slide at the end of this little --

24 MEMBER CORRADINI: Okay, that's fine.

25 MS. GHOSH: -- assessment that I think

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1 explains it.

2 MEMBER CORRADINI: All right. So if you
3 bring it up there, then I'll ask my question.

4 MS. GHOSH: Yes.

5 MEMBER CORRADINI: That's fine.

6 MS. GHOSH: Just for example, we looked at
7 steam generator tube ruptures just by itself and
8 then the non-SGTR just by itself, but we'll get to
9 it.

10 MEMBER CORRADINI: Okay, that's fine. I'll
11 wait. Thank you.

12 MR. WAGNER: Those are many UAs to focus
13 in on those. I'm a little nervous now.

14 (Laughter.)

15 CHAIRMAN STETKAR: Be very afraid but
16 launch into it.

17 MR. WAGNER: Because this is not my area
18 of expertise but Tina is going to help me and
19 others.

20 So the way the safety valves can operate
21 and fail have all sorts of possibilities, and
22 because we're doing the stochastic sampling on them
23 we get a lot of different possibilities that needed
24 to be considered. In most cases the failure to
25 close occurs on the lowest safety valve because

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1 they each have their own set points. And, in
2 general, we only operate in a one valve at a time
3 whether it's the primary or the secondary. And so
4 that valve would do its thing and then we would
5 move on to the next valve, if needed, depending on
6 what happened with that valve. So the things that
7 could happen with that valve, we didn't have any
8 thermal failures in the valves.

9 MS. GHOSH: Right. We modeled it but we
10 didn't see any --

11 MR. WAGNER: Okay, so --

12 CHAIRMAN STETKAR: KC, you mentioned -- I
13 was going to bring it up later, but I might as well
14 do it now. You mentioned that you didn't even
15 consider thermal failures of the main steam safety
16 valves because -- I'll paraphrase because I lost my
17 note. Because they always operate at design
18 conditions. That's not true once you get hot gases
19 ejected through the ruptured tubes, is it?

20 MR. WAGNER: At that point we weren't on
21 the valves any more.

22 CHAIRMAN STETKAR: Well, how does the
23 model -- this is something I don't know about the
24 model. When you model releases now through the
25 failed steam generator does the release fraction

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1 depend on the stuck open area of the safety valve?
2 In other words, this parameter, SVOAFRAC or
3 something like that, does the amount of release
4 depend on the value of that parameter?

5 MR. WAGNER: Not very much. That didn't --

6

7 CHAIRMAN STETKAR: Not very much. Well,
8 why?

9 MS. GHOSH: Yes, there is some --

10 MR. WAGNER: Some dependence.

11 MS. GHOSH: -- dependence. There's some
12 dependence.

13 CHAIRMAN STETKAR: Well -- but if it does
14 depend on that and if the valves are likely to fail
15 open due to high temperature conditions, couldn't
16 that change the nature of the releases
17 substantially, if that SVOFRAC value is simply
18 based on assumed normal operation of the valves?

19 MS. GHOSH: Okay. If I -- I don't know if
20 I -- I'm not sure I understand your question
21 completely.

22 CHAIRMAN STETKAR: Okay.

23 MS. GHOSH: But I think --

24 CHAIRMAN STETKAR: Let me walk you through
25 the scenario.

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1 MS. GHOSH: Yes.

2 CHAIRMAN STETKAR: A core damage occurs,
3 hot gases go into the steam generator tubes, tubes
4 fail, hot gases are now released into the secondary
5 side of said steam generators which are pressurized
6 to the steam generator safety valve set points
7 which are cycling and are failing with some
8 likelihood. If they fail they have some assigned
9 open fraction to them which is an uncertain
10 distribution. My question is will those safety
11 valves be exposed to temperatures above their
12 design ratings during these particular scenarios
13 with the release, and would that affect -- would
14 that high temperature condition affect either --
15 affect both, the likelihood that they stick open
16 and the open area if they stick open, and then
17 subsequently the amount and timing of the release?

18 MS. GHOSH: We did model the thermal
19 seizure and we varied the thermal seizure criteria
20 --

21 CHAIRMAN STETKAR: You did not for the
22 secondary safety valves.

23 MS. GHOSH: Okay, okay.

24 CHAIRMAN STETKAR: That's what I'm talking
25 about.

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1 MS. GHOSH: Yes. I mean, we have the
2 safety scale from overcycling at a lower number of
3 cycles and we would have --

4 CHAIRMAN STETKAR: That was before the
5 release though. Right?

6 MS. GHOSH: Yes.

7 MR. WAGNER: Yes. So I think --

8 CHAIRMAN STETKAR: When I say "release,"
9 before the release into the steam generator.

10 MR. WAGNER: It's a fair question, and for
11 completeness maybe it should have been done. But in
12 practicality the situation didn't arise. We had
13 already dried out the steam generator and that's
14 what leads us into --

15 CHAIRMAN STETKAR: I know how you got
16 pressure low in the steam generator, how you got
17 the high dry low condition.

18 MR. WAGNER: Well, so we had already
19 cycled and dried out the steam generator --

20 CHAIRMAN STETKAR: Right.

21 MR. WAGNER: -- which in most cases led
22 to valve failure of some area under weighted
23 conditions.

24 CHAIRMAN STETKAR: Okay.

25 MEMBER CORRADINI: So before degradation

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1 in most cases --

2 MR. WAGNER: Yes.

3 MEMBER CORRADINI: -- the valve cycling
4 popped open and stuck at some fraction.

5 MR. WAGNER: Yes.

6 MEMBER BLEY: Essentially guaranteed stuck
7 open after somewhere near 100 cycles.

8 MR. WAGNER: Yes.

9 MEMBER BLEY: Yes.

10 MR. WAGNER: So the generator dries out at
11 an hour and 10 minutes or so, and that's the strong
12 cycling. There's some continued cycling just to the
13 heating of the gas that's in there. That was a lot
14 of cycles getting to that point, and most of our
15 calculations had -- on top of that we also had
16 leakage around the MSIVs, and so that by itself
17 would depressurize the system.

18 CHAIRMAN STETKAR: I guess what I'm trying
19 to probe is, though, how the safety valves were
20 modeled after the tube failure, and how those
21 models might or might not affect the amount of the
22 subsequent release. And I just don't know, because
23 I --

24 MR. WAGNER: So what happened in the
25 evolution of the accident there, most of the time

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1 the valve was in whatever position it was because
2 it had failed. We have some leakage that's going on
3 around the MSIVs. The particles that we're worried
4 about, this is not addressing your gas problem just
5 yet, but the particles that are coming through are
6 all the small ones.

7 CHAIRMAN STETKAR: Yes.

8 MR. WAGNER: Because now an improvement
9 through this version was size dependent
10 decontamination factor.

11 CHAIRMAN STETKAR: Yes.

12 MR. WAGNER: And based on the hardest
13 test. And so all the small particles we calculated
14 at BF, but they're all floating through and they
15 get out whether it's through that MSIV leakage, or
16 whether it's through the stuck open valve. So you
17 look at the range of results that we have and
18 they're an order of magnitude higher than without
19 the tube ruptures, but there isn't a lot of -- I
20 mean, there's a decent variance there but those
21 small particles get out. And once they leave the
22 MSIV we conservatively put them in the environment.

23 CHAIRMAN STETKAR: Okay.

24 MR. WAGNER: They're gone at that point
25 and available for --

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1 CHAIRMAN STETKAR: If I can just make
2 sure. Essentially, you're saying that for practical
3 purposes everything that comes into the steam
4 generator for most of the realizations goes out to
5 the environment. Is that --

6 MR. WAGNER: Yes.

7 CHAIRMAN STETKAR: Am I correctly
8 interpreting what you said?

9 MR. WAGNER: Except for the big aerosols
10 that have some impaction, you know, on the tubes
11 just coming through the break.

12 CHAIRMAN STETKAR: Right. Okay. Okay,
13 thanks. That isn't what I was going to beat you up
14 on about.

15 MR. WAGNER: No, I'm sure there's more
16 coming.

17 CHAIRMAN STETKAR: That was just
18 education. Thank you.

19 MR. WAGNER: So I'll give a rudimentary
20 description of this graph which I think makes
21 sense, so that as valves fail you have the ability
22 to move on to other valves. If that's sufficient to
23 remove the energy that needs to be removed from the
24 system then no more valves open. There is a
25 possibility that all the valves could fail to

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1 close, or fail to open and that possibility is
2 included in there. And that would be State 5.

3 Well, what is that possibility of the
4 fail to open? It turns out that it's pretty low. We
5 did 100,000 samples looking at this and we didn't
6 find any. It doesn't mean that it couldn't happen,
7 but its likelihood is pretty low, and it's most
8 likely that we're going to have one or more valves
9 stick open. Now these are distributions.

10 CHAIRMAN STETKAR: Are you going to say
11 any more about that? Yes you are. I had questions -
12 - we discussed safety valves whenever it was on
13 Peach Bottom, and some of my same questions apply
14 today. But I thought about them a little bit more
15 in the context of a pressurized water reactor which
16 I'm more familiar with.

17 You have a table 4-2 in the report that
18 essentially shows the data that you used plus the
19 parameters of these particular distributions. And
20 there's some discussion of why you selected what
21 you selected, and why you discounted stuff that you
22 didn't use. In effect you said well, we looked at -
23 - I think you got the reference wrong, go check
24 your references because you refer to one NUREG that
25 -- you refer to an Appendix A.2.42 of NUREG/CR

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1 7037, and I think you're actually looking at
2 Appendix B to that report, but that's okay. I mean,
3 that's a bookkeeping thing.

4 You said, essentially, that you looked
5 only at safety valve failures after scrams, that
6 you discounted test data because you felt that the
7 test data was not prototypic. Okay, my first
8 question is why is test data not prototypic for
9 behavior of the valves? Because there were
10 failures?

11 MR. ROSS: Could I make a comment?

12 CHAIRMAN STETKAR: Yes, come on up and
13 comment on it.

14 MEMBER CORRADINI: You have to identify
15 yourself and speak with sufficient clarity and
16 volume.

17 CHAIRMAN STETKAR: To be readily heard.

18 MR. ROSS: I'm Kyle Ross with Sandia Labs.
19 Yes, the body of data in the two components. One
20 was testing, one was actual response to a scram.

21 CHAIRMAN STETKAR: Yes.

22 MR. ROSS: And the cycles, or the failure
23 probability was quite a lot larger for the actual
24 events, the testing.

25 CHAIRMAN STETKAR: I'm sorry, it was the

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1 other way around.

2 MR. ROSS: Well, the testing of --

3 CHAIRMAN STETKAR: For failure to open.

4 MR. ROSS: The testing valves cycle longer
5 before failing.

6 CHAIRMAN STETKAR: Yes, they have fewer
7 fail -- it depends on how you characterize what
8 you're calling a failure. The time to failure was
9 longer or the number of failures within a given
10 time period was lower.

11 MR. ROSS: Yes, yes.

12 CHAIRMAN STETKAR: Now my question is the
13 data are -- and you just said the data that you
14 used are from demands on pressurizer safety valves
15 after a reactor scram. It's really, really, really,
16 really, I'm not going to belabor it any more,
17 difficult to get a demand for a pressurizer safety
18 valve to open after a reactor scram. It like never
19 occurs, and yet somehow you counted up 773 of these
20 things. I would be really curious where those 773
21 demands of pressurizer safety valves came from,
22 because the experiments might be like zero failures
23 and zero demands, not zero and 773.

24 MR. ROSS: Yes, so those words are errant.
25 The database for the valves included those

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1 secondary and primary valve --

2 CHAIRMAN STETKAR: Oh, both secondary and
3 primary, but you only included primary in the
4 numerator, didn't you? Because you didn't take
5 secondary safety valves because they're not
6 published for pressurizer water reactors in that
7 report. They're published for BWRs and they've had
8 failures, but you didn't use BWR valves. They had
9 failures and more demands. So why are you cooking
10 the data?

11 MR. ROSS: Well, there's certainly no
12 intentional cooking of data.

13 CHAIRMAN STETKAR: Okay, but as best as I
14 can tell it was cooked pretty strongly. You took a
15 large number of demands of safety valves that
16 cannot be justified from operating experience. You
17 took zero failures, you discounted test data
18 because you said well, the failure rate is higher
19 during test data which is the only data that I have
20 for pressurizer safety valves, and I can't
21 reproduce -- I can't even find the failure to close
22 data that you used because I can't find it
23 published in that report anywhere. All of these
24 parameters are really important to these results.

25 MR. ROSS: Well, I mean, it sounds like

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1 what -- you're very knowledgeable, but the
2 difference for my interpretation of those NUREGs.

3 CHAIRMAN STETKAR: Okay. Find me the
4 evidence in the NUREGs of the 17 failures to close
5 and 773 demands on pressurizer safety valves.

6 MR. ROSS: Okay. I --

7 CHAIRMAN STETKAR: Please, and I'd like if
8 you can before the end of the day, I'd appreciate
9 that. And find me where -- I know where you got the
10 773 demands. I read that in a table. I don't
11 believe that. It's published as demands of
12 pressurizer safety valves after a scram. I
13 fundamentally --

14 MR. ROSS: And it's not. They have errant
15 words there. It was for safety valves period being
16 whether they're on a steam generator steam line --

17 CHAIRMAN STETKAR: Well, the cited NUREG
18 does not contain data for steam generator safety
19 valves. I couldn't find it.

20 MR. ROSS: No, but I believe it has a
21 statement that says the valves are not
22 distinguishable.

23 CHAIRMAN STETKAR: But it doesn't include
24 the numerator or the denominator for the data for
25 those valves, I don't believe.

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1 MR. ROSS: So it's been a year or so since
2 I looked at these NUREGS, but I have the ability to
3 look at them again --

4 CHAIRMAN STETKAR: Okay. I think just take
5 -- we don't need it but take that away because the
6 way that the data are presented in this report --
7 and, in fact, I raised this when we were talking
8 about Peach Bottom. The data in the cited NUREG are
9 in many cases contrived, and as best as I can tell
10 you simply took the data as if they're fact and
11 said well, we're going to create a beta
12 distribution about that evidence.

13 MEMBER BLEY: I think what John has
14 suggested is a good idea, but lest you go
15 overboard, I would caution that if you go to test
16 data you really understand it because most test
17 data I have seen on safety valves report a failure
18 if you don't lift by some percentage above the set
19 point, where here you will drive it well above that
20 point such that usually that's a small adjustment
21 and it would have lifted a little bit later, so you
22 can go way too far the other way.

23 CHAIRMAN STETKAR: Yes, and I'm not
24 advocating necessarily including all of the test
25 data --

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1 MEMBER BLEY: But reacting to your
2 comments that get us there.

3 CHAIRMAN STETKAR: In particular for the
4 failure to open, on the other hand the stuck open,
5 the test data might absolutely be valid.

6 (Simultaneous speaking.)

7 CHAIRMAN STETKAR: Because once it opens -
8 -

9 MEMBER BLEY: Then it's absolutely valid.

10 CHAIRMAN STETKAR: But I have real
11 questions about the data and how well you probed
12 that data. The other question that I had, as long
13 as you're taking notes, is -- and I agree with you
14 completely that a spring-loaded safety valve is a
15 spring-loaded safety valve, code spring-loaded
16 safety valve, shouldn't make any difference whether
17 it's on a steam generator, whether it's on a
18 pressurizer, or whether it's on a boiling water
19 reactor. To increase the population of both
20 numerator and denominator in terms of your
21 experiential evidence to inform the uncertainty
22 distributions did you think about using valve data
23 also, spring-loaded safety valve operation data
24 from boiling water reactors, because the same NUREG
25 does publish data about BWR safety relief valves

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1 operating in the safety mode, not the pilot relief
2 mode. They distinguish between that, both testing
3 and post-scrum data. And, in fact, on boilers there
4 are actually more legitimate demands on those
5 valves. So the question is, you know, in terms of
6 the distributions are based -- for failure to open
7 are based on zero and 773 with a data distribution
8 fit around that. And for failure to close, stuck
9 open is 17 failures and 773. I couldn't find the 17
10 stuck open failures. That may be too high.

11 MR. ROSS: I'm confident I can find --

12 CHAIRMAN STETKAR: The answer smells about
13 right, but I couldn't trace it back.

14 MR. ROSS: Yes, I'd be glad to find that
15 number.

16 CHAIRMAN STETKAR: That would be great.

17 MR. ROSS: Yes.

18 CHAIRMAN STETKAR: That would be great.

19 MS. GHOSH: Yes, so we'll follow-up on
20 that. Just to repeat what Kyle said, there was no
21 effort to cook the data. You know, and I know we
22 had extensive discussions about this as a team.
23 Unfortunately, it was two and a half years ago, so
24 it's a little difficult to remember all the details
25 of our discussion, but we did put a lot of thought

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1 into this because we knew it was going to be
2 important. It turns out to be important.

3 CHAIRMAN STETKAR: Yes.

4 MS. GHOSH: We just need to do a better
5 job of documenting where the numbers came from and
6 say more of the why.

7 MEMBER BLEY: If it's a citation problem,
8 let us know. I think the first part of John's
9 comment you won't find it that way. If you end up
10 having trouble here, I remember there was a big
11 EPRI program doing a lot of testing. I know it was
12 on PORVs in the '80s. I don't remember if they did
13 safety valves, too.

14 CHAIRMAN STETKAR: They mention that but
15 it's -- but only in passing. And ostensibly this
16 NUREG/CR-7037 is much more recent than that, and it
17 compiles much more experience data from actual
18 demand. And it actually is a pretty thorough
19 reference for safety and relief valves and all that
20 kind of stuff.

21 MEMBER BLEY: Yes, and I --

22 MR. FULLER: This is Ed Fuller. The -- I'm
23 familiar with this, with that program. There were a
24 lot of safety valves tested back in the '80s, and
25 we originally when I was at Pulstar, we did the

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1 steam generator tube integrity risk assessment
2 work. We actually have a separate report on what we
3 did investigating those valve failures. So I
4 somewhere still have some of that stuff.

5 MEMBER BLEY: You might want to share it
6 with your colleagues.

7 MR. FULLER: But I don't know where some
8 of it is right now. By the way, I did share it with
9 them two and a half years ago.

10 MS. GHOSH: Yes.

11 MR. WAGNER: Okay. Ready to move on?

12 CHAIRMAN STETKAR: Is it appropriate to
13 discuss now how the sampling algorithms for these
14 various failure modes were implemented in MELCOR,
15 or do you want to wait?

16 MS. GHOSH: I think it's fair to discuss
17 it now because we don't have more detailed slides
18 on that.

19 CHAIRMAN STETKAR: Yes.

20 MS. GHOSH: Maybe -- I don't know which
21 side is better, this data diagram or the
22 distributions? But as I mentioned in the first
23 overview talk we implemented both an epistemic and
24 aleatory aspect of the safety valves behavior, so I
25 think the more complex --

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1 CHAIRMAN STETKAR: Let me -- when -- I
2 know you make a lot of points about the difference
3 between aleatory and epistemic uncertainty. Let's
4 just say you implemented uncertainty for the valves
5 because valve failure data include both epistemic
6 and aleatory, and it's really, really difficult to
7 separate those two. So you had an uncertainty
8 distribution.

9 MS. GHOSH: We had an uncertainty --

10 CHAIRMAN STETKAR: It is what it is.

11 MS. GHOSH: But the -- okay, I guess the
12 reason I bring it up, the way that it was
13 implemented was to take a two-step process to both
14 first assume a sampled failure rate, and then given
15 that failure rate how many cycles the three valves
16 would experience were they called upon to cycle a
17 certain number of times. And then for a given
18 sampled failure rate the cycles to failure for
19 those three valves were different which represented
20 the aleatory nature given a failure rate that you
21 know or is true, how many cycles you could actually
22 experience.

23 CHAIRMAN STETKAR: Let me probe that, and
24 it was easier for me to frame my question if I
25 think about the steam generator safety valves than

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1 the pressurizer safety valves, because the -- my
2 question about the sampling algorithm applies
3 equally to both of them.

4 On the steam generators first principles,
5 all three safety valves should be challenged to
6 open at the same time. Right?

7 MS. GHOSH: Yes, and --

8 CHAIRMAN STETKAR: I mean, they're not --

9 MS. GHOSH: We model one valve per steam
10 generator.

11 CHAIRMAN STETKAR: Yes, you're modeling
12 the lowest set point valve.

13 MS. GHOSH: Right, that's right.

14 CHAIRMAN STETKAR: And that's why -- you
15 know, you don't run into the physical complications
16 on the pressurizer where you have staged --

17 MS. GHOSH: Right.

18 CHAIRMAN STETKAR: -- pressures. So if I
19 now think of three nominally identical valves
20 cycling open and closed, and I have a single state
21 of knowledge uncertainty distribution for the
22 failure rate of those valves. So if the world works
23 according to Sample 1, I should expect each of
24 those valves to have failure rate 1X. If the world
25 works according to Sample 2, I should expect each

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1 of those valves to have failure rate $2Y$. It's a
2 different sample, a different failure rate, but why
3 would I believe that each valve would have a
4 different failure rate? It may fail independently
5 in a logic model sense --

6 MS. GHOSH: Right.

7 CHAIRMAN STETKAR: -- so it's X cubed or
8 Y cubed to have all three fail.

9 MS. GHOSH: Yes.

10 CHAIRMAN STETKAR: But not different
11 failure rates.

12 MS. GHOSH: They shouldn't -- in a given
13 Monte Carlo realization where we're fixing a state
14 of knowledge, they should have an identical failure
15 rate.

16 CHAIRMAN STETKAR: Okay, but that's not
17 what I understood by the discussion about the
18 sampling algorithm because it says that the failure
19 to close distribution for the valves is
20 independently sampled three times to obtain the
21 numbers NSGAI, NSGBI, and NSGCI of demands for
22 which the lowest safety valve on steam line A, B,
23 and C. That leads me to believe that three separate
24 values were used.

25 MS. GHOSH: Right. And, actually, maybe

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1 Dusty can help me out --

2 CHAIRMAN STETKAR: They're not correlated.

3 PARTICIPANT: We have Matt on the phone.

4 MS. GHOSH: Oh, Matt is on the phone.

5 Okay. Yes, and I may have misspoken. Maybe that was
6 an attempt -- because I think we did a little bit
7 different modeling on the pressurizer side, which
8 I'm more familiar --

9 CHAIRMAN STETKAR: Yes, let's talk --

10 MS. GHOSH: -- with than the secondary
11 side. So on the secondary side, we think -- so we
12 have some additional members of the team who are
13 on the bridge line. I don't know how difficult it
14 would be --

15 CHAIRMAN STETKAR: We can get the bridge
16 line open if they can add --

17 MS. GHOSH: Yes, because we have Matt
18 Denman from Sandia who actually implemented.

19 CHAIRMAN STETKAR: Okay.

20 MS. GHOSH: Made all of this come to pass
21 in terms of the sampling, so he may be the best
22 person to have --

23 CHAIRMAN STETKAR: The second part of the
24 question while we're trying to get that open is
25 that the discussion about the sampling -- and this

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1 is for the -- I think the line is open, for the
2 fraction. It's open. There's some discussion about
3 well, we use the fraction open for valves in number
4 one and three, and we took the complement of the
5 fraction open for number two because we didn't --
6 we wanted to avoid something or other.

7 MS. GHOSH: Yes.

8 CHAIRMAN STETKAR: And that completely
9 confused the heck out of me.

10 MS. GHOSH: Right.

11 CHAIRMAN STETKAR: But let's get down to
12 the first question about whether or not --

13 MS. GHOSH: Yes.

14 CHAIRMAN STETKAR: -- the three valves
15 were correlated. And in my mind it would also apply
16 to the pressurizer safety valves despite the fact
17 that they open in a staggered -- you know, the
18 second one isn't challenged to open unless the
19 first one is -- fails to open. There are two,
20 though. If the world works according to our state
21 of knowledge sample 1, then all three of those
22 valves ought to have failure rate 1X.

23 MR. DENMAN: So this is Matt Denman at
24 Sandia.

25 CHAIRMAN STETKAR: Yes.

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1 MR. DENMAN: Can you hear me?

2 CHAIRMAN STETKAR: Yes, we can.

3 MR. DENMAN: Okay. So in any given MELCOR
4 simulation there was a draw of what we were calling
5 the epistemic failure rates for the valves, and
6 then that epistemic failure rate fed an aleatory
7 negative binomial distribution which was sampled
8 three times to give you your three number of cycles
9 until failure within that MELCOR simulation. And
10 then the next MELCOR simulation, a new epistemic
11 draw was taken and fed a single negative binomial
12 distribution which had three aleatory draws from
13 that negative binomial distribution. So for any
14 given MELCOR simulation all of the steam generator
15 safety valves, all of the safety valves on the
16 primary system --

17 MS. GHOSH: So I think, John, this goes to
18 the differences in how we were discussing the world
19 -- I'm sorry. I'm sorry. I think because in your
20 mind you are mapping everything onto one
21 uncertainty as you called it. We were attempting to
22 model both the epistemic and random aspects of that
23 parameter which, of course, at the end of the day
24 if you think in composite you can come up some
25 composite, you know, distribution of what it would

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1 look like. But the way we implemented it, the
2 reason you have the different cycles to failure of
3 the three valves is because you start with one
4 epistemic failure rate, but then you model the fact
5 that random -- you know, the random aspect that
6 given that failure rate you could have different
7 cycles to failure.

8 MEMBER BLEY: Failure and time is random
9 given the failure rate. That's the way it --

10 CHAIRMAN STETKAR: How did you divine the
11 failure in time though?

12 MS. GHOSH: Well, in this case it's demand
13 -- on demand --

14 CHAIRMAN STETKAR: This is number of
15 cycles because --

16 MS. GHOSH: Number of cycles --

17 CHAIRMAN STETKAR: -- inverse of the
18 failure rate, isn't it?

19 MR. DENMAN: So the inverse of the failure
20 rate is the average, or is the mean of the negative
21 binomial distribution.

22 CHAIRMAN STETKAR: Okay.

23 MR. DENMAN: But the negative binomial
24 distribution is a distribution. It's not just this
25 mean.

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1 CHAIRMAN STETKAR: Where is that negative
2 binomial distribution documented in the report? I
3 didn't -- I missed it.

4 MR. DENMAN: I mean, we can try to find
5 that for you.

6 MS. GHOSH: Yes.

7 CHAIRMAN STETKAR: If you could, I'd
8 appreciate it. I mean, you know, we're going to
9 break for lunch sometime, so you don't have to try
10 to do it in real -- I'd really appreciate that
11 because I get what you're doing if I had seen it
12 described that way with that binomial distribution
13 for the aleatory variability in the number of
14 cycles given the -- and you're saying you selected
15 the same -- the same failure rate applies for all
16 of the valves. Right?

17 MR. DENMAN: Within a single MELCOR --

18 CHAIRMAN STETKAR: Within a single MELCOR
19 simulation.

20 MS. GHOSH: Right, right.

21 CHAIRMAN STETKAR: Huh. Okay.

22 MS. GHOSH: Yes, we should -- if we
23 haven't sufficiently documented it, we should --

24 CHAIRMAN STETKAR: Well, I missed it, but
25 I might have been hanging up too much, Tina, as you

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1 said on trying to --

2 MS. GHOSH: Composite --

3 CHAIRMAN STETKAR: Yes, compile everything
4 in my head, so maybe I missed something there.

5 MS. GHOSH: We'll take a look. Either it's
6 there and --

7 CHAIRMAN STETKAR: Just do it over lunch,
8 don't try to do it in real time.

9 MS. GHOSH: Yes. Okay, I see that it is
10 here, but yes, let's talk after --

11 CHAIRMAN STETKAR: Okay. The second
12 question I had then may relate to this, is why did
13 you take -- and you did this for both the primary
14 and the secondary valves. You took a -- at least on
15 the secondary side you explicitly implemented it.
16 It sounded like you tried to do it on the primary
17 side but it didn't work so good for some reason.

18 You said that you -- on the secondary
19 side, if fails stochastically -- this is for the
20 stuck open area fraction. Sample value of variable
21 SVOAFRAC was applied identically in the case of
22 safety valve 1, and in the case of safety valve 3,
23 but in the case of safety valve 2, the complement
24 of SVOAFRAC was applied. This was done to prevent
25 the unlikely physical situation where all three

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1 valves fail stochastically.

2 MS. GHOSH: Right. So this -- yes, this
3 was an unintended sampling that we first
4 implemented in our MELCOR. We had some discussion.
5 Initially, that -- the safety valve open area
6 fraction was modeled as an epistemic uncertainty
7 and that every time the valve failed you would
8 always fail with a certain percentage open area
9 regard -- but in reality we don't think that mimics
10 reality, that it's more -- it has an aleatory
11 aspect to it.

12 CHAIRMAN STETKAR: Sure.

13 MS. GHOSH: So we unintentionally were
14 applying the same safety valve open area fraction
15 to every single failed valve in the system, and we
16 didn't mean to do that.

17 CHAIRMAN STETKAR: Okay.

18 MS. GHOSH: We found this very late in the
19 process, so that's why we created this workaround.
20 It's not really what we wanted to do.

21 CHAIRMAN STETKAR: Yes, but logically I
22 don't understand why your -- but you're treating --
23 I could understand treating SVOA -- I get hung up
24 on the alphabet soup. The open fraction as we're
25 just discussing an aleatory uncertainty for each

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1 valve independently for that particular epistemic
2 realization of the failure rate.

3 MS. GHOSH: Right.

4 CHAIRMAN STETKAR: But I don't understand
5 why you need to take the complement of that --

6 MS. GHOSH: Yes.

7 CHAIRMAN STETKAR: -- aleatory failure
8 rate for one particular valve to avoid some
9 undesired condition.

10 MS. GHOSH: Right.

11 CHAIRMAN STETKAR: I don't understand what
12 undesired condition you get.

13 MS. GHOSH: The -- if we did it again, if
14 we do it again we're not going to do it this way.
15 This was a fix to a problem that was discovered
16 very late in the process.

17 CHAIRMAN STETKAR: But what kind of -- I
18 mean, physically, if I step way back from all of
19 the math.

20 MS. GHOSH: Yes, sure.

21 CHAIRMAN STETKAR: Physically what kind of
22 problem were you running into?

23 MS. GHOSH: So we sampled a 10 percent
24 open area for the safety valve fraction.

25 CHAIRMAN STETKAR: Okay.

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1 MS. GHOSH: If you have the first valve
2 let's say on the pressurizer fail at a 10 percent
3 open area, it's very likely you're going to start
4 cycling the second valve. If you've modeled it as
5 an epistemic uncertainty now the second valve
6 cycles and gets stuck, is going to fail at some
7 point, get stuck at 10 percent open area. You can
8 create -- then the third valve starts cycling, also
9 gets stuck at a 10 percent open area. You can get
10 into a situation where the team judged was very
11 improbable that you stuck open all your safety
12 valves in an almost closed position.

13 CHAIRMAN STETKAR: And the problem with
14 that is --

15 MS. GHOSH: We don't think it's --

16 CHAIRMAN STETKAR: -- because it's not
17 very likely?

18 MS. GHOSH: Right. It's a combination of
19 we don't think it's very likely that all of the
20 safety --

21 CHAIRMAN STETKAR: But wouldn't the
22 uncertainty distributions -- are you now talking
23 about the version of the model which assigned a
24 particular value, or are you talking about a
25 version of the model where that open fraction is

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1 actually applied as an aleatory uncertainty?

2 MS. GHOSH: Right. So the error we
3 discovered very late in the game was that we were
4 sampling and applying the open area fraction value
5 as an
6 epistemic --

7 CHAIRMAN STETKAR: Right, and I can see
8 how you can get --

9 MS. GHOSH: -- across the globe.

10 CHAIRMAN STETKAR: Sure.

11 MS. GHOSH: We didn't mean to do that.

12 CHAIRMAN STETKAR: Right, so --

13 MS. GHOSH: So we devised a workaround
14 that we would not use again because we're not
15 advocating that it should be modeled this way.

16 CHAIRMAN STETKAR: Yes.

17 MS. GHOSH: But in order to avoid a
18 nonphysical situation we devised this workaround
19 kind of as a interim solution because --

20 CHAIRMAN STETKAR: When I -- let me stop
21 you to make sure I understand what the workaround
22 is doing.

23 MS. GHOSH: Yes.

24 CHAIRMAN STETKAR: The workaround is still
25 using though only a single value for that open

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1 fraction for --

2 MS. GHOSH: And --

3 CHAIRMAN STETKAR: It is not using the
4 aleatory distribution.

5 MS. GHOSH: No, and it creates an
6 artificial dependence of the second and third
7 safety valve open areas on the sample value for the
8 first pressurizer safety valve. So we artificially
9 created this dependence that you wouldn't do again
10 in order to avoid the nonphysical situation of
11 having all of the valves fail with a very --

12 CHAIRMAN STETKAR: Well, you said it's
13 nonphysical. Let's just say it is physically
14 possible but you don't believe the probabilities.

15 MS. GHOSH: Right. And that's --

16 CHAIRMAN STETKAR: I let the probabilities
17 say what they are.

18 MS. GHOSH: Yes. We think it's a very --
19 right. We think it's a very low probability
20 situation. We did do a sensitivity that we
21 documented in the report where we failed all the
22 valves closed just to see what would happen. But,
23 you know -- so the one thing we do say is in terms
24 of the open area fraction still shows up as very
25 important --

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1 CHAIRMAN STETKAR: Well, that's -- yes.

2 MS. GHOSH: I think if we had implemented
3 the sampling the way we intended but didn't achieve
4 it probably, if anything, would have increased in
5 importance.

6 CHAIRMAN STETKAR: Well, that's my concern
7 now, is -- I can -- I'll tell you, reading through
8 the report, I couldn't begin to understand what you
9 just described in five minutes.

10 MS. GHOSH: Okay.

11 CHAIRMAN STETKAR: The concern I have is
12 whether this kind of -- this workaround as you call
13 it which logically didn't make any sense when I
14 read it.

15 MS. GHOSH: Okay.

16 CHAIRMAN STETKAR: How that might affect
17 the overall results and conclusions, not only from
18 an overall risk perspective but in terms of the
19 uncertainty characteristics.

20 MS. GHOSH: Yes. If I could offer, in the
21 majority of the cases, and I forget the exact
22 percentage. I think it's close to 70 percent of the
23 time you only cycle that first valve so that's what
24 -- the behavior of the first valve is the most
25 important because you don't get up to the second

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1 and third.

2 CHAIRMAN STETKAR: Right. I get that. It's
3 still easier for me to think out on the secondary
4 side before we get into the primary side, because
5 the same workaround was applied, as I understand
6 it, on the secondary side with the safety valves
7 because the open fraction -- in fact, that's where
8 I ran into it first. It's discussed first for the
9 secondary safety valves.

10 MS. GHOSH: Yes.

11 CHAIRMAN STETKAR: I believe that's the
12 case. Am I -- tell me if I'm wrong.

13 MS. GHOSH: I think we only modeled one
14 valve, one safety valve for steam generator on the
15 --

16 CHAIRMAN STETKAR: That's true, but it
17 says -- I'll read you the quote that I found.

18 MS. GHOSH: Give a page number so --

19 CHAIRMAN STETKAR: Well, it's Section
20 41131. I don't have the page number here
21 immediately but it's only a couple of pages. And
22 this is talking specifically about the secondary
23 side. It says, "In applying SVOAFRAC given a
24 stochastic failure of a safety valve on the main
25 steam lines to close, the intention was to set the

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1 open area fraction of the failed lowest set point
2 valve on main steam lines A or C to the complement
3 of the sampled value of that fraction." Then says,
4 "To not affect all three steam generators with
5 identical safety valve failure position, open area
6 fraction for the lowest set point on main steam
7 line B given a fail to close was set to SVOFRAC."
8 So it's logic errors in the MELCOR model; however,
9 allowed valves on main steam lines A and C to fail
10 only in the fully closed position. Open area
11 fraction in the case of the lowest set point safety
12 valve on main steam line B was accomplished per
13 intention. So that tells me that some sort of
14 finagling of complement distributions was also
15 applied on the secondary side.

16 MS. GHOSH: Yes. I think that was a second
17 issue. Also, a separate issue on the secondary
18 side, but there were two loops that the valves
19 failed to close fully closed. And it wasn't
20 intended to be modeled that way. So we have one
21 steam generator --

22 CHAIRMAN STETKAR: But what -- you said it
23 wasn't intended to be modeled that way.

24 MS. GHOSH: Yes. But we still had the one
25 steam generator where we have the sampled open area

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1 fraction that was applied. And we evaluated what
2 the effect of that is; for example, actually one of
3 your earlier questions in terms of do you see a
4 difference, you know, a difference in how much, you
5 know, radionuclides get out for the open area
6 fraction? And we didn't see -- there wasn't a huge
7 difference as far as we can tell in terms of the
8 total release --

9 CHAIRMAN STETKAR: Well, the question is
10 would there have been if you had done the sampling
11 correctly? But the same motion of an aleatory
12 distribution --

13 MS. GHOSH: Right.

14 CHAIRMAN STETKAR: -- given an epistemic
15 realization, I'll call it that way.

16 MS. GHOSH: I think it would be worthwhile
17 for us to do a follow-up kind of mini UA kind of
18 sensitivity to test our -- what we believe to be
19 true at this point because we don't have enough
20 quantitative information to back up the specifics.
21 But we don't think it affects our results greatly,
22 and I think largely for the reason KC mentioned
23 earlier we have so many radionuclides getting out
24 through the leakage area that at the end of the day
25 that open area fraction on the secondary side

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1 doesn't contribute as much, if we hadn't had those
2 large, in some cases very large sampled areas for
3 the leakage on the secondary side.

4 MEMBER CORRADINI: Through the MSIV.

5 MS. GHOSH: Yes.

6 CHAIRMAN STETKAR: It's leakage through
7 the MSIV, yes.

8 MS. GHOSH: Yes.

9 CHAIRMAN STETKAR: I mean, that might be a
10 fortuitous -- well, fortuitous conclusion for this
11 particular model, but it --

12 MS. GHOSH: But I think it would be worth
13 following up with some kind of joint sensitivity
14 analysis to confirm that.

15 CHAIRMAN STETKAR: Are you going to
16 correct the math for Sequoyah? Has it been
17 corrected?

18 MS. GHOSH: We did correct it for
19 Sequoyah.

20 CHAIRMAN STETKAR: You did correct it. So
21 you are sampling --

22 MS. GHOSH: Yes.

23 CHAIRMAN STETKAR: -- the way we talked
24 about.

25 MS. GHOSH: Well, the way we intended.

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1 Right. We did correct it for Sequoyah.

2 CHAIRMAN STETKAR: Okay.

3 MR. WAGNER: I understand Sequoyah better
4 than Surry because it's more straightforward.

5 CHAIRMAN STETKAR: That wasn't too bad, it
6 was typical John ranting. But those were the basic
7 two issues, one was fidelity of the underlying data
8 that are used for all of the failure to open and
9 stuck open failure modes for the safety valves, and
10 then given the distribution, you know, how those
11 sampling algorithms were established in the models.
12 You still may want to better document that Section
13 41131 where it discusses these algorithms about
14 taking complements of the area fractions because I
15 certainly didn't get from that what you just
16 described.

17 MS. GHOSH: Oh, yes, we'll definitely look
18 at that again and see --

19 CHAIRMAN STETKAR: Okay.

20 MS. GHOSH: -- how we can better write it
21 up.

22 CHAIRMAN STETKAR: Sorry.

23 MR. WAGNER: Push on?

24 CHAIRMAN STETKAR: Push on.

25 MR. WAGNER: The decay heat cycle, the

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1 factor part cycle represents the time at cycle and
2 is varied from the beginning, the middle, and to
3 the end of the cycle. Cycle had an impact on a
4 number of things, including the radionuclide
5 inventory, so as there is more burnup the inventory
6 increases. And baseline decay heat curves were
7 developed for each cycle representative of BOC,
8 MOC, and EOC. For each realization, though, there
9 was a variation from the base decay heat curve
10 based on uncertainty in the decay heat
11 calculations.

12 The cycle directly affects the MELCOR
13 source term calculation through the decay heat, and
14 also through the amount of mass that is passed on
15 to MACCS. And cycle is the only parameter that has
16 this kind of dual status where it affects the
17 accident progression and it has a direct effect on
18 the inventories inside the MACCS calculation.

19 From a MELCOR perspective the decay heat
20 is the most -- one of the most important things.
21 And this shows what is the baseline BOC, MOC, and
22 EOC decay heat. The times were based on cycle 20,
23 we have good fuel data from Surry to do our origin
24 calculations. And BOC was selected as set days, MOC
25 was at 200 days, and EOC is at 505. And what you

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1 can see from this graph is that MOC starts
2 approaching EOC and there isn't a whole lot of
3 difference, and so the question came up how much
4 difference -- how long does it take for BOC to
5 approach MOC? We think that's about 30 days that
6 it's going to get into the vicinity qualitatively
7 of what an MOC looks like.

8 MEMBER CORRADINI: So what did SOARCA
9 originally do since this is new?

10 MR. WAGNER: They did an EOC --

11 MEMBER REMPE: That was a long time ago.
12 Earlier today you mentioned it, that was one of the
13 factors that did change the results a bit because
14 you'd done it a long time ago.

15 MR. WAGNER: Yes, and there was -- it was
16 based on origin calculation, but it's in support of
17 the high burnup program so it was kind of not the -
18 - it was biased a little high.

19 MEMBER CORRADINI: Higher than the red.

20 MR. WAGNER: Higher than the red. So that
21 would have been the original SOARCA, just a little
22 bit, not a whole lot.

23 MEMBER CORRADINI: Okay.

24 MR. WAGNER: The containment fragility,
25 some modifications were made on the -- how we

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1 interpreted and how we handled the containment
2 fragility going from SOARCA to the UA. And on the
3 right-hand side you can see how it was modeled, the
4 top graph is how it's modeled in the original
5 SOARCA, the lower one is how it's going to be --
6 how it was modeled for the Surry UA. They both are
7 based on interpretation of data from the One Six
8 Scale experiments that were done at Sandia, and a
9 method was developed to reconcile the scale, an
10 idealized nature and then above and beyond that
11 there was a 15 percent conservatism put on in that
12 their failure would shift all those values about 15
13 percent for things that were considered kind of a
14 stretch on how we interpreted the data.

15 Both original SOARCA and the UA use the
16 top three points for the -- once you get to gross
17 rebar failure what the leakage area might look
18 like. But what was changed was the onset of
19 leakage, and that became an uncertainty variable in
20 the UA where the first thing which is called the
21 liner yield, that was varied from -- across a span.
22 It's not actually on this plot but perhaps the
23 biggest difference between how SOARCA handled it in
24 the UA was the variability of that liner yield. So
25 I've got to flip back and forth once or twice here,

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1 so if you look at that lower graph, the lowest
2 point which is the start of large leakage, about
3 factor 10 larger than it is design leakage is the
4 liner yield. And that is the point that's going to
5 be varied. The best estimate was, or the
6 interpretation of the data with the conservatism
7 was around 1.55 for pressure ratio. And if we go to
8 the next slide we can see that that was varied all
9 the way down to design pressure up to the point
10 where the rebar yield would occur. So it was kind
11 of constrained between those two values. We didn't
12 think it should be less than design leakage, but it
13 could be delayed, liner yield could be delayed
14 almost as high as where we get the rebar fail, and
15 it all happened at the same time.

16 This effect combined with other sample
17 parameters such as the time of the cycle and the
18 nominal leakage is -- the UA realizations for
19 containment pressure remains lower for a longer
20 period of time because we get some leakage coming
21 out and we don't drive to the higher leakage areas.

22 MEMBER CORRADINI: So there's a leakage
23 rate that goes with the blue curve that is also
24 nonlinear? In other words, you're sampling -- I'm
25 trying to remember.

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1 MR. WAGNER: Yes.

2 MEMBER CORRADINI: So you would sample
3 here and say okay, I got a pressure. Am I leaking?
4 You go to the probability curve, it says at this
5 pressure, no, or yes. Then there's some leakage
6 rate at that pressure that's deterministic.

7 MR. WAGNER: Yes.

8 MEMBER CORRADINI: Okay.

9 MEMBER REMPE: When I read this in the
10 report, these 15 percent reductions, it talks about
11 there's always uncertainty in the approach when
12 you're going from the ones scaled down, but
13 basically you're making the assumption that
14 whatever you've done has resulted in something
15 that's conservative. And how do you know that it's
16 appropriate to assume that what you've done is
17 conservative versus non-conservative in the
18 approach? And again I'm not an expert in this
19 topic, so maybe it's --

20 MR. WAGNER: Me neither.

21 MEMBER REMPE: But if you can explain why
22 you know it's appropriate to assume it's
23 conservative?

24 MR. WAGNER: So the interpretation from
25 SOARCA moving onto the UA, that was the judgment of

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1 the team that looked at it. Conservative is the
2 wrong word, they said that that was appropriate to
3 kind of get the midline of the uncertainty that
4 they felt in the valuations from the One Six and
5 how we interpreted and changed the scale.

6 MEMBER REMPE: So there was some data that
7 led them to believe that it was conservative.

8 MR. WAGNER: Yes.

9 MEMBER REMPE: And that's why they had to
10 reduce it. Okay, that helps a little bit. Thanks.

11 MR. WAGNER: Ignition criteria. So this
12 was varied also, and in the base SOARCA
13 calculations we had -- used the default for
14 spontaneous burn which was 10 percent hydrogen
15 concentration. And we used the work of Kumar and
16 some of his experimental work to look at the lower
17 flammability limit. And based on the work of Kumar
18 it kind of depends on where the ignition occurs or
19 where the spark occurs on how much hydrogen you
20 need and oxygen in order to propagate the burn. And
21 there's some fantastic experiments that were run
22 where they have a sphere or a test chamber that you
23 look into and they put the spark source in
24 different locations and had different
25 concentrations of hydrogen and if you're burning

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1 upwards you only need about 4 percent hydrogen in
2 order for it to -- the spark to propagate and move
3 upward because it kind of follows the thermal loft
4 and the direction of the flame. You could have 4
5 percent concentration and move that to the middle
6 or the top and there's no propagation of the burn.
7 It just kind of fizzles out. You move that up to 7
8 percent and it kind of projects sort of
9 horizontally and upward, and so somewhere around
10 horizontal propagation is judged to be about at 7
11 percent. If you want to try and propagate downward,
12 say the ignition source which we treated as random
13 and unknown where its location was, it takes about
14 a 9 percent hydrogen concentration for the burn to
15 propagate downward.

16 All three of these were less but than
17 what was done in the original SOARCA, but they
18 represent the real flammability limit in a place
19 where ignition could go and propagate, and so we
20 sampled on those so we had cases where the default
21 ranged from the upward, the horizontal, to the
22 downward, and that would be in all cells inside the
23 model.

24 The hottest steam generator tube, this is
25 -- came up a little bit earlier. We had a separate

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1 effects model that was kind of inside the
2 calculation, and so based on the conditions that we
3 were seeing observed in the hot leg as we developed
4 the natural circulation flow we had a hot stream go
5 in and mix in the generator, go through the tubes
6 and come back, and we had a cold stream returning.

7 Chris Boyd's work on CFD characterized
8 what was the hottest spot for the plume going into
9 the steam generator, and he characterized that in
10 two different ways. One, if he said I'm going to
11 look at a given tube and figure out what is its
12 temperature as the CFD model was sort of jumping
13 around to different tubes as the hot plume moved
14 around, and he quantified at a given tube location
15 what would be the peak temperature that we might
16 expect for characteristic conditions. And then he
17 also looked at and non-dimensionalized it, and then
18 he looked at if we followed that flame around what
19 would that be? And so that was our source of data,
20 was based on the CFD model which goes back to
21 benchmarking. I believe you've had a number of
22 presentations on that maybe, goes back to the One
23 Seven Scale test and comparisons.

24 And finally, this is how we did the
25 regression evaluation for -- no, actually, yes,

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1 it's a regression evaluation for MELCOR.

2 MS. GHOSH: Yes, I can speak to this
3 slide, but unfortunately just last night he was
4 asking about how we looked at I guess some groups
5 of the results.

6 MR. WAGNER: Okay.

7 MS. GHOSH: Anyway, we can -- I guess just
8 the table kind of summarizes it. We did multiple
9 sets of regressions and different ones for the
10 different metrics, the different figures of merit
11 that we were looking at in terms of the MELCOR
12 results. We knew that for -- when we looked at the
13 whole set of realizations, because the steam
14 generator tube ruptures led to the order of
15 magnitude higher release magnitudes that often
16 ended up dominating the entire -- the results for
17 the entire set, and we thought may mask some of the
18 things that would show up important if we looked
19 at, you know, the non-steam generator tube rupture
20 group. So we wanted to look at both all
21 realizations but also the group of just steam
22 generator tube ruptures alone, and then the group
23 of non-steam generator tube ruptures by themselves
24 to see what pops up as important when for if you
25 don't get to a steam generator tube rupture,

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1 they're still variations in behavior and what pops
2 up as important.

3 And in addition to that since for the
4 first time in this study we looked at the time at
5 cycle, we knew that the things that might be
6 important for beginning of cycle may be different
7 than what's important at middle or end of cycle, so
8 we also did regression the subset of results for
9 the beginning of cycle, middle of cycle, and end of
10 cycle to see what might be different variations in
11 that. And, you know, the beginning -- what ends up
12 being important to beginning of cycle, you know, is
13 different from what ends up being important to end
14 of cycle. And I guess that's expected but we wanted
15 to see what types of things would pop out if we
16 looked at subsets of the data. I think that was my
17 last -- yes?

18 MEMBER REMPE: I'm not quite sure how to
19 ask this, but where I think Mike was going about
20 the crosswalk, and where I was kind of pointing out
21 about the natural circulation. With respect to
22 what's been predicted for Fukushima in MAAP versus
23 MELCOR, a lot of it's embedded in assumptions with
24 respect to this filling or the way the melt
25 relocates in the core and the hydrogen production.

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1 And so although a lot of the sensitivity -- I
2 believe you that your regression analysis is
3 showing these things, but there's still some
4 assumptions based on lack of knowledge embedded in
5 the code that are difficult to quantify. And I --
6 it's just a comment, and I mean, you all are
7 struggling with that problem.

8 MS. GHOSH: Right. I think that's fair,
9 and any results that we're teasing out are based on
10 what we've thrown into the pot.

11 MEMBER REMPE: Right, I know.

12 MS. GHOSH: There are things we didn't
13 throw into the pot, so everything is always
14 predicated on the set of -- the scope of our world
15 which does not include --

16 MEMBER REMPE: We don't know.

17 MS. GHOSH: Yes.

18 MEMBER REMPE: Yes, it's just a situation.

19 MS. GHOSH: I think that was our last
20 slide for this section.

21 CHAIRMAN STETKAR: Are you going to do the
22 tube thickness?

23 MS. GHOSH: Do you want --

24 CHAIRMAN STETKAR: Ron is not here. Let's
25 bring that up after lunch, issues with the tube

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1 modeling, thickness, cracking.

2 MS. GHOSH: Okay, yes.

3 CHAIRMAN STETKAR: Because Ron and you
4 need to engage.

5 MEMBER BLEY: Yes. John was focused on the
6 modeling as you got to the end of that story on the
7 safety valves, and I didn't bring it up then but I
8 wanted to now.

9 I just don't buy the distribution you
10 came up with. You give some arguments about how the
11 valves work, how it might hang, what might happen,
12 and those are pretty good. And then you say but I
13 don't have any basis for a quantifiable likelihood
14 so I'll just draw a straight line, I'll assume a
15 uniform distribution. You gave arguments and I've
16 seen it. When the safety valves pop open, they bang
17 open, and sometimes they cock when they do that,
18 and sometimes they stick wide open. I've seen it
19 happen. Sometimes after they shut down they'll
20 weep. I doubt you care about weeping, but maybe you
21 do. From your story and from what I've seen, and
22 your discussion of the thermal side, too, I think -
23 - and if you've gotten a valve person, maybe call
24 Crosby and talk to him, they might have had some
25 ideas here, too. I think a distribution that has a

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1 real high chance of wide open and a fairly
2 reasonable chance of weeping if you care about
3 that. I would be tempted to ignore that and
4 extremely low chance of hanging somewhere in
5 between. I just don't think those happen. My
6 experience isn't enough to say they never happen,
7 but as you're shutting down it's a more smooth
8 process. And sometimes when they hang open they
9 then go shut after banging around and shaking for a
10 while, or if somebody hits them with a hammer. I'd
11 hate for him to do that. But I just think it's a
12 really funny distribution, and I think you give
13 enough arguments about how they work that you could
14 do better. I know we drove you to do uncertainties
15 but I think that one you didn't think through even
16 with the arguments you gave, so I don't quite get
17 it.

18 CHAIRMAN STETKAR: Even with -- and I know
19 -- since you gave me the open, I'll follow-up on
20 it. I completely agree with Dennis on the uniform
21 distribution for what you call the stochastic stuck
22 open failure mode. It doesn't make much sense, and
23 it doesn't seem that you really discussed it with a
24 valve person.

25 There's also a more -- there's more

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1 discussion in the report on the stuck open fraction
2 for thermal-related failures which you say well, we
3 used the uniform distribution. But if I read --
4 when I read that I said well, gee, it sounds like
5 the people you talked to would advocate a
6 distribution that sounds more like what Dennis is
7 talking about, a higher probability of it being
8 open or higher probability of it being only
9 slightly open with a low probability that it's
10 stuck somewhere midway. You then say well but, you
11 know, we didn't have any thermal demands on the
12 valves anyway, so it doesn't make any difference.

13 Well, the part of this that I'm sensitive
14 to is that you are now enshrining forever the NRC
15 accepted not only methods but data that people will
16 use. And people will point to these distributions
17 and say the NRC spent bazillions of taxpayer
18 dollars, licensee dollars if any licensees are
19 listening out there, and they judged that this is,
20 indeed, the distribution that shall be used,
21 regardless of whether or not you actually ever have
22 a thermal demand, you know, a demand that exceeds
23 the thermal rating on those safety valves. And, in
24 fact, regardless of whether or not in a practical
25 sense the stuck open area fraction, at least on the

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1 secondary side, I don't have a good sense of what's
2 going on on the primary side, but regardless of
3 whether that fraction really contributes much to
4 your overall conclusions in this particular study
5 of the releases. So paying attention to some of
6 those things is worthwhile.

7 MS. GHOSH: Yes, thank you for the
8 comment. I think we can work on improving the
9 discussion about parameter. It certainly one we
10 talked about a lot and struggled with, and went
11 back and forth. You know, I don't know if you
12 remember the early Peach Bottom days we had talked
13 about sampling the open area only for thermal
14 seizure and for stochastic failures just assuming
15 it blows open and it's --

16 CHAIRMAN STETKAR: Yes.

17 MS. GHOSH: You know, we changed our
18 thinking this time around, and we modeled more
19 valves. You know, we --

20 CHAIRMAN STETKAR: You did, but see the
21 problem is you made your MELCOR-type models a lot
22 more sophisticated, but then just sort of spray
23 painted something in there that doesn't necessarily
24 sound like it's well justified based on experience.

25 MS. GHOSH: And having the open area

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1 fraction, yes.

2 CHAIRMAN STETKAR: Yes.

3 MS. GHOSH: Okay.

4 CHAIRMAN STETKAR: I don't know whether
5 different distribution -- how or whether a
6 different distribution would affect the overall
7 results very much. I don't know, but at a different
8 level one ought not to make conclusions about
9 having something that is not justified simply
10 because you don't think it makes any difference.

11 MEMBER SKILLMAN: I would like to add that
12 about 25 years ago this issue of safety relief
13 valve or safety valve performance became a very
14 significant topic in the industry. In fact, it was
15 one of the triggers for reporting from the plants
16 to the NRC and the INPO of OE, so I would think
17 that there is a very solid database of safety valve
18 performance. Years ago these things would lift.
19 What we learned is that they weren't adjusted
20 properly and the blowdowns were much greater than
21 anybody anticipated. What happened was that the
22 owners began to get very serious about adjustment
23 of the blowdown rings so that the blowdown
24 percentages were what they should be for the
25 analyses for the plants. I would think that there's

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1 data here at the NRC for the performance of these
2 valves, but I know that INPO has the data because
3 industry was reporting all of these events so that
4 there's probably a goldmine if you were to tap into
5 it.

6 MR. WAGNER: From the perspective of the
7 thermal-hydraulic response, and to the timing of
8 MELCOR, there's not a whole lot of difference
9 between 50 percent and 100 percent. It
10 depressurizes --

11 CHAIRMAN STETKAR: That's okay, but the
12 problem is if you put a uniform distribution in
13 there and you run 1,200 samples of which you get
14 1,000, there's a measurable chunk of probability of
15 it being less than half open, of being, you know,
16 where a different probability distribution, one
17 that is high likelihoods of being very open or not
18 open very much would give you a much different set
19 of samples. Now if the difference doesn't make any
20 difference, let the analyses show that, don't try
21 to justify something that might be fundamentally
22 not physical ---

23 MR. WAGNER: That's probably why we did
24 the zero to one, was we were afraid to miss
25 something that we maybe didn't know, but I hear

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1 your arguments that maybe valve people would have
2 steered us in another direction.

3 CHAIRMAN STETKAR: Certainly for a
4 different -- well, I don't want -- I'm not a valve
5 person, but a different shape of the distribution,
6 rather than saying there's an equal likelihood that
7 it's 37.265 percent stuck open, as it is 99.38
8 percent stuck open.

9 Anything more for Tina and KC? If not,
10 let's recess for lunch, and I'm going to be a hard
11 taskmaster. Let's come back at 1:15, please.

12 (Whereupon, the above-entitled matter
13 went off the record at 12:18 p.m. and resumed at
14 1:17 p.m.)

15 CHAIRMAN STETKAR: We are back in
16 session. We're going to hear about MACCS this
17 afternoon first.

18 MR. BIXLER: All right. First of all,
19 I'm Nate Bixler from the Sandia National Labs. Can
20 you all hear me okay? This mic is working?

21 (Off microphone comment.)

22 MR. BIXLER: Okay, now it's on. Okay.
23 So my conclusion from this morning's session is
24 that I'm sure glad there are no valves in MACCS.

25 MEMBER CORRADINI: But there's weather.

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1 MR. BIXLER: There's weather. Yes, I
2 don't know if that's a winning situation. Maybe I
3 come out behind.

4 (Off microphone comment.)

5 MEMBER BALLINGER: --the last couple of
6 weeks.

7 MR. BIXLER: Okay. This is kind of an
8 overview picture of some of the functions in MACCS,
9 broken into core or three main modules, ATMOS,
10 EARLY and CHRONC. ATMOS does the Atmospheric
11 Transport and Dispersion; EARLY does the emergency
12 phase. So it's handling the emergency response of
13 individuals who are usually described as being in
14 cohorts, and then CHRONC does the long-term phase
15 and looks at the longer term remedial actions in
16 doses, and all together we calculate that doses and
17 health effects, risk developed effects and things
18 like that.

19 MACCS right now is based on a dispersion
20 model. We've referred to it as a plume segment
21 model because we have a number of plume segments.
22 Each has a front and each has a back, and usually
23 we make those our alarm plume segments. We can
24 model up to 200 of them.

25 MACCS treats radioactive decay and

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1 ingrowth, and it -- as we just said or someone just
2 said a minute ago, it treats the aleatory
3 uncertainty from random weather. So that's part of
4 the calculation, and we'll talk a little bit about
5 that as we go through the slides.

6 Okay. This is a picture to help
7 illustrate the idea of emergency response. During
8 the emergency phase, we model evacuation,
9 sheltering. Sheltering would normally precede
10 evacuation, so it's really the opposite order.

11 Potentially KI ingestion to reduce the
12 amount of exposure from radioiodine from
13 inhalation, and we also have another type of action
14 that we can model, which is called relocation. I
15 think there's a bullet on relocation here. That's
16 the bottom one, so I'll wait until I come to that.

17 Evacuation speeds and evacuation
18 directions can be developed, and they're usually
19 based on ETEs that each plant has to publish. We
20 can have up to 20 cohorts but in both Surry and
21 Peach Bottom for the purposes of doing the SOARCA
22 analyses we define six cohorts, and those are the
23 same basically as the ones in the original SOARCA
24 work that we used for the uncertainty analysis as
25 well.

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1 Each cohort can have its own unique
2 response. So typically we'll have the large body
3 or the large part of the public as one cohort,
4 maybe a tail as another cohort. Special facilities
5 might be their own cohort etcetera, and each of
6 those can have their own unique response
7 characteristics.

8 As far as relocation of the public,
9 that's treated differently in MACCS than
10 evacuation. Evacuation is triggered generally by a
11 declaration of an emergency at a plant, and it's
12 done regardless of -- with no knowledge
13 necessarily of what the release is going to look
14 like.

15 Relocation is done on the basis of dose
16 projections. So that typically happens on a slower
17 time frame, takes a little longer to occur. In
18 MACCS we have two types of relocations. One is
19 called hot spot relocation; the other is called
20 normal relocation. The idea is, and you can
21 collapse those into just one set of relocation
22 parameters if you want.

23 But you can try to -- as a user, you can
24 try to prioritize that folks with a dose projection
25 of a higher dose would receive priority treatment

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1 over those who are projected to get a lower dose.
2 So that's the idea for that.

3 Okay. These are the MACCS parameters
4 that we made uncertain in the Surry work, and
5 basically it's almost the same set as we had as
6 uncertain parameters in the earlier Peach Bottom
7 study. There are a couple of deposition parameters
8 for wet deposition and dry deposition.

9 Dry deposition, we usually have ten
10 aerosol bins and each of those has its own
11 deposition velocity that characterize the influence
12 on aerosol size on the way it deposits. We have a
13 couple of dispersion parameters for cross-wind and
14 vertical dimensions, a couple of shielding factors,
15 one for ground shine and one for inhalation that
16 characterize how much shielding or protection a
17 person would get from the direct exposure to the
18 plume.

19 The baseline is direct exposure to the
20 plume. The shielding factor is scale that exposure
21 down to be what might be more realistic. One thing
22 that we included in the earlier Peach Bottom study
23 that we didn't include here is uncertainty in the
24 shielding factor for cloud shine.

25 Cloud shine turns out to only contribute

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1 typically something like one percent of the total
2 dose through the ground shine or the cloud shine
3 pathway. So we didn't consider it to be -- we did
4 consider it earlier in the Peach Bottom work, but
5 decided to drop it as a parameter here.

6 There are several parameters that affect
7 latent health effects. I won't go into each of
8 those. We'll talk about them later. Early health
9 effects also. Early health effects turn out not to
10 be very important in this uncertainty analysis
11 because there's essentially no early health
12 effects. So these parameters tend to turn out not
13 to have much impact on the answers that we get.

14 Also we looked at a set of emergency
15 response parameters that are listed here,
16 evacuation delay and speed, hot spot and normal
17 relocation times, hot spot and normal relocation
18 dose as uncertain, and we'll talk about some of
19 those. Finally, weather is the single parameter
20 that we treat as being an aleatory uncertainty, and
21 we'll talk in a little bit of detail about how the
22 weather sampling works.

23 Okay. So for ground shine, that's our
24 first -- the first set of parameters that we're
25 going to talk about, these are the curves that we

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1 use to describe them. There are separate curves
2 for normal activity, for sheltering and for
3 evacuation. The trend is that sheltering is always
4 the lowest normal activity, somewhere in between,
5 and evacuation is the highest.

6 Generally those are bounded by zero on
7 the bottom side and one on the top side. Ground
8 shine is particularly important because while it
9 turns out to have -- to represent more than 50
10 percent of the total doses that are received from
11 an accident, 75 percent is probably kind of a
12 common number that you would expect to get through
13 the ground shine pathway.

14 So it's definitely very important, and
15 the ground shine shielding factor directly -- it's
16 a direct multiplier that affects how much dose a
17 person would potentially get from ground shine.
18 There are several things that we're trying to
19 account for when we make the ground shine shielding
20 factor uncertain.

21 Those include the amount of time spent
22 indoors versus outdoors; the amount of shielding or
23 protection that a person gets from being in a
24 house, depending on the construction of the house
25 and so forth, and also deviations from the -- from

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1 an infinite, the flat plane.

2 The dose conversion factors for ground
3 shine are calculated as though a person is standing
4 on an infinite flat plane with a uniform
5 concentration, ground concentration surrounding him
6 or her. So obviously that's not the real
7 situation.

8 We have at least small variations in the
9 ground around us, and we have buildings and other
10 structures, a whole variety of things that might
11 offer some level of protection from the simple
12 assumption that is used in creating the dose
13 conversion factor.

14 Oh, one thing that this slide doesn't
15 mention is that the dose conversion factors
16 themselves are also uncertain, and that's not
17 folded into the curves that are shown here on this
18 slide. But ultimately we did include uncertainty
19 in dose conversion factors for ground shine doses,
20 and we folded that together with the other
21 uncertainties and made a modified set of curves
22 that account for that as well.

23 Okay. The next slide here shows the
24 uncertainties in the cancer fatality risk factors.
25 The way we calculate cancer fatalities in MACCS is

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1 we start out by calculating individual organ doses
2 for eight types of health effects, and then each of
3 those organ doses is multiplied by a risk factor to
4 estimate what the potential for -- the potential
5 risk for cancer is.

6 The results that I'm going to present
7 today are all based on a linear no threshold dose
8 response assumption. So we're going to assume that
9 there are effects of receiving a dose all the way
10 down to infinitesimal doses. Okay, let's see. The
11 risk factors that we used --

12 MEMBER BLEY: Not that I want to pursue
13 it any further, but since we're treating
14 uncertainties in all other places, did you think
15 about treating uncertainties in dose response
16 models, and what led you to just use the --

17 MR. BIXLER: Well in the report we
18 discuss three different dose response models, so
19 those are included in the report. I don't think I
20 have any of those results to show in the slides for
21 today. But if you read the report or look through
22 it, you'll see that there are other dose response
23 models that we considered.

24 That's certainly a large form of
25 uncertainty. Up to -- at this point we haven't

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1 included it as an uncertain parameter. I think it
2 could be. Some of the health physics folks don't
3 like that idea and have discouraged us from doing
4 it. But it seems to me that it's a legitimate
5 uncertainty that maybe we should be modeling.

6 MEMBER BLEY: Well can you -- are they
7 here?

8 MR. BIXLER: Who, the health physics
9 folks?

10 MEMBER BLEY: Yeah. I wonder why they
11 don't like considering it. Is it just that so you
12 won't get the argument with people who say that's
13 drastic?

14 MR. BIXLER: I don't know, to tell you
15 the truth. I'm not sure what the thinking behind
16 that is. They think it's completely fine to
17 consider it as a parameter uncertainty separated
18 from the overall uncertainty, where you just make
19 different assumptions on the dose response model
20 and present the results, and that's what we've
21 done.

22 MEMBER CORRADINI: You just use a
23 different supposition versus linear?

24 MR. BIXLER: Yeah, yeah. It's a
25 different model for how health effects are induced

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1 by receiving doses.

2 MS. GHOSH: Yeah, we have two alternate
3 models. It's the same ones we had in the base. I
4 think it's -- we used the same two alternate models
5 that we used in the base, the original SOARCA study
6 as well as the Peach Bottom UA.

7 MR. BIXLER: Yep, that's true.

8 MS. GHOSH: So they're, yeah.

9 MEMBER BLEY: I know we're not planning a
10 follow-on, well except the next study maybe. I'm a
11 little curious about their arguments as to why they
12 don't think it should be built into the overall
13 uncertainty calculation.

14 MS. GHOSH: Yeah, we don't have the right
15 people here to engage on that topic.

16 MR. BIXLER: Yeah. I'm sure I'm not the
17 right person to represent that argument. So I
18 don't think I would want to even give it a shot.

19 MEMBER SKILLMAN: Nate, what is residual?
20 I understand all the organs, but I don't understand
21 residual.

22 MR. BIXLER: That's a good question.
23 Okay. So the way we model the cancers, as I
24 mentioned, is by looking at specific doses to
25 different organs and modeling specific cancer

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1 types. For example leukemia is associated with a
2 dose to the bone marrow, etcetera. You can think
3 of an organ that goes with each of these types of
4 cancers.

5 But there's a bunch of cancers left over.
6 We only have seven specific cancer types that we've
7 modeled. So whatever is left over we've modeled as
8 residual cancers, and we've associated those with a
9 dose to the pancreas as a kind of a surrogate
10 tissue to represent soft body tissues in general
11 that would be responsible for the other types of
12 cancer not specifically included in the list. So
13 that's the idea.

14 MEMBER SKILLMAN: So that would be a DDE?
15 That's a deep dose equivalent. It's an organ dose.

16 MR. BIXLER: Yeah.

17 MEMBER SKILLMAN: All right, thank you.
18 Got it.

19 MR. BIXLER: Okay. All of this is based
20 on BEIR V. BEIR VII is out now. We haven't at
21 this point updated the BEIR VII because not all the
22 pieces of the model are really -- are really put
23 together to go with a BEIR VII type model. So
24 we've stuck with a slightly older document, BEIR V,
25 and we got Keith Eckerman, who's considered an

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1 expert in this area, to put together the curves for
2 us for how they -- the uncertainties for each of
3 the organs that are displayed here on the plot.

4 The triangles, and you'll see this on
5 subsequent slides too, represent our SOARCA,
6 original SOARCA estimate for each of those
7 uncertain parameters. So those are the values that
8 we used in the original SOARCA study. They're not
9 necessarily right at the 50th percentile, but those
10 are the ones that you would get straight out of
11 BEIR V if you go and interpret the information
12 there.

13 Okay. Along with the cancer risk
14 factors, what goes along with that is thing called
15 DDREF. DDREFA is the term that we use in MACCS.
16 It stands for dose and dose rate effectiveness
17 factor. The idea is that, and this comes out of
18 BEIR V, is that for larger doses, you use the doses
19 themselves for calculating cancer risk.

20 For the smaller ones below the one
21 recommended by BEIR V is 0.2 Sieverts, 20 rem.
22 Below that dose threshold you divide by DDREFA. So
23 basically the linear on threshold model that you
24 think of is not really completely linear. It has
25 two slopes, one for low dose rate and a higher

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1 slope for higher dose rate.

2 So we employ that part of the BEIR V
3 model as well in what we do in MACCS. There are
4 two different curves here. One for all of the
5 organs other than breast, and then a separate one
6 for breast. They each have their own
7 distributions. The nominal value is one and two
8 for those two types of tissues, and that's what's
9 recommended in BEIR V. But here we accounted for
10 uncertainty on those parameters as well.

11 Okay, the next parameter is dry
12 deposition velocity. As I mentioned earlier, there
13 are ten of them representing the ten different
14 aerosol bins that we get straight out of a MELCOR
15 analysis. That's a user choice, but I think that's
16 the default in MELCOR is to have ten aerosol sized
17 bins.

18 So for each of those bins, we define a
19 deposition velocity. The median value on those
20 curves is taken from expert elicitation data that
21 was performed by NRC and CEC back in the 90's. But
22 for this study, we decided that the distributions
23 that they had prescribed were too wide, too broad.

24 What we realized is that the original
25 expert elicitation was soliciting day or hour by

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1 hour variations that you might get in deposition
2 velocity, whereas what we wanted to do is apply a
3 value or a set of values for a whole year's worth
4 of weather data.

5 It wasn't really fair to include all of
6 the uncertainty in the expert elicitation data, if
7 you're applying the same exact value for a whole
8 year's worth of weather trials. For one thing, you
9 would bias -- the means for a year would be too
10 broad. They would not be representative of what
11 you would really expect.

12 So we modified the distributions. We
13 made some arguments and judgments in the report
14 that describe what we thought was reasonable to do
15 and used that instead. Okay. So that's one
16 departure from the earlier Peach Bottom work, by
17 the way, is that we used a narrower distribution.

18 CHAIRMAN STETKAR: Nathan?

19 MR. BIXLER: Yeah.

20 CHAIRMAN STETKAR: The argument that you
21 made regarding well, the uncertainties were too
22 broad from the expert elicitation because you felt
23 they were too broad for a representative value to
24 be applied over an entire year's worth of data.
25 That similar type of argument is made in several

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1 areas for reducing the uncertainty.

2 I quite honestly don't understand that.
3 So can you explain it in sort of layman's terms
4 about why that is?

5 MS. GHOSH: I'll take a crack at it, and
6 then you can elaborate.

7 CHAIRMAN STETKAR: Sure, go ahead.

8 MS. GHOSH: I think that when we went
9 back to the documentation of what the experts were
10 providing in the elicitation data, Nate's already
11 said this. I'll just say it in a different way.
12 It seems that they were also considering the
13 weather variations and their impact that we
14 explicitly considered in our weather variation
15 portion of the modeling, also in their described
16 description for this parameter.

17 So we wanted to -- we felt that in the
18 original implementation we were in fact double-
19 counting some of that uncertainty by applying their
20 distributions, where part of that variation was
21 meant to account for the weather. Wherein the
22 MACCS approach, we're also explicitly accounting
23 for the weather variations.

24 CHAIRMAN STETKAR: Okay. Let me probe
25 that a little. I get that.

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1 MS. GHOSH: Yes.

2 CHAIRMAN STETKAR: For some of the
3 parameters. How would it apply to this, because
4 they were somehow accounting -- this is a dry
5 deposition velocity.

6 MR. BIXLER: One of the things they were
7 accounting for was variation in aerosol size,
8 because at that time that the expert elicitation
9 was done, most people were modeling all aerosols as
10 being a single size, as though they could all be
11 collapsed into a single definition for --

12 CHAIRMAN STETKAR: So they only had a
13 single distribution for velocity, a single
14 distribution for the uncertainty in the deposition
15 velocity?

16 MR. BIXLER: To account for all --

17 CHAIRMAN STETKAR: To account for any
18 size aerosol?

19 MR. BIXLER: No. They had aerosol size
20 as a parameter, but they realized that people would
21 -- the way people would use that distribution is
22 they would use the size of the aerosol that they
23 were providing to you as a mean for what was really
24 an aerosol distribution.

25 So they were only treating the mean of

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1 the aerosol distribution -- mean size of an aerosol
2 distribution as a parameter, and they gave you the
3 information that would allow you to vary that size,
4 but not to account directly for deposition
5 velocity.

6 CHAIRMAN STETKAR: And what does that
7 have to do with average over an annual weather?

8 MR. BIXLER: Yeah. I think -- actually,
9 I think I misspoke. I mean the annual weather
10 really applies more to what I'll get to in just a
11 minute, which is dispersion.

12 CHAIRMAN STETKAR: Right. That's --

13 MR. BIXLER: Okay. So yeah, so that's a
14 different thing. Here, I think the reasoning is
15 that the intention of these distributions is that
16 you would use a mean aerosol size to characterize
17 all of the aerosols that you were modeling --

18 CHAIRMAN STETKAR: Which you have done
19 here?

20 MR. BIXLER: Pardon?

21 CHAIRMAN STETKAR: Which you have done
22 here?

23 MR. BIXLER: We're using -- no. We're
24 using ten bins. So we're modeling different
25 aerosol sizes as having their own deposition

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1 velocity.

2 CHAIRMAN STETKAR: But I thought you told
3 me -- I asked you originally, maybe not well
4 enough, did they have only a single uncertainty
5 distribution for dry deposition velocity that
6 applied to all aerosol sizes, any aerosol size?

7 MR. BIXLER: In a sense, yes. They
8 characterized variations in the mean but not -- the
9 intention was not to characterize the actual
10 distribution itself.

11 CHAIRMAN STETKAR: But the distribution -
12 - that's like the ground mean?

13 MEMBER BLEY: Yeah.

14 CHAIRMAN STETKAR: Which 30 years ago
15 caused us problems in failure rates.

16 MR. BIXLER: But the intention was that
17 you would pick a --

18 MEMBER BLEY: Going back to way Tina
19 described it, after you did this, it sounds kind of
20 arbitrary. We just shrunk them a bit to cover
21 that. If you go back and play it against the
22 weather and particle sizes and see if you've kind
23 of covered their intent in those elicitations, or
24 is it just since we were doing those separately, we
25 now just felt knocking it down by a factor ought to

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1 be kind of okay?

2 MR. BIXLER: We didn't go back and do any
3 comparisons with the original data, to see how that
4 would have played out. But so to do that, I think
5 we would have had to have varied the -- to do -- to
6 faithfully do what expert elicitation had intended,
7 we would have needed to use just a single size --
8 single aerosol size, one of these curves from the
9 set of curves that we used, and then use that --

10 MEMBER BLEY: So faithfully, you know,
11 you could do like a back of the envelope and say
12 well we covered these weathers and covered these
13 sizes and then with this distribution, we're kind
14 of mapping roughly what they were intending
15 because, you know, they were the experts --

16 MS. GHOSH: I guess we haven't done that
17 yet, but it's a good -- it's a good suggestion.

18 MR. BIXLER: I'm not -- I'm just trying
19 to think of myself how I would even go about doing
20 that. I'm not sure how I would do it. It's not
21 clear to me how I would go back with the model that
22 we used being different than the older models,
23 where you just have --

24 MEMBER BLEY: If I ask it another way,
25 what gives you confidence this reduction that you

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1 did is a reasonable thing to do, given what you
2 were trying to accomplish?

3 MR. BIXLER: It adequately captures the
4 experts' state of knowledge on certainty about the
5 phenomenon.

6 MEMBER BLEY: But did you go back to the
7 experts and show them what you've done and said
8 gee, given what we're doing here, does this kind of
9 makes sense, to even a few of the experts just to -
10 -

11 MR. BIXLER: We have -- we did get some
12 feedback from one expert, and I think he was one of
13 the ones who originally contributed to this, Steve
14 Hanna, and he told us that our distribution was too
15 broad, the one that we had used for Peach Bottom.
16 That was part of the motivation for reducing --

17 MEMBER BLEY: After he saw how you were
18 modeling it?

19 MR. BIXLER: Yeah. After he looked at
20 what we were doing and what the results looked
21 like, he thought that we -- our distribution was
22 way too broad, and that we should rethink it, so we
23 did.

24 MEMBER BLEY: You saw that, but did you
25 rethink this is what I'm asking?

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1 MR. BIXLER: We put thought into it. We
2 looked at the different types of things that would
3 lead to uncertainty, the different mechanisms.
4 Things like particle density, shape factors, a
5 variety of things like that that would potentially
6 give you a different deposition velocity, and we
7 specifically included things that we thought should
8 be included, and excluded things that we thought we
9 were already accounting for separately and should
10 not be included. So I think if you read that
11 section of the report --

12 MEMBER BLEY: That sorts of makes me feel
13 a little better.

14 MR. BIXLER: Okay.

15 MEMBER BLEY: And I didn't study that
16 section in detail.

17 MR. BIXLER: Yeah, that is described. I
18 think it's documented pretty well in the report.
19 So if you look that over, hopefully that will
20 answer your questions.

21 CHAIRMAN STETKAR: Nathan, let me ask you
22 what I hope is just a really simple, silly
23 question. But I have to. On this plot, and in
24 fact in the supporting table of the distributions,
25 I note that the dry deposition velocity for a .29

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1 micron aerosol is less, lower, than the dry
2 deposition velocity for a .15 micron aerosol.

3 There's a statement in the study that
4 says "VDEPOS is assumed to be perfectly rank order
5 correlated across aerosol sizes. This prevents
6 small aerosols from depositing faster than large
7 aerosols, which would contradict our understanding
8 of aerosol physics. The red and the dark green
9 lines on this curve seem to contradict our
10 understanding of aerosol physics."

11 MR. BIXLER: Okay. Well generally it's
12 true that larger aerosols deposit faster than small
13 ones. But you're right. It's a well-known feature
14 of deposition velocities that there's a minimum in
15 the curve. The reason is that there are competing
16 deposition mechanisms.

17 Brownian motion tends to dominate it for
18 very small aerosols, gravitational deposition tends
19 to dominate for large ones. In the middle of the
20 range that we're interested in, there is a real
21 minimum in the curve for deposition velocity.
22 You'll see that in a number of publications where
23 they plot -- they have a figure showing deposition
24 velocity as a function of size.

25 So that was actually intended. It should

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1 be there. It's a real feature of aerosol
2 mechanics. But our simple generalization did not
3 capture that feature.

4 CHAIRMAN STETKAR: Okay. I know nothing
5 about what you just said, but you at least have a
6 good reason, so thanks.

7 MR. BIXLER: Okay, okay. Now we'll move
8 on to the dispersion parameters, and I'm just going
9 to discuss the cross-wind ones, but we do basically
10 the same thing for the vertical dispersion
11 parameters. Here again, in this case we were
12 thinking specifically in terms of weather.

13 Since we're looking at a realization and
14 capturing a mean result as our primary result that
15 we're trying to capture for a whole year, it's not
16 really fair to use a value that is too strongly
17 biased to represent a whole year's worth of weather
18 samples.

19 If we were sampling individual weather
20 trials and choosing a large value or a small value
21 of dispersion, and then averaging that over the
22 whole year, then I think we would have done what
23 the experts had intended us to do.

24 But since we're using one value for a
25 dispersion parameter to capture a whole year's

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1 worth of data, then representing that as an
2 average, too much bias one way or the other in the
3 dispersion parameters doesn't give the right
4 answer.

5 It would bias the mean.

6 And so what we chose to do was again
7 define a narrower distribution, this time for a
8 little different reason but the same general
9 concept.

10 CHAIRMAN STETKAR: But in this case, I
11 had some real questions about this one, not knowing
12 anything about the physics again, but just reading
13 what was documented. In this case, it's noted that
14 the expert elicitations spanned about an order of
15 magnitude uncertainty with a 90 percent confidence
16 interval and about two orders of magnitude to
17 capture the full range. So they're pretty broad.

18 MR. BIXLER: Yep.

19 CHAIRMAN STETKAR: You've reduced those
20 uncertainties to a factor of 6.25 over the full
21 range, which is --

22 MR. BIXLER: 2.5 squared.

23 CHAIRMAN STETKAR: 2.5 squared, that's
24 exactly correct, and it covers now the 100 percent
25 confidence interval as shown on these curves.

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1 There's a lot of discussion that I couldn't quite
2 understand. Part of the discussion notes that
3 there are a number of other sources for CYSIGA,
4 three of which are given as examples in the MACCS
5 users guide.

6 These values were compared to the best
7 estimate values from expert elicitation. It was
8 found that two-thirds of the values were within a
9 factor of three of the best estimate value, meaning
10 two.

11 You don't discuss what the third one.
12 I'm assuming that the third one was more than a
13 factor of three different, which would sort of
14 corroborate larger uncertainties that you've
15 assigned.

16 I felt really uneasy about this thing. I
17 don't know how important it is, but again in the
18 sense of I don't particularly care about how
19 important it is. I care about the technical
20 justification for reducing something that experts
21 assess as quite uncertain to something that seems
22 quite certain.

23 The factor of six range over the full,
24 you know, 100 percent confidence interval is quite
25 certain.

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1 MR. BIXLER: No, go ahead.

2 MS. GHOSH: The original distributions
3 that we had in Peach Bottom, which we initially had
4 just taken from the expert elicitation, again were
5 criticized quite a bit for being way too broad,
6 both by a couple of the peer reviewers who had seen
7 at least the initial uncertainty distributions
8 before we completed the project, as well as again
9 Steve Hanna.

10 So we had external feedback that our use
11 of the expert, original expert elicitation data was
12 not appropriate, that it was too broad for our
13 purpose.

14 CHAIRMAN STETKAR: Okay. Let me try to
15 pin you down though, because on the record I want
16 to make sure that we have a good justification
17 here. People often say the uncertainties are too
18 large. I can't deal with uncertainties that are
19 that large. In fact, for some things that
20 uncertainties are very large.

21 So just a criticism saying the
22 uncertainties are too large doesn't tell me why
23 were the uncertainties too large for the purposes
24 of the way you're treating these parameters in this
25 particular study?

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1 MS. GHOSH: I think again it has to go
2 back -- it goes back to the way we combine, that
3 we're explicitly modeling the year of weather data,
4 along with the sampled parameters. I don't know if
5 you want to give more.

6 MR. BIXLER: Yeah. So if what we had
7 done was used a larger or dispersion parameter
8 distribution, say even two or three orders of
9 magnitude wide, and sampled for each of our
10 thousand or so weather trials we had chosen a
11 different dispersion value for that sample, and
12 then done that for a year.

13 I think what we would have done would
14 have been what the authors of the expert
15 elicitation had really had in mind, and if we
16 average those values over a year, we would end up
17 with something much closer to the mean of their
18 distributions than we would have -- for each of our
19 weather clouds we would have ended up with
20 something much closer to the mean of their
21 distribution.

22 But all we're trying to do is capture
23 that lower uncertainty that you have when you're
24 using the same value for a year's worth of data.

25 CHAIRMAN STETKAR: You said a couple of

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1 important ifs there. If you had something and if
2 you had done something, then maybe we would have
3 captured the uncertainty. That implies to me that
4 you didn't actually do that, because I know you
5 didn't have that number of weather trials initially
6 for different wind conditions.

7 MR. BIXLER: We did not.

8 CHAIRMAN STETKAR: You had a very limited
9 set.

10 MR. BIXLER: Yeah.

11 CHAIRMAN STETKAR: And just simply trying
12 to do something that reproduces somebody else's
13 thing that they have called a mean value is not the
14 purpose of this study. The purpose of this study
15 is to examine the actual uncertainties, and how
16 those uncertainties may affect things.

17 So trying to get something that's narrow
18 enough to comes back to a mean value that somebody
19 else had is not what I think this study should have
20 been doing.

21 MS. GHOSH: That wasn't the purpose. I
22 think we took the criticism that we heard as a
23 criticism of the technical basis for the original
24 distributions we had, and I completely agree with
25 you. There are some legitimate uncertainties out

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1 there that may be four or five orders of magnitude.

2 The criticism didn't come simply from the
3 how wide the distributions, but for the technical
4 justification for those original distributions as
5 we were using them.

6 CHAIRMAN STETKAR: But Tina for example,
7 if the criticism in this particular case was that
8 well, the experts were trying to combine both
9 uncertainty and the weather parameter and the
10 dispersion parameter, and you ought not to do that
11 because you're separately considering uncertainty
12 in weather.

13 But if you have not adequately considered
14 the uncertainty in the weather, especially in the
15 extremes, are you now then artificially reducing
16 the composite uncertainty by separating the
17 variables and having narrower distributions for
18 both them? In other words this comes back to
19 something that Dennis asked earlier.

20 Did you go back to the experts and say
21 well, the way we've broken apart the problem, the
22 two separate now treatments of uncertainty, does
23 the composite uncertainty of our results replicate
24 what you were trying to do in your expert -- in
25 your elicitation?

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1 MEMBER BLEY: Or even if you can't do it
2 that way, are you comfortable with the way we've
3 reformatted it and the uncertainties we're using
4 now?

5 CHAIRMAN STETKAR: Considering the
6 variations in the weather sampling that you used,
7 the data, the supporting data and the sampling
8 algorithm that you used.

9 MR. BIXLER: Yeah. We have not done that
10 stuff. We haven't gone back and talked to any of
11 the experts to see if they agree that these are
12 reasonable distributions. But --

13 MS. GHOSH: We'll take it as a comment.

14 MR. BIXLER: Yeah.

15 MS. GHOSH: We probably --

16 CHAIRMAN STETKAR: There's a couple of
17 reasons. Number one, this kind of seems to make
18 sense. But number two, but you rely very, very
19 heavily, you rely entirely on the results from
20 those expert elicitations, that NUREG that's cited,
21 for the nominal mean value. You put 100 percent
22 confidence in those expert elicitations, saying yes
23 indeed, that's the thing that we're going to rely
24 on and try to hold fast to. And yet you haven't
25 gone back and talked to them about the ranges of

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1 the uncertainties?

2 MR. BIXLER: All right. We'll take that
3 as an action item to --

4 MS. GHOSH: Comment noted.

5 MR. BIXLER: Yeah. Okay. Next, we're
6 going to talk about the way weather is actually
7 modeled in MACCS, and the way -- the method that we
8 use for doing the weather uncertainty modeling
9 typically is to divide all the weather into a set
10 of bins. There are some that are called rain bins
11 and then there's a set that are based on stability
12 class and wind speed.

13 This is a standard approach that's been
14 used since NUREG-150, maybe even earlier than that.
15 The idea is that for situations -- first of all,
16 you take all 8,760 hours of the year and put each
17 hour, each starting hour into one of the bins. So
18 you end up with 8,760 samples to represent a year
19 of data.

20 Each bin, for the rain bins represents a
21 rain intensity and a distance that the plume would
22 travel before rain starts. So we're looking at
23 specific situations where the plume would travel a
24 distance, then you would get some precipitation,
25 and it would fall out perhaps over a population

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1 center or something like that.

2 The other set of stability or weather
3 bins is based on stability class, which affects the
4 amount of dispersion that you get and wind speed,
5 which obviously affects the duration and length of
6 a plume as it's traveling through the grid.

7 Okay. So that's the basic idea, and I
8 know it's a little difficult to conceptualize what,
9 how all this modeling works when we're looking at a
10 set of plume segments. So I constructed an
11 animation to give you an idea. Each plume segment
12 can travel in its own direction, which is the
13 direction that the wind happens to be blowing at
14 the start of the weather trial, and each plume
15 segment will have a different length, depending on
16 the speed of the wind as it's exiting the source.

17 The width will be varying, depending on
18 how much dispersion occurs along the length of the
19 plume segment as it's traveling through the grid.
20 So each plume segment is different in those
21 regards, but it's also different in terms of its
22 activity, the activity content of it. Some plume
23 segments will have a lot of activity, some only a
24 little because we're coupling a time-dependent
25 release, a source term with time-dependent weather.

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1 So I think this hopefully gives you an
2 illustration of how the modeling goes together
3 between following the weather and following the
4 pattern of the release. This is for one of the
5 weather trials that we happen to use for this
6 analysis.

7 CHAIRMAN STETKAR: Okay. The weather
8 data were based on two years of experience?

9 MR. BIXLER: One year of weather data.

10 CHAIRMAN STETKAR: One year of weather
11 data, but you looked at, if I recall, two years of
12 met tower, right?

13 (Simultaneous speaking.)

14 MR. BIXLER: That's right, two years.

15 CHAIRMAN STETKAR: Two years of met tower
16 and selected one as being --

17 MR. BIXLER: The two were not terribly
18 different, for one thing. So we chose one of them.
19 I don't recall, but one of the criteria for
20 choosing is that you would like to have a good
21 recovery, data recovery rate where there aren't a
22 lot of hours of the year with missing data. That's
23 one thing, and secondly you would like to find one
24 that's typical for that area, as far as rainfall
25 and other general characteristics.

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1 CHAIRMAN STETKAR: Depending on what
2 typical means.

3 MR. BIXLER: Well yeah. Not different
4 than the -- too different than the averages for
5 that area.

6 Okay. Next thing is speed of evacuation.
7 I mentioned that there are six cohorts. The
8 cohorts are listed here. Each cohort has its own
9 distinct characteristics and one of those
10 characteristics is how fast does it evacuate. The
11 timing of the cohort of when does it begin to
12 evacuate is also distinct, that the speed of
13 evacuation is distinct.

14 One of the six cohorts is non-evacuating.
15 By assumption we have a half a percent of the
16 population that we model as not being -- not
17 evacuating. So the other five are represented
18 here. The SOARCA values of the triangles in the
19 curves are the distributions that we used.

20 The basis for this comes out of the ETE,
21 the Evacuation Time Estimate report that each of
22 the plants produces. Those ETE reports have
23 variations depending on time of day that the
24 accident occurs, time of year, whether there's
25 adverse weather, a whole variety of things. So you

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1 get some sense of uncertainty in the timing based
2 on that.

3 CHAIRMAN STETKAR: This particular --
4 back to this one.

5 MR. BIXLER: Yeah.

6 CHAIRMAN STETKAR: This particular
7 scenario, according to the documentation, is
8 initiated by an earthquake with a peak ground
9 acceleration of somewhere between .5 and 1G, which
10 is strong enough to disabled safety-related
11 equipment inside a nuclear power plant. How did
12 the evacuation time estimates account for those
13 types of scenarios?

14 MR. BIXLER: Joe, correct me if I'm
15 wrong, but I don't think the published ETES
16 specifically look at earthquake situations, do
17 they?

18 (Off microphone comment.)

19 MR. BIXLER: But we did make, put an
20 effort into going to fairly low evacuation speeds
21 here to cover what we thought the damage to the
22 road structure might do as far as evacuation
23 speeds. So we did try to model a very low end
24 evacuation speed to specifically account for
25 degradation of the road network.

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1 But we don't find published values to
2 support that. That was our own judgment of how we
3 should do that.

4 CHAIRMAN STETKAR: Something you haven't
5 talked about, and I don't know how the model does
6 it. How much -- how does the model account for
7 initial sheltering, and does that make a difference
8 in terms of the accumulated dose?

9 MR. BIXLER: The model allows for
10 treatment of sheltering. That's a user input, and
11 we did model sheltering in this case. Our main
12 uncertain parameters though were delay to
13 evacuation and evacuation speed.

14 CHAIRMAN STETKAR: I don't think any of
15 us have been in an earthquake that is anywhere near
16 this strong. I've been in a few earthquakes, and
17 the initial response of most people is to run
18 outside and stay outside and not go back inside
19 those darn buildings that are going to fall down
20 and hit me on the head. That's true for schools,
21 it's true for members of the public, it's true for
22 businesses.

23 So you wind up getting an earthquake. I
24 know people in the North Ridge earthquake who were
25 pitching tents out in their backyard, because they

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1 didn't want to go back inside the buildings for
2 days, because of the aftershocks. Also people are
3 generally reluctant to leave their homes when
4 they're damaged and the bad guys can come in and
5 start looting.

6 So how did you consider that effect in
7 terms of the efficiency and effectiveness of
8 sheltering and possible delays in evacuation
9 because A, the public doesn't want to go inside,
10 despite the fact that maybe there's something going
11 on down the street in the nuclear plant, and B,
12 maybe they want to get out of town really fast and
13 clog up everything because everything's damaged and
14 there's something going on down the street.

15 Or C, maybe they don't want to get out of
16 town because they don't trust those nuclear plant
17 people and they want to stay home and protect all
18 their belongings, because all their windows are
19 broken.

20 It's very, very unique scenario these
21 seismic events. It's not a random weather pattern.

22 MR. BIXLER: Yeah, right. Our thinking
23 here was that our primary focus on emergency
24 response was not on sheltering, that it was on
25 evacuation, which I think is pretty typical.

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1 That's the more likely response that would be
2 triggered.

3 And so we were focusing on things leading
4 to evacuation, people getting out of the area, how
5 long would they stay put before they leave, and
6 then how long would it take them to evacuate. You
7 want to add any more detail to that Joe?

8 MR. JONES: This is Joe Jones with
9 Sandia, and I did the emergency planning work on
10 this working with Nate and with Randy Sullivan,
11 beginning with the early analyses in Surry, in the
12 Surry SOARCA document. We need to remember a few
13 things unique about Surry.

14 One is the vast majority of people are on
15 the easterly side of the James River, which is
16 about five miles wide. So given the travel time of
17 a plume and the delays and the releases, from an
18 evacuation time estimate perspective they are all
19 departing within a few hours.

20 So the sheltering, whether or not there's
21 a sheltering need here to assess, you know, the
22 broken windows or people being outdoors, we
23 consciously did not think we needed to address
24 that.

25 CHAIRMAN STETKAR: Is that true also even

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1 for the early releases from the faulted steam
2 generator cases?

3 MR. JONES: I believe those are in the
4 three hours' time frame, and an hour or so to
5 release and get across the river, if the wind
6 happens to be going in that direction.

7 CHAIRMAN STETKAR: So you're still kind
8 of on the margins?

9 MR. JONES: We're on the margins, when
10 people would be getting on the road and evacuating.

11 MS. GHOSH: Which is why we don't -- we
12 continue to see no -- it's very hard for us to
13 calculate an early fatality risk, because the plume
14 doesn't really catch up with even a greatly delayed
15 population leaving.

16 MR. JONES: Now with regard to the
17 looting and people wanting to stay, we've done a
18 lot of research for the NRC in evacuations, and
19 looting is a minor issue in an actual emergency
20 where there's a hazardous material of some sort.
21 It's fairly infrequent.

22 CHAIRMAN STETKAR: Is it? Okay.

23 MR. BIXLER: Any other questions?

24 MEMBER BLEY: Not to throw a monkey
25 wrench, but I think you've done the best you can

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1 with this. But I want to share something that we
2 found about 30 years ago. We hired some human
3 performance people to try to address this question,
4 of what people would do after a very strong motion
5 earthquake.

6 They weren't able to do it thoroughly.
7 They made some judgmental estimates, but they
8 brought back a lot of anecdotes. The anecdotes
9 were really interesting because -- and these are
10 the kind of earthquakes, the ones that knock you
11 off your feet and do a lot of damage. It's
12 something that's outside of the experience of
13 almost all of us.

14 The one thing we anchor to is the earth
15 and it's acting up. What they found was many, many
16 cases people remembered the earthquake and the next
17 thing in their memory was they were home or ten
18 miles away, somewhere else, and they had no
19 connection. They did a bunch of things
20 automatically. They got in their cars and drove
21 from their office to somewhere else, and they had
22 absolutely no memory of it.

23 We're talking about people doing all
24 these rational things during this period of time,
25 and I don't think anybody's really thought hard

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1 enough about that.

2 MR. BIXLER: Okay. The next parameter
3 for discussion is the -- and there are a couple of
4 slides that go with this, is the hot spot
5 relocation criteria. As I mentioned, there's a
6 dose that goes with that and that's the next slide.
7 But this slide shows the amount of time that it
8 would take to relocate.

9 For the base case analysis, the original
10 SOARCA work we used 24 hours. Here, we assumed a
11 relocation time in the range of 12 to 30 hours. We
12 just chose here a uniform distribution, because we
13 didn't think we had any basis for biasing the
14 distribution towards either end of the range.

15 So this is the distribution that we used
16 for time hot, and there's an equivalent value or a
17 curve rather than goes with time norm, the normal
18 relocation parameter. Then along with that goes
19 this distribution for the dose that would trigger
20 normal or hot spot relocation.

21 Nominally we used a value of five rem or
22 .05 Sieverts, and we have a distribution that goes
23 from one up to seven and a half. One is what we
24 nominally use for normal relocation, so we didn't
25 want to go below that.

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1 So here that's kind of -- so we made that
2 our lower bound in seven and a half rem or upper
3 bound. I think this is based on a triangular
4 distribution that we sat with. The mode of the
5 distribution is the base case value. Okay. That's
6 all the MACCS parameters.

7 MS. GHOSH: Are there any questions on
8 the MACCS parameters? Okay. KC, would you mind
9 joining? Thanks.

10 Okay. So we'll move on to the MELCOR
11 analysis results.

12 CHAIRMAN STETKAR: Before we go to the
13 results, the good Doctors Ballinger and Shack, when
14 is it an appropriate time for you to grill folks?

15 (Off microphone comments.)

16 CHAIRMAN STETKAR: Okay. I just didn't
17 want to get a steam roller going and then suddenly
18 -- okay, fine.

19 (Simultaneous speaking.)

20 CHAIRMAN STETKAR: Thank you. People
21 always berate me for reminding people who have
22 given up.

23 MS. GHOSH: Okay. So we just wanted --
24 this is just a quick review of where we ended up
25 the beginning of our earlier session on the

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1 parameters. Once we got all of the Monte Carlo
2 results we -- oh Mike, you might have been out of
3 the room for this, because you were asking earlier
4 whether we looked at logical groupings of results
5 to get additional insights.

6 We did think that it would be useful to
7 look at the steam generator tube rupture cases on
8 its own and then the non-steam generator tube
9 rupture case on its own in addition to the whole
10 set, because we thought we could get some good
11 insights, especially for the non-SGTR cases, that
12 we could discover what would be important for that
13 set that gets masked when you look at all of them
14 together, because that's really driven by the fact
15 that the steam generator tube ruptures have an
16 order of magnitude higher release.

17 So the parameters that are important for
18 that end up showing as masking what might be
19 important in other population. Then we also looked
20 at, since this was the first time we were looking
21 at time at cycle, we also wanted to look at the
22 time at cycle independent results. So we looked at
23 the beginning of cycle, middle of cycle and end of
24 cycle cases to see. So that's just the preface. We
25 already talked about that and then --

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1 MEMBER CORRADINI: So you took the 1,003
2 and broke them into subgroups?

3 MS. GHOSH: That's correct, right. So we
4 had about 104, about ten percent that went to steam
5 generator tube rupture. So we then -- we looked at
6 the whole set and we segregated the 104 that went
7 to tube rupture, looked at that. Then we looked at
8 the complement and the whatever 900 that didn't go
9 to tube rupture.

10 Then we had roughly a third of the
11 realizations that fell in the beginning of cycle
12 versus middle of cycle, end of cycle. So we looked
13 at all of those groups about the need to see what
14 we could discover about what becomes important.

15 For example, when you look at just the
16 non-SGTR cases, when you look at everything that's
17 dominated by what drives you to a steam generator
18 tube rupture or not. So should I start this out
19 and then you ask your question, or do you want to
20 ask first? It's up to you.

21 CHAIRMAN STETKAR: Well, let's get the
22 material stuff out of the way first.

23 MS. GHOSH: Okay.

24 MEMBER BALLINGER: Bill and I are pretty
25 much on the same page about -- my comment earlier

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1 was going through a logical analysis of why you
2 chose to treat rupture the way you did, in terms of
3 just using wall thinning as a parameter. Bill is
4 going to say that you could do it with wall
5 thinning no matter what, no matter what the actual
6 cause is, just changing the distribution.

7 So but I'm still interested in
8 understanding why you didn't deal with cracking in
9 an explicit way. I can't understand. There's no
10 comment in there about how you went from it's an
11 important thing to we didn't do it, because I don't
12 see it in the -- you know, see what effect it might
13 have been on the distribution, if you had chosen to
14 treat cracking.

15 Same thing, right Bill?

16 DR. SHACK: Similar, you know. I don't
17 have a problem with the parameterization of using
18 thickness or --

19 MEMBER BALLINGER: But thickness is
20 euphemism for -- yeah.

21 DR. SHACK: The distribution you chose,
22 and again is this is one problem where you actually
23 do know the ranges. That's the good news. The
24 distribution that you chose just doesn't make sense
25 to me, and unlike most cases, I think you actually

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1 have data for all this.

2 I mean you could have gone to Surry.
3 They have multiple inspections. You could have
4 seen what the flaw distribution looked like, you
5 know, and so there was no need to make a
6 distribution --

7 Again, your argument that you're looking
8 at the most degraded tube, I get my gut feeling,
9 without obviously having looked at all those
10 inspections, is that you've got far too broad a
11 distribution if you're really looking for a
12 distribution of the most degraded tube in a steam
13 generator.

14 Now so you're -- a non-conservative kind
15 of distribution, you then team that with a
16 conservative assumption that it's sitting in the
17 middle of the hot spot. So I multiply a non-
18 conservatism with a conservatism and I get ten
19 percent, and I have no idea, you know.

20 Your results are just dandy if you want
21 to see what happens and the consequences of a steam
22 generator. Whether the ten percent number means
23 anything at all, you know, is to me totally
24 fictitious. But again, the main reason is why
25 didn't you go back and actually look at the data?

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1 MR. FULLER: Bill, I shouldn't need to
2 remind you that since the industry has by and large
3 replaced all the original steam generators, that
4 essentially cracking is not an issue anymore. But
5 volumetric wear and other volumetric mechanisms
6 are.

7 DR. SHACK: I've got no problems with
8 that.

9 MR. FULLER: Okay.

10 DR. SHACK: But you know what the wear
11 and, you know. You can go to Ken Kowalski and look
12 at the operational assessments for Surry. You'll
13 find results from inspections. You'll find defect
14 populations, and you know, whether those defect
15 populations give you anything that look like the
16 distribution that's chosen. I'd be surprised. I
17 mean I could be wrong. That's certainly happened
18 before.

19 MR. FULLER: I've been out of the steam
20 generator business for a few years now. But I
21 would be surprised if there was significant
22 degradation in Surry.

23 DR. SHACK: Oh no. You probably plug a
24 tube every time you look at it, just because you
25 know --

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1 MR. FULLER: From where?

2 DR. SHACK: From where. But that's just
3 fine and dandy. They don't care why the tube dies,
4 as long as -- you know, if the tube dies, it dies.
5 So you've got a high degradation mechanism that may
6 only affect one or two tubes. But they're looking
7 for the most degraded tube.

8 I'll agree if I looked at the
9 distribution of degraded tubes it looks a whole lot
10 better. But if I'm looking for the most degraded
11 tube in the steam generator, I would guess I'd get
12 a pretty narrow distribution down near that bottom
13 edge.

14 MR. FULLER: Indeed, for a volumetric
15 mechanism, the probability of detection is very
16 high.

17 DR. SHACK: Right.

18 MEMBER BALLINGER: Yeah, but then you
19 won't get anything more than 40 percent through
20 wall, because they'll be plugged.

21 MR. FULLER: That's correct. So what it
22 comes down to is the wear rate.

23 MEMBER BALLINGER: Rate.

24 DR. SHACK: And your -- essentially your
25 air, your probability of detection, your

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1 probability of sizing. I mean I can take the
2 reported results. I can, you know, manipulate them
3 for growth. I can manipulate them for errors. But
4 I still end up, I would argue, with something
5 that's going to be a whole lot narrower than the
6 distribution they're using, which is basically
7 spread over the whole range.

8 MEMBER BALLINGER: The probability of
9 detection for cracks is way different than the
10 probability -- if you get 40 percent through wall,
11 the probability of detection is pretty darn high.

12 MR. FULLER: Yeah. But I think that as a
13 practical matter, the likelihood of getting
14 significant attack from cracking on the new steam
15 generator tubes is much lower than on the original
16 steam generators.

17 MEMBER BALLINGER: If it's 690 for sure,
18 thermally treated most likely, and these are
19 thermally treated.

20 MR. FULLER: Yeah. These are Alloy 600
21 thermally treated, yeah.

22 MEMBER BALLINGER: Yeah.

23 DR. SHACK: Well the last inspection I
24 could find any information on, they did have some
25 cracks.

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1 MEMBER BALLINGER: For thermally treated?

2 DR. SHACK: Thermally treated.

3 MEMBER BALLINGER: But again, I think you
4 know, I'm fully confident that most of the damage
5 is where? That's just -- I mean my only question
6 is why not use the data rather than, you know, an
7 impressionistic kind of hand waving argument that
8 got you to the triangular distribution with your
9 mode at .69.

10 DR. SHACK: For 690 it will all be wear.

11 MEMBER BALLINGER: For 690 it will
12 probably all be wear.

13 MR. WAGNER: So we cite NUREG-1740 for
14 that 60 percent --

15 MEMBER BALLINGER: Yeah. That's the
16 plugging limit. But that doesn't tell you, you
17 know, what the actual flaws are. As I said, the
18 flaws that you find would be determined by the
19 flaws that you find plus your errors, your
20 probability of detection, your probability of
21 sizing error.

22 MR. WAGNER: Okay. So your
23 recommendation is the site-specific?

24 DR. SHACK: Yeah, I do. Go talk to Ken
25 Kowalski and see what he thinks of that

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1 distribution. Look at least at an expert.

2 MEMBER BALLINGER: Because it's going to
3 be way narrower.

4 MR. WAGNER: Smaller wear?

5 DR. SHACK: No, no. Narrow towards the -
6 - biased towards the bad end, because you're
7 looking for the deepest crack. Now again I can,
8 you know, that will give you a conservative result
9 I think when you're all said and done. If you did
10 that, if you got that distribution and then you
11 timed it with your, you know, my most degraded tube
12 sits in the middle of the hot tubes.

13 You might talk to Ken about whether that
14 degradation is kind of randomly spread around. You
15 know, could you take -- you know, could you look at
16 the whole degradation profile and take samples of
17 that and find out what the likelihood of getting a
18 tube in the hot spot is. I can see that can lead
19 to unconservative, but probably more realistic
20 results.

21 MR. WAGNER: We're probably -- I mean to
22 address that, we probably ought to beef up our
23 modeling of the location of it and, you know, our
24 hot tube modeling.

25 DR. SHACK: Yeah. Well the trouble is

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1 that spot kind of moves around, and but --

2 MR. WAGNER: But I'm then thinking more
3 distance away from the tube, you know. The round
4 is -- I think we kind of accept that, that it could
5 be --

6 (Simultaneous speaking.)

7 MR. WAGNER: But what you see is the
8 temperature jumps pretty fast as you move into the
9 tube any distance, and we based it all, you know,
10 on that hot spot model near the tube sheets.

11 DR. SHACK: Near the tube sheet.

12 MR. WAGNER: So it's very conservative
13 that way.

14 MEMBER BALLINGER: I think that's where
15 the wear would be minimal.

16 MR. WAGNER: Yeah. So if we --

17 MEMBER BALLINGER: Up in the top is where
18 it's going to be --

19 MR. WAGNER: If we did a better job
20 modeling, you know, near the braces where there's
21 maybe a little bit of vibration, we're going to get
22 kind of two benefits. We'll get, you know, the
23 full resistance getting to that spot and then we'll
24 also get the cool down and what the stream would be
25 by the time we got there.

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1 We considered that, and there was already
2 -- the model was getting very -- that requires if
3 we're sampling on that to create that input for the
4 model. There's some mechanics problems or
5 complications, and we had already kind of had a
6 bunch of that with --

7 DR. SHACK: Radionuclides.

8 MR. WAGNER: Yeah. So we thought by
9 going over that full distance, we would survey the
10 --

11 DR. SHACK: Well and again, as long as
12 you only look at the consequences and the
13 difference in consequences that's fine.

14 (Simultaneous speaking.)

15 DR. SHACK: Any credit to the ten percent
16 becomes, you know, the real question here.

17 MR. WAGNER: Yeah.

18 MEMBER BALLINGER: And how far up before
19 the temperature drops to say below 600 C, below 500
20 C?

21 MR. WAGNER: 500 C probably not. I mean
22 the core return is -- so we're coming in there
23 maybe 1,000 or 1,100.

24 MEMBER BALLINGER: Fahrenheit or
25 Centigrade?

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1 MR. WAGNER: Kelvin, Kelvin. So let me
2 go to Celsius. I want to talk Celsius, so coming
3 back at 500 Celsius. So we would be maybe a meter
4 or so in.

5 MEMBER BALLINGER: A meter. So that's
6 two or three support plates?

7 MR. WAGNER: Yeah.

8 MEMBER BALLINGER: Okay.

9 CHAIRMAN STETKAR: I just wanted to make
10 a comment, Bill, in regard to that ten percent.
11 The ten percent is important.

12 MEMBER BALLINGER: That's right.

13 CHAIRMAN STETKAR: Because I mean you
14 said it well. If you don't care about the ten
15 percent. In my mind, one of the notable
16 conclusions of this work is indeed the fact that
17 these consequential tube ruptures can be an
18 important contribution to risk and early releases.
19 Now regardless of what's been done about the
20 consequences of those early releases, that's
21 important.

22 Now if that was, you know, one-tenth of
23 one percent, that's a much different conclusion.
24 And if it's 30 percent, that's an even different
25 conclusion, because you might start to pick up some

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1 other things.

2 MEMBER BALLINGER: And it was big to
3 start with.

4 CHAIRMAN STETKAR: Bill, turn your
5 microphone on.

6 DR. SHACK: Yeah, I agree. I mean it's
7 an important number. It is. So you know, it's
8 worth -- it's worth some attention.

9 MEMBER BALLINGER: Because I think if you
10 find, if you look at the real data, you will
11 discover that the wear pattern, if it's wear, is
12 not down in the lower part of the bundle. It's in
13 the upper part of the bundle. So we're saying
14 we're choosing a hot tube to be the place where we
15 have the maximum wear.

16 Well, I don't know that that's actually -
17 - it's a conservative assumption, but I'm not sure
18 it's an actual realistic assumption.

19 MR. WAGNER: Yeah. So we thought about
20 trying to model, you know, the penetration to
21 deeper levels to get the thermal conditions,
22 thermal mechanical conditions.

23 (Simultaneous speaking.)

24 MEMBER BALLINGER: Depends on how far up
25 you got hot.

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1 MR. WAGNER: And that created a host of
2 complications. So it was ruled out. But it was a
3 step forward to do the hot spot modeling and to
4 model the hottest tube and bring in the CFD there
5 results.

6 DR. SHACK: Again, it will be fine to be
7 consistently conservative, you know. What bothers
8 me is I've now got a problem where I'm conservative
9 in one thing and non-conservative in another, and I
10 don't know where that leaves me. But if I was
11 consistently conservative, then ten percent would
12 be --

13 CHAIRMAN STETKAR: No. But Bill the
14 point of this is not to be consistently
15 conservative; it's to realistically assess the
16 uncertainties based on our current understanding of
17 the physics and the materials.

18 This isn't the licensing basis
19 calculation where you have to have assurance that
20 you're consistently conservative. It's supposed to
21 be a realistic analysis with an appropriate
22 assessment of uncertainty.

23 DR. SHACK: But sometimes you can assess
24 uncertainties in terms of a conservative
25 assessment, and if that's the best you can do

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1 without making --

2 MEMBER BLEY: And bound the problem, at
3 least you know something. Or you don't know.

4 DR. SHACK: You know something. My
5 problem is now I don't know whether this is a
6 conservative or non-conservative, and so that's
7 quite a --

8 (Simultaneous speaking.)

9 MR. FULLER: Can I shed some light on
10 this? About more than ten years now I guess ago,
11 there was foreign object wear above the tube sheet,
12 an ANO tube that caused a leak and it was -- it was
13 either the first or the second cycle after the
14 steam generator was replaced.

15 Now that's kind of down where they're
16 putting their failure here, right above the tube
17 sheet. So as far as I'm concerned, the
18 conservative approach is to assume you might get
19 foreign object wear that's going to pretty bad
20 damage.

21 MEMBER BALLINGER: But I don't see
22 foreign object wear in any of this.

23 MR. FULLER: It's what causes --

24 (Simultaneous speaking.)

25 MEMBER BALLINGER: I understand what

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1 causes it. But you're talking about creep rupture
2 due to a hot --

3 DR. SHACK: Well no. You can get foreign
4 object wear to give you degradation, because you
5 can -- essentially it gives you the stress
6 multiplier for thinness. I mean it doesn't have to
7 completely go through. All it has to do is do some
8 --

9 As I say, you can lump all kinds of
10 degradation into the parameterization, you know.
11 That's --

12 MR. WAGNER: Well currently we surveyed
13 the bounds and our mode was picked, you know, based
14 on when you would need to. If they caught it
15 through their testing during outage, it would be
16 caught at that 40 percent. So that was -- that was
17 our rational, short of going to -- doing more
18 elaborate modeling and going to point-specific
19 data.

20 MEMBER BALLINGER: I mean I guess our
21 overall point is you have this -- in this case, you
22 have data that you can go look at.

23 DR. SHACK: Yeah. Nobody's going to melt
24 down reactors for you to do a better job of some of
25 that relocation. But in this case --

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1 MR. WAGNER: Now what we found, I mean I
2 think you're going to get to it, is the tube
3 fitting was important but if you get a, you know, a
4 hot -- if the high dry low conditions, we have a
5 good chance of getting there before -- well not a
6 good chance. But we have to have all those
7 conditions, and then -- and then I guess we do have
8 to have a week or two.

9 (Simultaneous speaking.)

10 CHAIRMAN STETKAR: KC, it's part of what
11 Tina said is really introduction this morning is
12 that some of these analyses in this work is being
13 used and will be used to support the ongoing Level
14 3 PRA project for Vogtle. They are, to my
15 knowledge anyway, explicitly trying to account for
16 these consequential tube rupture scenarios.

17 A seismically induced station blackout is
18 one way you might be able to get to those high dry
19 low conditions. I personally, it's my own personal
20 belief is that there are many other scenarios that
21 may occur at higher frequencies that you can get to
22 those conditions also.

23 Therefore, kind of understanding this and
24 having a reasonable model could be quite important,
25 not only for the narrow purpose of this particular

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1 Surry SOARCA analysis or a comparison with
2 Sequoyah, but in the grander scheme of kind of a
3 more comprehensive evaluation of the sources of
4 risk. So that's my bigger concern.

5 MR. WAGNER: Don Helton, yeah. If Don
6 Helton's here, and he could kind of -- they have a
7 little bit different approach in Vogtle.

8 MR. HELTON: Don Helton, Office of
9 Research. I guess just to respond to Dr. Stetkar's
10 point, we are following, sort of modeling a
11 consequential steam generator tube rupture in this
12 project, but we are also following the modeling in
13 what we refer to as the C-SGTR project, which
14 you've also been briefed on.

15 Probabilistically, we are following that
16 project's approach more closely, so we can use it
17 for the C-SGTR calculator that takes into account
18 flaw distributions and other things.

19 So we are following it here and we are
20 sort of periodically meeting between the three
21 projects, to understand where we're seeing
22 likenesses, where we're seeing differences, and
23 obviously the ten percent that appears here versus
24 different numbers that appear when we apply the
25 different tools for those other plants is, you

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1 know, one of those focuses of those discussions.
2 But I guess I would just encourage don't get too
3 bogged down --

4 CHAIRMAN STETKAR: Don't get too -- okay,
5 thanks, thanks Don.

6 (Simultaneous speaking.)

7 MR. HELTON: --with the fact that we're,
8 you know.

9 CHAIRMAN STETKAR: And that's really good
10 to have on the record. Thank you.

11 MS. GHOSH: Should I start the slides?
12 Are there any more questions? I won't repeat the
13 first bullet. You've talked about that a lot.
14 I'll just note that when we did get a SGE on TR, we
15 also got a hot leg nozzle rupture in every one of
16 those cases.

17 CHAIRMAN STETKAR: Let me stop you at the
18 second bullet.

19 MS. GHOSH: Okay.

20 CHAIRMAN STETKAR: And this I hope is
21 easy. Somewhere I read, and it's in my notes here
22 but it's kind of burned in, that the -- on average,
23 the hot leg nozzle rupture occurred 28 minutes
24 after the tube failure. In fact, if you looked at
25 over, over all of the 104 or however many.

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1 That to me -- Rick, I didn't look up the
2 previous results. But my recollection is that in
3 most cases, the hot leg was rupturing, failing
4 before the tube rupture occurred in previous
5 analyses. What changes -- is it only the changes
6 in the characterization of the stainless steel
7 sheeting of the nozzle and the nozzle materials?
8 Is that what led to the delay?

9 DR. SHACK: In the hot leg failure?

10 CHAIRMAN STETKAR: In hot leg failure
11 relative to the timing of the tube failure.

12 DR. SHACK: But they had lots of hot leg
13 failures without steam tube ruptures.

14 CHAIRMAN STETKAR: It's just the timing
15 of them. What I'm talking about is the timing.
16 Previously, you got a hot leg failure so you never
17 got the tube rupture, because you blew down.

18 MEMBER BLEY: And I think that started
19 way back in the consequential tube rupture study
20 as well.

21 MR. WAGNER: So I guess what -- I hope
22 I'm answering your question. I guess if you look
23 at NUREG-CR-6995, which was all the SCDAP/RELAP
24 work that supported the tube rupture valuations.
25 So they were working close with Chris Boyd at the

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1 time and they were running SCDAP/RELAP.

2 Consistent with what we're seeing here,
3 we had to have a stress multiplier in order to get
4 tube failure prior to hot leg failure. The wealth
5 of analysis in probably a decade of work done using
6 SCDAP/RELAP prior to us, we benefitted from their
7 approach.

8 They looked and surveyed the stress
9 multipliers all over the map, with much more
10 sophisticated modeling than in some aspects than
11 what we're doing. They needed a stress multiplier,
12 about two or so in order to get a failure of the
13 tube.

14 So if we had -- if we didn't have
15 something in the hot spot or on the sending side or
16 with a stress multiplier, our best tools would say
17 that hot leg comes first.

18 Now in the original SOARCA, I tried to
19 answer that question, because it came up from the
20 peer review. So I prevented a hot leg failure and
21 let it run more minutes, and what you see is on our
22 measure for failure, creep rupture, it goes up
23 orders of magnitude in the next to 10 to 20 or 30
24 minutes.

25 So it was a very compelling reason that

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1 that hot leg's going to fail, given that there
2 wasn't a pressurizer stuck open valve, that we get
3 to damage levels that would give us complete
4 confidence in hot leg failure.

5 So we had to have these stress
6 multipliers in order to get the failure in MELCOR,
7 and quite frankly we were doing the results based
8 on the CFD to match the conditions that they had
9 surveyed and the right boundary conditions for when
10 we're in natural circulation, that would lead to,
11 you know, a tube rupture.

12 MEMBER BLEY: I kind of understand
13 everything you said, but I didn't -- don't think I
14 heard an answer to what John asked, which is why
15 are we now seeing ten percent of the time we're
16 getting a tube rupture? Is it assumptions about
17 the tube? Is it something different about the
18 tube? Is it a change in the nozzle?

19 MR. WAGNER: Okay. Nope, we didn't
20 include -- the nozzle had a minor influence.

21 MEMBER BLEY: And that the difference in
22 the nozzle was just accounting for the stainless
23 steel?

24 MR. WAGNER: Yeah, the cladding.

25 MEMBER BLEY: Then before we leave that

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1 one, I have a little question for you.

2 MR. WAGNER: Okay.

3 MEMBER BLEY: In the real nozzle, you
4 have a stainless steel clad nozzle. But you also
5 have a weld --

6 MR. WAGNER: A safe cylinder?

7 MEMBER BLEY: Yeah, and the weld is of --

8 MEMBER BALLINGER: I sent you a picture.

9 MEMBER BLEY: Yeah, I saw the picture.
10 It would be nice to put it up here. But the weld
11 is of another material, and did you consider that
12 weld, could it be a weaker spot? Was it in the
13 modeling? I don't have any idea, or did you think
14 about it and say it wouldn't matter?

15 MR. WAGNER: No. We thought about it,
16 and you know, I think there has been NRC 3D
17 conduction research on that, you know, more
18 sophisticated 3D models trying to look at the
19 temperature distribution. We have got a simple
20 representation, so we're representing something
21 that looks --

22 MEMBER BLEY: Kind of what I'm asking if
23 you modeled that more realistically, might we see
24 more or less tube rupture percentage?

25 MR. WAGNER: I think we would see more.

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1 Oh, tube rupture, more hot leg.

2 MEMBER BLEY: You'd see more hot leg
3 failure, because of weakness there.

4 MR. WAGNER: Right, yeah.

5 MEMBER BLEY: Then you didn't -- I cut
6 you off before you got to the thing John was asking
7 about. You said the nozzle was a small contributor
8 to why we're now seeing more tube ruptures. What's
9 the big contributor to that?

10 MR. WAGNER: Adding the stress
11 multiplier.

12 MEMBER BLEY: Okay, and that wasn't done
13 before at all?

14 MR. WAGNER: No, no.

15 MEMBER BLEY: Okay. It was just done in
16 sensitivity studies before?

17 MR. WAGNER: Yeah, yeah. So in the
18 original SOARCA, we didn't have the sophistication
19 of a stress multiplier at the time, but we had to
20 force it because our model wouldn't naturally
21 develop it without a stress multiplier.

22 MEMBER BLEY: And now when you use it you
23 get it, and there's our ten percent. Okay.

24 MS. GHOSH: Okay. The third bullet.
25 Prior to core damage, the secondary side

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1 depressurized through main steam line leakage and
2 safety valve failure to close. Actually, we talked
3 about that this morning. And then we note that a
4 safety valve on the primary side, on the
5 pressurizer line failed to close in 68 percent of
6 the realizations.

7 So actually in 32 percent of the
8 realizations, we depressurized it some way before
9 we hit that failure point. But it stopped cycling
10 before it would have failed. But in 68 percent of
11 the time, we did have a failure to close at one of
12 the safety valves.

13 The steam containment liner yielded or
14 tore in 74 percent of the realizations, and the
15 containment area yielded in seven percent of the
16 realizations, which led to a larger open area in
17 the containment. So that the next slide just shows
18 --

19 MEMBER BLEY: Just I think it's related.
20 What fraction of the time, and it shouldn't have
21 been much if at all, did all the safety valves fail
22 closed?

23 MS. GHOSH: Zero.

24 MEMBER BLEY: Zero. They concluded that?
25 Well, they kind of did. I mean there's a ten to

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1 the minus 5th chance of it happening or something
2 like that.

3 MS. GHOSH: But because there was so much
4 --

5 MEMBER BLEY: That's what I thought, but
6 I just was wondering if it was any way related to
7 that last thing you had there.

8 MS. GHOSH: Yeah, no. We did sample for
9 that possibility, but it didn't occur in the
10 thousand realizations.

11 MEMBER BLEY: That's close to reality, I
12 think. Okay.

13 DR. SHACK: The 10,000.

14 MS. GHOSH: Yeah. We would have needed
15 10,000. But we did use --

16 DR. SHACK: But that still wouldn't have
17 happened.

18 MS. GHOSH: No, we did -- it could have
19 happened, ten percent chance in the 10,000
20 realizations. But we did do a sensitivity study,
21 to see what would have happened if we had failed
22 all three closed. But we continue to believe
23 that's an extremely low probability outcome.

24 Okay. So this slide shows one of the
25 primary metrics we care about, the cesium release

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1 to the environment, because really the cesium
2 dominates the long-term health risks or the offsite
3 consequences. So we're always interested in what
4 is happening with cesium.

5 So this plot is showing the release for
6 the 48 hour simulation time. We're only showing
7 the first 300 out of the 1,003 successful
8 realizations, and the reason for that is because
9 it's interesting to try to take out some of the
10 variations in the individual gray curve, each gray
11 curve.

12 (Off microphone comment.)

13 MS. GHOSH: Right. If you put too many
14 on the plot, then you can't -- they all just look
15 like one big gray bar and you can't really pick out
16 individual variations any more. Maybe three --

17 MEMBER BLEY: You still have to make
18 space between the two points.

19 MS. GHOSH: Right, right, right, which is
20 one of the key kind of outcomes of this. So each
21 gray curve is one realization. So it's the results
22 of one set of samples or parameters for each MELCOR
23 input parameter that was sampled.

24 The summary curves are not -- are
25 calculated statistics for each point in time. So

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1 they are not necessarily representative of any, you
2 know, subset of realizations. The median kind of
3 falls in the non-SGTR cases. But these are just
4 purely arithmetic averages for the mean and then
5 for the 50th and 95th percentile calculated at each
6 point in time.

7 So we can clearly see the bifurcation in
8 the results. We have one set of results, 104, that
9 go to steam generator tube rupture. Those start on
10 the earlier side and they result in an order of
11 magnitude roughly higher, and the cumulative
12 magnitude of release is by 48 hours and --

13 MEMBER CORRADINI: So can I ask. I know
14 you're going to have conclusions. So the upper
15 band is all steam generator tube ruptures.

16 MS. GHOSH: Yeah, are all steam generator
17 ruptures.

18 MEMBER CORRADINI: Whether they one, two,
19 three, five, because there was somewhere in your
20 notes, in your explanations that five looks like
21 three; three might be worse than one but so --

22 MS. GHOSH: So this is all for one tube.
23 In the integrated uncertainty analysis where we
24 varied all the parameters, if we had a steam
25 generator tube rupture we failed one tube. We did

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1 a separate sort of mini-uncertainty analysis or
2 joint sensitivity analysis, whatever you want to
3 call it, where we varied the number --

4 MEMBER CORRADINI: Okay. That's what I
5 was remembering. Excuse me.

6 MS. GHOSH: And that's documented in a
7 separate part of the report, and there we sampled
8 up to five tubes failing, not just one. We also
9 varied -- the reason we call it a mini-uncertainty
10 analysis is because we didn't vary all of the
11 uncertain parameters.

12 But we varied those parameters that were
13 most important to steam generator tube ruptures, so
14 that we could try to get a sense of what the real
15 variability might be and the results of having
16 multiple tubes fail.

17 CHAIRMAN STETKAR: Just for reference, I
18 stumbled over that also. So I went back and I
19 looked at the consequential tube rupture NUREG that
20 was published a year ago. I guess it isn't
21 published yet, but -- and in that report they say
22 that the conditional probability of a single tube
23 failure, one and only one, is about $1E$ to the minus
24 2 for the conditions that they assigned.

25 The conditional probability of two tubes

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1 is about 5E to the minus 5. It's much, much, much
2 lower, and more than two is negligible or whatever.
3 They used the word "negligible." So it gives you a
4 little -- because that's one of the things I was
5 worried about is you did that sensitivity study and
6 said well, it doesn't make too much difference if
7 you get more than three.

8 MS. GHOSH: Yeah.

9 CHAIRMAN STETKAR: But the likelihood of
10 apparently having more than one is, at least from
11 that, whatever stage that research is in is pretty
12 small.

13 MS. GHOSH: Yeah, and I think we've
14 arrived on the same data and we had access to that
15 draft report. That gave us confidence to use the
16 one tube for the --

17 CHAIRMAN STETKAR: It's just when you
18 reported the results of the sensitivity, you didn't
19 discuss at all the likelihood of any of those
20 conditions --

21 (Simultaneous speaking.)

22 CHAIRMAN STETKAR: You know, it just says
23 well, we looked at one, we looked at two, we looked
24 at three, we looked at more than three or something
25 like that.

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1 MS. GHOSH: You're right, and that's a
2 very good point. I think that's why we were trying
3 to characterize that as a joint sensitivity
4 analysis rather than a true uncertainty analysis,
5 because we have inflated -- I think we have
6 inflated weight of sampling in a higher number of
7 tube areas than one would expect as reality,
8 because we wanted to --

9 It was really more to see how sensitive
10 the consequences were. So we did have a higher
11 weight of sampling in those higher number of tubes.

12 MEMBER CORRADINI: So I had a second
13 question. So that explains one thing. So now I've
14 got the gray lines above and I've got the gray
15 lines below. Is the important variables that
16 caused the upper set of gray lines to be two
17 percent or, looking at all this and I'm not sure if
18 that's two.

19 But let's say a few percent of cesium
20 versus a few tenths of percent of cesium. Is that
21 rank ordering of the parameters that caused that
22 spread the same rank order of the parameters that
23 caused the spread below?

24 MS. GHOSH: No, and that's why we were --
25 that's what I was trying to explain before. We did

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1 regression analyses on different subsets of the
2 results. Because of this big spread in the
3 results, the things that are important to steam
4 generator tube rupture ended up being important to
5 the entire population as a result.

6 MEMBER CORRADINI: Okay. So the answer
7 to my question is yes.

8 MS. GHOSH: Yeah.

9 MEMBER CORRADINI: So for example, end of
10 cycle is more important than the beginning of the
11 cycle, for example?

12 MS. GHOSH: Well but okay. But let me
13 just -- so I don't forget, if I could complete
14 this. I can talk about that.

15 MEMBER CORRADINI: Sure, sure.

16 MS. GHOSH: So we removed the steam
17 generator tube rupture and then looked at what are
18 the things that are just important to the STSBO
19 scenario as we have described it, if it hadn't
20 progressed to a steam generator tube rupture.

21 You do see a different ranking of the
22 variables that are most important to that, because
23 now you're no longer just worried about whether or
24 not you're going to drive to a steam generator tube
25 rupture. So the ranking changes depending on what

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1 subset you're looking at.

2 For some things, and I think we talk
3 about that later, like hydrogen, you know,
4 production that doesn't matter --

5 MEMBER CORRADINI: Well if you're going
6 to talk about it later, I'll wait.

7 MS. GHOSH: Because if it, you know, it
8 doesn't matter to hydrogen production. But for
9 something like cesium release magnitude, you know,
10 it does make a difference and you'll see that in
11 the regression.

12 MEMBER BALLINGER: Once again, not to
13 beat dead horse on the steam generator tube rupture
14 thing, but I look at this and I say my gosh, we
15 really need to do the best job we can related to
16 steam generator tube rupture and what the issues
17 are.

18 MS. GHOSH: Okay, and that should be
19 maybe independent of what percentage of the gray
20 curves end up in that population.

21 MEMBER BALLINGER: Well, what I mean the
22 net result is nobody dies.

23 MS. GHOSH: Exactly, right. Yeah. So
24 the one other thing I'll point out, you know, this
25 is one of those things. So because the statistical

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1 summary measures are basically mathematically
2 computed at each point in time, you'll see that the
3 mean curve is in the middle.

4 There's no actual outcomes that look
5 anything like the mean curve. That's just a
6 mathematical average of everything added together.
7 But clearly we have these two distinct populations.
8 The other thing, we talked about a reduced set. I
9 know that the lower set of gray curves still kind
10 of blend together.

11 But you can kind of see that there's some
12 inflection points basically where you get liner
13 yield or in the few percentage of cases where you
14 also get rebar yield. The curve starts going up at
15 a higher slope. We talk about later, you know, we
16 did do some sensitivity calculations, because the
17 question always comes up to 72 hours, to see what
18 difference it would make in the source term.

19 The ones that are still going up, you get
20 a higher -- you get a higher source and some are
21 leveling out. But then you might hit a new yield
22 point related to containment and you get that new
23 inflection. So it kind of depends -- it's just
24 dependent on kind of where you are in the sequence
25 of things.

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1 So we also wanted to show where the
2 original SOARCA results lie with respect to the set
3 of UA cases, and so we have here -- I think we
4 already talked about this in the original SOARCA.
5 We have the station, the short-term station
6 blackout scenario on its own, and then we did the
7 sensitivity for the steam generator tube rupture.

8 So that's what those two yellow curves
9 are. The one on the bottom is the original SOARCA,
10 STSBO unmitigated curve, and the SGTR sensitivity
11 is the one that's closer to the gray population,
12 just for a comparison of how things have
13 progressed.

14 We just make a number of observations.
15 The environmental release fractions are equal or
16 lower from the UA for the Surry than the original
17 calculation, except when an SGTR occurs, and in
18 general you have an earlier start time to release.
19 But the total magnitude at 48 hours is lower
20 compared to the original SOARCA, and there are a
21 number of reasons for that.

22 The earlier start time is because we are
23 sampling a nominal leakage that goes up to one
24 percent in this case. We did switch out the
25 concrete type, which we talked about before. In

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1 the original SOARCA, we had the rebar yield at 25-
2 1/2 hours, which we don't have any more with the
3 new containment modeling.

4 This time, the uncertainty analysis SGTR
5 results, the population for the most part are
6 higher than the sensitivity we had captured, and
7 due to one of the changes we talked about earlier,
8 that KC also talked about, we have size-dependent
9 aerosol capture.

10 So now we have a lot more of the smaller
11 particles getting out in essence. So when we do
12 have a steam generator tube rupture, we're seeing
13 higher magnitude of releases on the original SOARCA
14 sensitivity calculation.

15 MEMBER BLEY: If you'd leave that one
16 back for a second. You don't draw -- on the new
17 calculations, you don't draw the mean value without
18 a tube rupture and the mean value with a tube
19 rupture. But if I draw it by eye, it looks like on
20 the right side probably the new mean without a tube
21 rupture is close to the old SOARCA, where on the
22 left side the new is about a factor of ten higher.

23 It looks like with a tube rupture, the
24 mean would be about a factor of ten higher all the
25 way across. So some of the things you said didn't

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1 quite jibe with my eyeballs. If we break it into
2 the two pieces, with the tube rupture and without,
3 they never drew the mean value for the new
4 calculation under each of those cases.

5 They draw the mean of everything, which
6 is halfway between the two cases. But the mean is
7 going to be toward the high end of the gray areas
8 for each one.

9 CHAIRMAN STETKAR: In effect the red
10 dashed line --

11 MEMBER BLEY: Is a mean.

12 CHAIRMAN STETKAR: --looks like the
13 median.

14 MEMBER BLEY: It's exactly the median,
15 because ten percent -- half of ten percent is five
16 percent.

17 CHAIRMAN STETKAR: An the green line on
18 the bottom is closer to --

19 MEMBER BLEY: Not the mean. It's not
20 high enough. It's not quite high enough. It's
21 above the median.

22 MS. GHOSH: So I think that's a good
23 comment. We can plot the means of those two
24 populations, because I think it's a valuable
25 comparison point. I believe the mean is lower than

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1 the yellow SOARCA curve, because we did look at the
2 distribution --

3 MEMBER BLEY: But it's sure not the 430
4 hours.

5 MR. WAGNER: Oh no.

6 MS. GHOSH: No, no, no. You're right.

7 MEMBER BLEY: But on the right side, with
8 48 hours, I'll bet they're close. But it would be
9 interesting to see when you actually do it, and
10 with the tube rupture it's way above what you got.

11 MS. GHOSH: It's hard to tell and I
12 apologize. It is hard to tell from this graph.
13 But the gray lines at the 48 hour mark are getting
14 pretty sparse by the time you -- because we're
15 looking at --

16 MEMBER BLEY: Yeah but the high ones, you
17 know, it's still --

18 MS. GHOSH: Yeah. Anyway, it would be
19 somewhere between the median and the SOARCA line.
20 But you're absolutely right, you know. Because of
21 the new containment modeling with this higher
22 leakage, the earlier releases are all higher than
23 what was originally modeled.

24 MEMBER BLEY: Now there are some changes
25 in modeling, but there's also uncertainty. I don't

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1 know that you've done this. If the modeling were
2 all the same but now all we were seeing is the
3 difference of doing uncertainty, we'd see that the
4 uncertainty was clearly very important to
5 understand what's going on.

6 I don't have a clue what the SOARCA
7 yellows would look like if you did your old point
8 estimates with the new modeling.

9 MR. WAGNER: Appendix A tries to do that
10 for -- not for the steam generator tube rupture,
11 but for the non-steam generator.

12 MEMBER BLEY: Yeah.

13 MR. WAGNER: So there, you sort of see a
14 base case for the UA, compared to what would be
15 representative of SOARCA.

16 MS. GHOSH: Yeah, but there's multiple --
17 sorry. But there's multiple steps in that
18 appendix. The first comparison is just the
19 straight conversion to 2.1. By the time you get to
20 the end of that, near the end of that appendix, we
21 have the comparison of the new base case, I
22 believe. So I know it's a long appendix, but it is
23 in there.

24 MR. WAGNER: Okay. They're the same
25 code, so we remove that variability? So it's best

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1 approximation of the historical SOARCA with MELCOR
2 2.1 and what we are saying is the base case for the
3 UA.

4 MEMBER BLEY: Did you actually do a curve
5 or just some update or table on that?

6 MR. WAGNER: No, there's a lot of pots in
7 there. It goes out.

8 MEMBER BLEY: I'm looking at it now. I
9 haven't found it yet, but okay.

10 MS. GHOSH: Right. Yeah, there are a lot
11 of pots.

12 MEMBER CORRADINI: It starts on page A-8
13 are all the curves.

14 MS. GHOSH: Did you have a comment? I
15 don't know if I interrupted you.

16 MEMBER CORRADINI: No, I think KC
17 answered my question. I'm fine.

18 MS. GHOSH: Okay. So next slide. This
19 is the first set of regression results that we're
20 showing. So I'm just going to quickly run through
21 what's actually in these tables. You have a set of
22 these tables for cesium, iodine, hydrogen and then
23 the consequence results later.

24 The elements are going to be the same in
25 all of the tables. So I mentioned in the

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1 introduction we used the same four regression
2 methods that we use for Peach Bottom. The first is
3 the linear rank regression. That's the traditional
4 method, was used in 1150 and a variety of other
5 studies.

6 That one doesn't capture non-monotonic
7 effects and interaction effects between variables.
8 The other three methods do do that. So the
9 quadratic recursive partitioning in MARS are all
10 more advanced methods that are able to capture non-
11 monotonic effects or some interaction effects.

12 So what you have for the measures that
13 you have in the rank regression, this SRRC is
14 basically a measure of how much more variance that
15 you can explain by adding the variable that's
16 listed, you know, to the regression equation. The
17 R square is the same. The SRRC kind of shows you
18 the direction of the dependence, whether they're
19 inversely related or directly proportional.

20 In the more advanced methods, the SI
21 index tells you, gives you a measure of how
22 important that variable is on its own, and the TI
23 index gives you an indicator of the total
24 importance of that variable.

25 MEMBER CORRADINI: So just so -- so for

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1 no steam generator tube rupture, the path length
2 for the leakage is the most important?

3 MS. GHOSH: Yeah. That's the design
4 leakage. So the way that the leakage was
5 translated is it's implemented as a leakage path,
6 right? That's the translation of the leakage area.

7 MEMBER CORRADINI: So you invent the pipe
8 length, it makes the leak less than a different
9 pipe length?

10 MR. WAGNER: Yes, yes. So it gave us the
11 .01 percent to one percent volume per day.

12 MEMBER CORRADINI: Okay. But maybe then
13 I misunderstood an explanation you said earlier,
14 because I thought -- I thought that was a
15 deterministic coupling to the pressure and the
16 failure. So that if I had low pressure, the
17 probability of failure was low, but there was a
18 deterministic leak rate at that pressure.

19 So because later on you've got down here,
20 I forget what all these things stand for, but
21 somewhere further down on the list is the CFC, and
22 I think that's the failure. So I felt the two were
23 linked. So if I knew the pressure, if I computed
24 the pressure and I looked at that pressure and I
25 looked at that, that would tell me the probability

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1 of containment failure.

2 With that probability of containment
3 failure, there's some associated deterministic leak
4 rate. I didn't know that the leak rate was also
5 variable given a pressure and a probability. It
6 seems like they should be deterministically linked.
7 I've got a pressure or am I missing something?

8 MS. GHOSH: I think the CFC is giving you
9 the yield pressures, and this is giving you the
10 translation of leakage area.

11 (Simultaneous speaking.)

12 MEMBER CORRADINI: So can I give it back
13 to you a different way? So you're saying if I have
14 a -- if I compute a pressure with MELCOR and I look
15 up on the CFC chart and it says your chance of
16 failing at that pressure is five percent. Still,
17 there's an uncertainty at what the leak rate would
18 be at that five percent, and that's the D leak?

19 MR. WAGNER: Nope. The D leak -- why
20 don't I describe it. There's two different leakage
21 paths. One leakage is design leakage, and that's D
22 leak and --

23 CHAIRMAN STETKAR: Oh. That's just what
24 it's sitting there doing today.

25 MEMBER CORRADINI: Excuse me, I'm sorry.

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1 Got it.

2 (Simultaneous speaking.)

3 MR. WAGNER: And then the other one is
4 exactly kind of what you were describing.

5 MEMBER CORRADINI: Okay. So D leak is
6 just the operational leakage whatever it might be
7 in between the containment leak rate test. Then I
8 have to screw it down to keep it within the limit?

9 CHAIRMAN STETKAR: Right, and they have
10 uncertainty about that, anywhere from whatever it
11 is, .01 percent.

12 MEMBER CORRADINI: Okay. So they're
13 totally separate. I misunderstood.

14 CHAIRMAN STETKAR: Totally separate.

15 MEMBER CORRADINI: Okay, thank you.
16 Sorry.

17 MS. GHOSH: Right. So then -- so I guess
18 getting back to the metrics of reporting in the
19 regression tables. So if you -- essentially if you
20 subtract to the SI from the TI for the more
21 advanced methods, it gives you an indicator of how
22 strong that variables effects are in interaction
23 with other variables, because the SI is what it's
24 doing by itself. The TI is the total effects.

25 If you subtract the two, it tells you how

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1 -- whether there may be strong synergistic effects
2 with that variable combined with others. Now with
3 Peach Bottom, we kind of left the regression tables
4 as that. But it does get to be difficult to
5 process all of that information.

6 So this time around, we added what we
7 hope was a process improvement in trying to come up
8 with a summary measure, which is the last two
9 columns in this table. The first one is the main
10 contribution, which we're calling the contribution
11 of that variable acting on its own. The last
12 column is the conjoint contribution, which is a
13 summary measure of how influential that parameter
14 is in interaction with other variables.

15 We came up with this summary by basically
16 -- oh, the other thing I should mention. This
17 final R square row right underneath the names of
18 the regression methods tells you kind of how much
19 of the variance in the output the regression model
20 would be able to explain.

21 So the larger that number is, it tells
22 you that the regression model came up with a way to
23 explain more of the variance and the output
24 results. So the way that we came up with our
25 summary measures was to basically take the

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1 individual contributions from all four of the
2 methods and weight them by how much of the variance
3 that method was able to explain, given the total, I
4 guess, some of the variance that all the methods
5 we're able to.

6 So the equations are in the report. I
7 don't want to say much more about it. It's in
8 Chapter 3 if anybody's curious. But that's kind of
9 how we tried to come up with a weighted summary of
10 the importance of these variables, according to the
11 regression models.

12 Okay. So that said, this is the first
13 set of results. As I mentioned, we split the
14 results into the SGTR and non-SGTR populations, as
15 well as looking at all of them, because we do see
16 different things pop up as important. So if you
17 remove the SGTR cases and we're looking at all the
18 cases that didn't go to SGTR, the design leakage
19 turns out to be the most important parameter, in
20 terms of the cesium release magnitude at 48 hours.

21 Then the next two that pop up as
22 important are the time at cycle and the particle
23 shape factor. Most of the uncertainty seems to be
24 explained by those three parameters. But we
25 highlighted in yellow those things that we thought

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1 were significant enough to say that they clearly
2 have some important contribution to the variation
3 in the results.

4 In this case, it also included the
5 containment failure curve sampling, the deviations
6 from the decay heat curves given the time at cycle,
7 as well as the chemical form of cesium.

8 MEMBER BLEY: You rank these by the main
9 contribution. But when you get on the conjoint
10 contribution, you see a few down below that have
11 quite a bit higher conjoint contributions, and you
12 don't highlight those.

13 Even though -- even though it's a small
14 individual effect like the next one that isn't
15 yellowed, the conjoint's quite a bit higher and I'm
16 just -- I haven't thought this all through very
17 much.

18 MS. GHOSH: Right, right. I mean, you
19 know, what we decided --

20 MEMBER BLEY: So it's making others --
21 it's combining with other things to make things
22 more important.

23 MS. GHOSH: Exactly, right. What we
24 ended up deciding, it's this very tiny footnote at
25 the bottom of the table. We thought it was worth

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1 highlighting any individual contributions that were
2 at least a .02 or larger, or if the conjoint
3 contribution was .01 or higher.

4 MEMBER BLEY: And nothing is .01?

5 MS. GHOSH: Not in this table. But in
6 other results we did have ones that showed up.

7 MEMBER BLEY: In some others they are,
8 yeah. Okay.

9 MEMBER CORRADINI: So just help me.
10 Conjoint means that so if I go look at D leak, if
11 it's married with something else, it's a .077? But
12 what is it married with that makes it .077? Who
13 knows.

14 MS. GHOSH: Well right, and that's what
15 we can't decipher from just looking at the
16 regression results itself. This is telling us the
17 statistical answer, and the way we try to get at
18 that is through the single realization analyses,
19 where we try to phenomenologically explain the
20 differences and some of the realizations that we
21 had.

22 So in the report, we have another section
23 that documents our explanation of what happened in
24 some of the more interesting realizations. We also
25 look at scatter plots, where we try to see, you

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1 know, how samples, variables contributed to
2 outcome. We try to take all of that together to
3 come up with our conclusions and insights.

4 Because the regression methods are great,
5 but it's one step, you know. It doesn't tell us
6 the whole story. It gives us a statistical answer.

7 MEMBER CORRADINI: But just to push my
8 point so you can say I'm wrong, if I look at SC-
9 1132, which I looked that up; I couldn't remember
10 what the hell that was, which is not the Zircaloy
11 melt breakout temperature but the detected
12 temperature, that's approximately 100 times less of
13 a main contribution than D leak.

14 MS. GHOSH: Uh-huh, yeah.

15 MEMBER CORRADINI: And that's the first -
16 - that's the first physical one. All the stuff
17 before that doesn't surprise me. It's beginning of
18 cycle, end of cycle, uncertainty and decay heat
19 which we've always known decay heat's kind of
20 important. It's the -- it's physical parameters in
21 the machine, whether it be the leakage rate or the
22 structural capability.

23 That's the first one that shows up.
24 Well, there's a valve. I have that, but it's a
25 valve. Sorry. It's just interesting that I go

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1 down a significant amount of contribution on the
2 physical models. So are you telling me as long as
3 I balance mass and energy, it doesn't matter what I
4 do? Everything is the initial boundary conditions?

5 MS. GHOSH: If I could jump ahead a
6 little.

7 MEMBER CORRADINI: Would you go back to
8 hot drop and melt clog?

9 (Simultaneous speaking.)

10 MS. GHOSH: If you'd allow me. Well if
11 we -- there are physical parameters. It depends on
12 what you're looking at and by the way, I apologize.
13 This slide should say "In Vessel Hydrogen
14 Production." I don't know if it's still possible
15 to correct this slide for the record, just because
16 --

17 Anyway, this should say In Vessel
18 Hydrogen Production. But I pull this up because
19 there are instances where depending on what outcome
20 you're looking at, that particular parameter that
21 you pointed out does show up as important. For the
22 in vessel hydrogen production, it's the second-most
23 important parameter, which also makes sense, you
24 know, because --

25 CHAIRMAN STETKAR: Tina, don't worry

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1 about the slides, because we always publish the
2 slides as an addendum to the transcript and you
3 have now corrected this slide orally.

4 MS. GHOSH: Oh okay, okay, yeah, all
5 right.

6 CHAIRMAN STETKAR: Thank you.

7 MS. GHOSH: Thanks. But with regard to
8 the cesium non-SGTR, those are the results that we
9 got. We also looked at the SGTR realizations
10 separately. As some people have pointed out, you
11 know, that is the higher magnitude release group.
12 So we also want to understand what would lead to
13 important differences in the release magnitude for
14 that group of outcomes.

15 We have a different set of parameters
16 that show up as important, and there too it's not
17 surprising. The first two are the safety valve
18 open area fraction and the tube thickness. I think
19 tube thickness we've already talked about. It's
20 intuitive. Of course that's important.

21 The safety valve open area fraction acts
22 in two ways, I think, to be significant for SGTRs.
23 One is it, along with other parameters such as the
24 number of safety valve cycles that you experience,
25 basically explains the deep pressurization rate for

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1 the most part that you have, which is important to
2 whether or not you're driving to an SGTR.

3 So that makes sense on primary side. On
4 the secondary side, it also acts as part of your
5 area for release to the environment. We talked
6 earlier about the fact that this may end up being
7 swamped by the leakage area that we also modeled.
8 But that's a potential contribution.

9 That's another one that we can't from the
10 statistical analyses alone be able to separate the
11 exact, you know, contribution in these different
12 ways. But at least from a phenomenological
13 standpoint, we can discuss those qualitatively as
14 making sense, ways that it would contribute to the
15 leak.

16 CHAIRMAN STETKAR: Well, that's why I was
17 trying to probe this morning on that secondary side
18 how important that is, because all I could read
19 from everything is just that variable name and it's
20 important. The fact that it's assigned to two
21 different -- two different functions if you will.

22 MS. GHOSH: Yeah, yeah.

23 CHAIRMAN STETKAR: You know, what I heard
24 orally is that it doesn't affect much on the
25 secondary side. But what I'm hearing now is you're

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1 not really sure about that, unless you know
2 something more about the model.

3 MR. WAGNER: No. I think it's extremely
4 important on the primary side.

5 CHAIRMAN STETKAR: Yeah, obviously.
6 Sure, sure.

7 MR. WAGNER: To get a --.

8 CHAIRMAN STETKAR: Got it, yeah.

9 MR. WAGNER: The second side is more
10 confusing.

11 CHAIRMAN STETKAR: Okay.

12 MEMBER CORRADINI: So can I ask? So tube
13 thick for this important. That I understand. So
14 why is tube temp at the bottom of the barrel?

15 (Off microphone comment.)

16 CHAIRMAN STETKAR: Yeah. Well that one
17 it makes sense, because there's no tube failure.

18 (Simultaneous speaking.)

19 MEMBER CORRADINI: It's the highest --
20 mine's on. It's the highest tube normalized
21 temperature.

22 MS. GHOSH: Yeah. So okay. So it's an
23 interesting thing, you know. Now we're not looking
24 at all of the realizations together but just the
25 subset that led to SGTR. So you know, one

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1 possibility is that there may be things that drive
2 you to an SGTR, may be very important in deciding
3 whether you get an SGTR.

4 But once you're within that population
5 may not contribute a lot to release magnitude
6 differences within that population. But I do want
7 to -- I want to mention one other thing though.

8 CHAIRMAN STETKAR: But be careful then.
9 What's your argument for SVOA frac on the primary
10 side if it's driving you to the SGTR?

11 MS. GHOSH: Yeah. I think it continues
12 to -- yeah, but I think it continues to contribute
13 to the accident progression. Yeah, I don't know.

14 MEMBER BALLINGER: I don't know. It may
15 be that the tube temp for these cases is already so
16 high that it doesn't --

17 CHAIRMAN STETKAR: Ah, that might be.
18 Maybe that's it.

19 MEMBER BALLINGER: That it doesn't
20 matter. That's the only thing that makes sense.

21 CHAIRMAN STETKAR: The uncertainty
22 doesn't make any difference --

23 MEMBER BALLINGER: Yeah, doesn't make any
24 difference.

25 CHAIRMAN STETKAR: Because the absolute

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1 value is always high enough.

2 MR. WAGNER: In a matter of minutes, with
3 the temperature escalation, the lower sample gets
4 there anyhow.

5 CHAIRMAN STETKAR: Yeah, yeah. That
6 could be.

7 MR. WAGNER: Now the SV frac was -- we
8 just had to have the primary system at high
9 pressure. You can see that in all these cases. If
10 we had a larger failure, we just didn't get any
11 tube ruptures.

12 MEMBER REMPE: Well what's interesting,
13 again I'm kind of thinking about what you said.
14 Well Sequoyah, because of this plot you showed us
15 earlier today, what was it, how many days that the
16 beginning of cycle becomes mid-cycle and end of
17 cycle.

18 Earlier today you also said this was a
19 major effort to include this, but we decided not to
20 with Sequoyah because we decided it wasn't so
21 important. It seems like you didn't need to do all
22 of the analysis to decide that beginning of cycle
23 would become mid-cycle within so many days and all
24 that effort.

25 I mean I'm not throwing stones at you,

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1 but I'm just wondering some of the history behind
2 that.

3 MS. GHOSH: Yeah. I don't think that
4 tells the whole story. The story is more
5 complicated. It's always more complicated. But
6 there are multiple aspects to the time at cycle. I
7 think there's the inventory as well as the decay
8 heats. I think the answer we gave is not the whole
9 story. I don't know if you want to elaborate.

10 MEMBER REMPE: John said we could stay
11 until midnight tonight. Go ahead.

12 CHAIRMAN STETKAR: Some of us are going
13 to need to take a break here and I was hoping we'd
14 get through the cesium regression analysis before
15 we do that, but keep going.

16 MEMBER REMPE: Because I mean it's
17 showing up as important here and that's why I had
18 that perception.

19 MR. WAGNER: The BOC stands out and
20 sometimes the statistics will pick up that low BOC.
21 You can -- Cal just made last week or something, he
22 plotted all the containment pressurizations and I
23 believe it's in the report too, and the BOCs really
24 kind of stand out. So you -- for the non-SGTR,
25 that's where it pops up as, you know.

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1 MEMBER REMPE: But it isn't doing too bad
2 here for the CG SGTR. It's showing up in one of the
3 highlighted areas.

4 MR. WAGNER: Yeah. So it's a little bit
5 hotter and temperatures are a little bit hotter and
6 we get to hotter times before we could fail a
7 valve. So all those facts. I probably misspoke a
8 little bit on it.

9 MEMBER REMPE: But the bottom line is
10 that even though it's showing up as important, it
11 was decided, because it was so much work, not to
12 include it in Sequoyah then later on even --
13 because everyone stepped back and said well,
14 eventually it will go to mid-cycle.

15 MS. GHOSH: Well, I don't want to get too
16 much into Sequoyah, because I think we're going to
17 come back to -- we're going to come back to you all
18 and talk more about it. The Sequoyah analysis was
19 meant to be a reduced scope in some ways, because
20 we've done all these work on Surry and there's
21 ongoing work on Vogtle and other things in terms of
22 PWRs in general.

23 But it was supposed to be expanded in
24 scope specifically for ice condenser, you know,
25 parts of the analysis. So you know, the team kind

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1 of tried to make a judgment of which were the most
2 important parameters to include, to be able to
3 explain ice condenser-specific, you know,
4 variations and what might happen.

5 In terms of the time at cycle, I think we
6 felt we had done enough with Surry that we could --
7 we have some idea of what the magnitude and nature
8 of the effect is of having the beginning of cycle
9 versus the middle or end of cycle.

10 We're not sure what more we would have
11 gained by continuing to include that for Sequoyah.
12 We could probably have a separate qualitative
13 discussion that explains what the impact is if
14 you're closer to beginning of cycle versus middle
15 and end of cycle.

16 We just -- for the purposes of that
17 analysis, we didn't think it was worth continuing
18 to include that, given that we did do all this work
19 for Surry and we do have very good insights into
20 the differences.

21 MEMBER REMPE: Okay.

22 MS. GHOSH: But we'll be coming to talk
23 to you about that certainly at some point.

24 CHAIRMAN STETKAR: I'm now going to
25 intercede. A couple of constraints. We need to

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1 finish no later than, no later than 5:30. So
2 despite of all of my ranting, we will finish by
3 5:30. Let's take a recess. I'm going to try to
4 hold us to ten minutes if we can do that. Let's
5 come back at 3:30.

6 (Whereupon, the above-entitled matter
7 went off the record at 3:21 p.m. and resumed at
8 3:30 p.m.)

9 CHAIRMAN STETKAR: I'm going to try to
10 get us done by 5:30. So we are back in session.

11 MS. GHOSH: Okay. I think we finished
12 talking about the cesium regression results. This
13 is a set of results for iodine. The general
14 characteristics of the iodine releases pretty much
15 follow what's going on with cesium. You see the
16 two groups, SGTR versus no SGTR. You see the
17 inflection points for the non-SGTR where you have
18 various containment yield points. And we have in
19 the backup slides the comparison to the original
20 SOARCA curve, but again there wasn't anything
21 terribly new and interesting compared to the cesium
22 comparison.

23 MEMBER BLEY: Is that in the package you
24 gave us?

25 MS. GHOSH: Yes, it's in the back,

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1 towards the back. You have some backup slides
2 there.

3 So for the non-SGTR realizations for
4 iodine we see a similar set of results in terms of
5 what's important, what's most important to the
6 cumulative magnitude of iodine fraction release by
7 48 hours. The time at CYCLE here is -- it becomes
8 most important, but the containment failure curve
9 sampling and the design leakage rate sampling
10 continues to be important. And we also see here
11 the chemical form of iodine becoming a little bit
12 more important. And it makes sense for the reasons
13 we discussed before. We're sampling on how much of
14 the iodine is gaseous which is much more mobile.
15 So it makes sense that that pops up for iodine.

16 This is the distribution of the in-vessel
17 hydrogen production.

18 MEMBER CORRADINI: Can we get a
19 clarification?

20 MS. GHOSH: Yes?

21 MEMBER CORRADINI: So we're just debating
22 with each other here. I think I understand why
23 CYCLE beats D leak and CFC, okay, for iodine. I
24 think I understand that. But does the sum of the
25 main contribution have to add up to one? So if one

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1 wins, something else has to lose in terms of
2 contribution?

3 MS. GHOSH: Let me think about --

4 MEMBER CORRADINI: In other words, if
5 CYCLE is 0.38, the larger the main contribution is
6 with the top dog, do all the other ones suffer?

7 MS. GHOSH: Yes, and I think that's
8 generally true. The way we have done it, because
9 we're showing you a summary measure across the four
10 methods, it may not add up perfectly; and Dusty can
11 correct me if I'm wrong, but that's roughly the
12 idea.

13 MEMBER CORRADINI: So it does have to add
14 up to -- it all has to sum up to the same value?

15 MS. GHOSH: Yes.

16 MEMBER CORRADINI: So if one gains in
17 importance, the others have to lose in relative
18 importance.

19 MS. GHOSH: In relative importance.
20 Exactly.

21 MEMBER CORRADINI: Okay. Then I
22 understand.

23 MS. GHOSH: It's all relative, right.

24 MEMBER CORRADINI: Okay. All right.
25 That explains it. Thank you.

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1 MS. GHOSH: So this is the in-vessel
2 hydrogen production. And I would say it's fairly
3 well-behaved. Everything is generated by 10 plus a
4 little bit hours. And the spread is roughly
5 between and 200 and 600 kilograms at the end of 48
6 hours. And the regression results are -- in this
7 case it doesn't matter whether or not you have an
8 SGTR. And the most important parameters that show
9 up are really a proxy for depressurization, which
10 in this case is the safety valve open area fraction
11 as well as the effective melt temperature.

12 MEMBER CORRADINI: So two things here.

13 MS. GHOSH: Yes.

14 MEMBER CORRADINI: So the one thing is
15 that this all occurs before this bifurcation of the
16 -- most of it occurs before the bifurcation of
17 steam generator tube rupture. Things start cooking
18 inside the vessel before we decide that we go hot
19 leg or go steam generator tube. I think I'm
20 correct there.

21 The second thing is you said that you
22 accidentally had the wrong concrete. Where do I
23 see the accident had the wrong concrete effect?
24 Because I would assume I produce a whole lot more
25 hydrogen with limestone common sand.

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1 MEMBER BALLINGER: This is in-vessel.

2 CHAIRMAN STETKAR: This is in-vessel.

3 MEMBER CORRADINI: Oh.

4 CHAIRMAN STETKAR: This is in-vessel.

5 She corrected this slide.

6 MEMBER CORRADINI: Sorry.

7 MS. GHOSH: Yes.

8 MEMBER CORRADINI: I'm sorry. Sorry.

9 Thank you. Never mind.

10 MS. GHOSH: Sorry about that.

11 (Simultaneous speaking.)

12 MS. GHOSH: And I think this is our last
13 slide for this section. As I noted earlier, we did
14 extend a handful of the realizations, nine of them,
15 out to 72 hours to see what the effect would be on
16 the release fractions of any containment failures
17 that might occur beyond 48 hours. And I think we
18 already talked about this. In essence, for cases
19 in which the rebar yield was reached, the pressure
20 temps to level off and then gradually decrease as
21 leakage more than compensates for the steam
22 generation and heating of the atmosphere, but in
23 some cases there are marked increases in cesium and
24 iodine release at the pointer of liner yield or
25 rebar yield. And if that happens after 48 hours,

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1 you can get up to an order of magnitude increase
2 between that 48 hours and 72-hour simulation times.

3 Any questions before we move to the MACCS
4 analysis results?

5 MEMBER REMPE: Just a question on this
6 slide.

7 MS. GHOSH: Oh, yes, thank you. Joe's
8 reminding me. Oh, go ahead. On this slide, yes.

9 MEMBER REMPE: Yes, it just says that the
10 results are in the process of being updated. And I
11 didn't hear that today. I didn't remember seeing
12 that in the report.

13 MS. GHOSH: No, this is fresh, hot off
14 the press --

15 (Laughter.)

16 MS. GHOSH: -- that information.

17 MEMBER REMPE: What was the reason. I
18 wanted to ask earlier, but I didn't.

19 MS. GHOSH: Before we get to that, can I
20 just ask -- Kyle Ross has looked up the information
21 on the numerator that you were asking about from
22 NUREG/CR 7037, and he's prepared to discuss it --

23 CHAIRMAN STETKAR: Oh, okay.

24 MS. GHOSH: -- when it's a good time. Is
25 this a good time?

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1 CHAIRMAN STETKAR: This would be a great
2 time, because otherwise we'll lose it.

3 MR. ROSS: Yes, so someone was kind
4 enough to print out the NUREG, the question, and I
5 left one page on my chair, but there's a table 20
6 on page 42 that I worked from. And there's
7 information here for main steam system valves and
8 reactor coolant system valves. And there is
9 failure to close and failure to open.

10 MEMBER CORRADINI: Where are you? Can
11 you say again where you are?

12 MR. ROSS: It's in a different NUREG.

13 MEMBER CORRADINI: Or a different NUREG?

14 CHAIRMAN STETKAR: It's a different NUREG
15 and it's -- I printed out the tables in the
16 appendix.

17 MR. ROSS: Yes, I think it's NUREG/CR
18 7037.

19 MEMBER CORRADINI: What was that page
20 number again?

21 MR. ROSS: Forty-two.

22 CHAIRMAN STETKAR: Okay. We've got the
23 table, table 20.

24 MR. ROSS: Yes, it will be -- you see the
25 differentiation between main steam system valves

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1 and reactor pump system valves.

2 CHAIRMAN STETKAR: Yes.

3 MR. ROSS: And the distinction between
4 open and closed. So it's failure to open and
5 failure to close distinction.

6 CHAIRMAN STETKAR: Yes.

7 MR. ROSS: And all that I looked at was
8 the non-recovery probability numbers.

9 CHAIRMAN STETKAR: Yes.

10 MR. ROSS: So for failure to close there
11 were 769 demands and 5 failures.

12 CHAIRMAN STETKAR: Yes, but --

13 MR. ROSS: On the bottom half of the
14 table for the reactor coolant system valves there
15 were -- again under non-recovery probability there
16 were --

17 CHAIRMAN STETKAR: Yes.

18 MR. ROSS: -- four demands and two
19 failures. So summing those, assuming that the
20 valves on the secondary side and valves on the
21 primary side are quite similar --

22 CHAIRMAN STETKAR: Yes.

23 MR. ROSS: -- then you have seven
24 failures to close out of 773.

25 CHAIRMAN STETKAR: Right. In table 4-2

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1 in your report the distribution is based on 17
2 failures to close in 773, not 7.

3 MR. ROSS: Yes, it does. Yes.

4 CHAIRMAN STETKAR: Yes, it does. And the
5 distribution actually comes out -- I ran out the
6 distribution.

7 MR. ROSS: Comes out with --

8 CHAIRMAN STETKAR: 17/773 is the expected
9 value of the data.

10 DR. SHACK: It looks like it's all
11 failures recovered and non-recovered plus recovered
12 and non-recovered.

13 CHAIRMAN STETKAR: Yes, and most of these
14 are actually from -- the main steam stuff is all
15 from boilers, because I don't think they -- if you
16 go back to the appendices, the appendices don't
17 have pressurized water reactor steam safety valves,
18 which is fine. I'm not arguing about compiling the
19 two. But anyway the table 20 is what you used?

20 MR. ROSS: It is.

21 CHAIRMAN STETKAR: Okay.

22 MR. ROSS: I guess I went back to my
23 chair thinking it was seven. I'm looking for 7 and
24 17 was --

25 (Simultaneous speaking.)

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1 CHAIRMAN STETKAR: Well, I found some 15s
2 and 2s and stuff like that, but I couldn't find any
3 17s with 773. So I was --

4 MR. ROSS: Yes.

5 CHAIRMAN STETKAR: -- I honestly tried to
6 kind of gin up those numbers, and I couldn't get
7 them. Anyway, that's -- I did not look at this
8 table. I was back in the appendix. There are
9 several tables in the appendix for both pressurized
10 water reactors --

11 MR. ROSS: Okay.

12 CHAIRMAN STETKAR: -- and boiling water
13 reactors. And I was trying to compare those two
14 and add up demands and failures and I still
15 couldn't get them to add up.

16 MR. ROSS: No, I can understand.

17 CHAIRMAN STETKAR: And this is -- I
18 didn't look at this table, so I don't know how they
19 compiled the values in this table from the
20 appendix.

21 MR. ROSS: The other issue, on the next
22 page is table 22, and it is failure probabilities
23 based on testing. And the numbers are so
24 dramatically different than the ones that we just
25 talked about.

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1 CHAIRMAN STETKAR: Yes, and as we were
2 talking earlier, I -- from my own experience for
3 failure to open testing in many cases they'll
4 report a failure if it opened at a half a pound
5 higher than the range on its set point. Failure to
6 close on the other hand might be valid from
7 testing, because once it's open if it sticks or
8 binds mechanically, that might be valid. I don't
9 know how that stuff is reported.

10 MR. ROSS: Well, what spooked me out from
11 using the failure probabilities based on testing is
12 that they are so dramatically different than the
13 ones from behavior after scram.

14 CHAIRMAN STETKAR: Yes.

15 MR. ROSS: That's why I used the 17 out
16 of 773.

17 CHAIRMAN STETKAR: But part of what I
18 hung up on, if you go back in the appendix to this
19 report, if you look at table B-6 in the appendices
20 -- I think it's B-6. Let me get to it. You may
21 not have it there in front of you, but it's failure
22 probabilities for pressurized water reactor code
23 safety valves. SVV failed to open not recovered
24 given a scram is 0 in 773. And the 773 demands,
25 scram related demands for pressurizer safety valve

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1 is what I was taking issue with. And that 773
2 happens to be the same denominator as your 769 plus
3 4.

4 MR. ROSS: Right.

5 CHAIRMAN STETKAR: So anyway, at least in
6 the interest of time I think we probably both need
7 to do a little bit more homework on this. And
8 thanks for pointing me to that table 20, because I
9 immediately went to these tables in the appendix.

10 MS. GHOSH: Okay. So getting back to
11 your question, our cryptic note that you may have
12 noticed here. So as often happens with our codes,
13 sometimes we discover issues, and we discovered an
14 issue very late last week in the middle of
15 preparing for this meeting. And we're not prepared
16 to talk a whole lot about it today, but we
17 discovered that it does affect our MACCS results
18 for the Surry UA. It was an issue with MELMACCS
19 where it was case-sensitive in a way that we didn't
20 anticipate or didn't know, so that the MELMACCS
21 translation of the MELCOR output to MACCS ended up
22 inputting to MACCS a source term that was roughly a
23 factor of two lower than what it should have input
24 to MACCS.

25 So actually over the weekend we re-ran

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1 most of the MACCS calculations. We still need to
2 rerun the sensitivity calculations from what I
3 understand. We reran the regressions. And we know
4 that we need to update all the results in the
5 report, but we literally just found out about it
6 late last week, so we couldn't up[date the report
7 or all of the slides in time for this meeting. But
8 this is just to let you know that the report is
9 going to be updated. So all the quantities are
10 going to change in terms of the tables and the
11 graphs that are there for the MACCS results, but
12 our conclusions and insights don't change.

13 We reran the regressions, essentially the
14 things that were previously shown to be important.
15 For the most part the most important things
16 continue to show to be important. And we have in
17 the slides an example just to show you -- give you
18 some indicator of the magnitude of the changes that
19 you might eventually expect.

20 So the only comparison we have here is
21 just for the 0 to 10-mile latent cancer fatality
22 risk. And on the left we're showing you the
23 complementary cumulative distribution functions for
24 LCF risk for the five radial distances, the
25 circular distances. And I see our label is gone.

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1 This is for all five distances. On the right is
2 the old LCF risk results. And what we've put in
3 the table, just to give you some indication of the
4 magnitude of the fact, is how much higher the new
5 results are to the old results.

6 So the source term roughly went up by a
7 factor of two. As we expected, in terms of the
8 lower percentiles up through the median, and we
9 don't know where this levels off, there's a roughly
10 linear effect between source term and the LCF risk.
11 When you get to the higher percentiles, it kind of
12 starts curving over like this, so you end up with a
13 sublinear effect. So by the time you get to the
14 mean, the new mean is about 1.6 times as high as
15 what we previously calculated. The 95th is about
16 1.5 times as high. But that's just to give you a
17 sense again of the magnitude of the fact.

18 So we're going to update the report with
19 all of the new results, and so all the graphs and
20 tables will be replaced. But again, it doesn't
21 change our conclusions. And what we see is still
22 showing up as important in terms of the regressions
23 are the same.

24 So later in this portion of our talk we
25 do show some other consequence results. Those are

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1 going to be updated. But in terms of the insights
2 we don't expect them to change. So we thought it
3 would still be worthwhile to talk about it today.

4 MEMBER SKILLMAN: Tina, how confident are
5 you that you've been thorough in identifying all of
6 the areas that are affected by that change in
7 source term?

8 MS. GHOSH: You mean for this project?
9 Right now we're doing kind of an extensive -- we're
10 in the middle of an extensive condition evaluation
11 to understand how it impacts other projects. We
12 know that it doesn't impact the Peach Bottom
13 uncertainty analysis that we did. It did impact
14 also the Sequoyah uncertainty analysis we did, but
15 we haven't come to you with those results yet. So
16 we'll update them before we come to you.

17 MEMBER SKILLMAN: So you're doing some
18 form of an extended condition review?

19 MS. GHOSH: Yes. Yes.

20 MEMBER SKILLMAN: And is that part of
21 your internal processes here at the NRC, or is that
22 something you're doing just as a matter of being
23 good soldiers?

24 MS. GHOSH: Well, I think -- well, Sandia
25 is conducting that, but I think that is -- whenever

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1 we find an issue, we need to know what it impacts
2 with regard to our ongoing and past projects. I
3 think it's part of our standard processes. I don't
4 know if it's formal somewhere, but we're doing that
5 evaluation now to see what else might be affected.

6 MEMBER SKILLMAN: Thank you.

7 MS. GHOSH: Okay. So I'm going to turn
8 it over to Nate.

9 MR. BIXLER: Okay. So this is
10 sensitivity regression analysis for -- in this case
11 we're looking at within 10 miles and we're looking
12 at all 1,004 realizations and looking at the most
13 important parameters that affect the results. And
14 the two that go at the top are tube thickness and
15 SV open area fraction, which are the two parameters
16 that Tina talked about earlier as being highly
17 influential on determining whether you get an SGTR
18 or not. So roughly you get something like an order
19 of magnitude jump in the source term depending on
20 whether you get the SGTR. And these two parameters
21 influence that, so it's not hard to imagine why
22 they should be right at the top.

23 The next parameter in order there is the
24 time at CYCLE. And as was described before, the
25 primary difference is between beginning of CYCLE

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1 and middle -- end of CYCLE. But that does end up
2 having kind of a twofold impact on the max results
3 because it influences the MELCOR source term that's
4 calculated, but it also influences the core
5 inventory that goes directly into the MACCS input
6 that determines if we have a release fraction from
7 MELCOR. That release fraction multiplies a core
8 activity and then -- so it directly impacts the
9 consequences through that.

10 MEMBER SKILLMAN: Nate, throughout these
11 slides and also in the report the words "circular
12 area" are used. From my background it was always
13 radius near the center --

14 MR. BIXLER: Yes.

15 MEMBER SKILLMAN: -- for emergency
16 planning and for EPZs.

17 MR. BIXLER: Right.

18 MEMBER SKILLMAN: Is the 10 mile and the
19 50 mile and 20 mile the same as the radius as in an
20 EPZ?

21 MS. GHOSH: Yes.

22 MR. BIXLER: Yes, that the radius. Those
23 distances are the radius defining a circular area.

24 MEMBER SKILLMAN: I thank you for the
25 clarification. I did not find that anywhere in the

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1 report. I was looking for it as a definition.

2 MR. BIXLER: Okay.

3 MEMBER SKILLMAN: Okay. Thank you.

4 MR. BIXLER: Okay.

5 MS. GHOSH: Yes, thanks for that. Yes.

6 MR. BIXLER: Thanks for that comment.

7 That's a good comment.

8 Okay. And then the fourth parameter on
9 the list that -- I think five are highlighted here,
10 I believe. The fourth one of the list is
11 groundshine shielding factor, which I had described
12 earlier as being one of our uncertain parameters.
13 It's accounting for things like the time spent
14 indoors versus outdoors and how protective a
15 building is in terms of reducing groundshine dose,
16 etcetera. So that turns out to be a very important
17 parameter. Not surprising also, since groundshine
18 is the dominant dose pathway for the overall
19 analysis.

20 And then I think the last one that's
21 highlighted is the D leak parameter. That's
22 related to the design leakage rate that's used in
23 the MELCOR. So those are the most important
24 parameters. And I think we see those parameters
25 showing up quite consistently through most of our

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1 results.

2 Let's see, this is for -- by the way,
3 these are all LNT. The last slide and this one are
4 LNT results. And those are the ones that I'm going
5 to talk about today. This is also for a 10-mile
6 area, or 10-mile radius, 10-mile circular area,
7 radius of 10 miles, but just selecting the cases
8 where there is no SGTR. And in this case time at -
9 - since we don't have an SGTR, the parameters that
10 influence whether you get an SGTR are not on the
11 list here, or at least not important. They're not
12 at the top of the list. But the time at CYCLE is
13 important. The groundshine shielding factor, the
14 design leak rate.

15 And one additional parameter comes up
16 here as being important. That's the risk factor
17 for the -- No. 8 there stands for the residual
18 cancer risk factor, which ends up being the most
19 important contributor overall to risk of all the
20 risk factors that we have on the list. So that one
21 ends up being an important one.

22 Okay. Here we're looking at a 50-mile
23 radius, circular area with 50 miles, all
24 realizations. And so again the tube thickness and
25 the SV open area fraction show up as being the most

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1 important ones, groundshine shielding factor as
2 also important, but down the list.

3 And similarly to the results that I
4 presented before, this is 50-mile radius, but just
5 the subset without SGTR. And here CYCLE is at the
6 top. So the time at CYCLE, the groundshine factor,
7 the design leak rate, and again the cancer risk
8 factor for residual cancers.

9 Okay. These are some single realization
10 examples that we looked at. There are two curves
11 for each color. One represents 0 to 10 miles. The
12 second one represents 10 to 20 miles. The 10 to
13 20-mile one are all lower than the 0 to 10 miles.
14 And the yellow curve here, or the two yellow curves
15 represent the basic Surry uncertainty analysis
16 results that we got. And what's different about
17 the colored, the blue, green and red-colored curves
18 is that those are for single MELCOR source term
19 results, but we're sampling on the other MACCS
20 parameters other than source term. So we're just
21 looking at an individual source term description
22 definition and looking at all the other uncertain
23 parameters in MACCS in those, in the blue, green
24 and red curves.

25 PARTICIPANT: Can you say that again --

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1 MR. BIXLER: Okay.

2 PARTICIPANT: -- because I don't
3 understand.

4 MR. BIXLER: Okay. Sure. The yellow
5 curves are SOARCA uncertainty analysis results, so
6 those consider all of the uncertain parameters in
7 MELCOR plus MACCS.

8 And the other curves, the blue, green and
9 red are just looking at MACCS uncertain parameters
10 for a fixed MELCOR source term. And the blue is --
11 it's pretty obvious from looking at the curves
12 here, but the blue curves are for relatively small
13 end of the source term range, green somewhere in
14 the middle and red towards the upper end of the
15 source terms.

16 And one thing you can see is that the
17 curves by and large overlap each other, or overlap
18 with the yellow curve, except for the red ones at
19 the upper end of the range extend beyond the yellow
20 curve, which indicates that there are some
21 combinations of large source term with other MACCS
22 parameters that would give you an ever larger risk
23 that are not captured in our basic uncertainty
24 analysis.

25 CHAIRMAN STETKAR: If I look at this,

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1 though, one thing it tells me, if I compare the
2 general shape and -- let's say the range of the
3 yellow to the range of any of the other colors, is
4 that most of the uncertainty in the overall Surry
5 results comes from the MELCOR part of the analysis
6 and not from the MACCS part of the analysis.

7 MR. BIXLER: Yes.

8 CHAIRMAN STETKAR: I guess that to me is
9 a bit surprising.

10 MEMBER CORRADINI: I was going to say
11 didn't you make that same comment when we were in
12 Peach Bottom? I seem to remember.

13 CHAIRMAN STETKAR: I probably did --

14 MEMBER CORRADINI: You kind of pondered
15 the table a little bit.

16 CHAIRMAN STETKAR: -- but I don't
17 remember this morning.

18 MR. BIXLER: Yes, we found the same
19 relationship between the two sources of uncertainty
20 in Peach Bottom that we see here, and that's that
21 source term contributes more to the overall
22 uncertainty than all the other uncertain parameters
23 that go into the consequence analysis.

24 CHAIRMAN STETKAR: Do we actually believe
25 that?

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1 MS. GHOSH: Yes.

2 MR. BIXLER: I think we do, yes.

3 MS. GHOSH: I think we do, but let me
4 just add one thing: Just a reminder that the
5 distribution we're plotting here is the
6 distribution of the means from all the weather
7 trials.

8 CHAIRMAN STETKAR: Right.

9 MS. GHOSH: So in the Peach Bottom work,
10 some of the add-on work that we did, in fact in
11 response to questions that were raised by the ACRS,
12 we also separated out the contribution of the
13 weather variability and the source term variability
14 and the MACCS variability.

15 MR. BIXLER: Yes.

16 MS. GHOSH: The weather variability
17 actually is a significant contribution as well.
18 Here the reason you don't see it pop up is because
19 we're looking at the means of the weather
20 variability. So here we're just looking at the
21 contribution of the epistemically uncertain MACCS
22 parameters.

23 MEMBER CORRADINI: So can I say it
24 differently? You have all sorts of relatively
25 fancier terms from me. The weather is highly

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1 variable. We don't see it here because you've
2 taken the mean value over a year?

3 CHAIRMAN STETKAR: But you do see it in
4 the yellow?

5 MR. BIXLER: No, you don't.

6 CHAIRMAN STETKAR: You don't?

7 MR. BIXLER: Yellow is also averaged.

8 MEMBER CORRADINI: Oh, okay.

9 MR. BIXLER: These are all points that
10 are averaged --

11 (Simultaneous speaking.)

12 MEMBER CORRADINI: So I would expect to
13 see the weather would broader all this out?

14 MS. GHOSH: Exactly.

15 MR. BIXLER: Well, it would.

16 MS. GHOSH: Exactly.

17 MR. BIXLER: It would if we plotted that
18 along with the other uncertainty. But let me make
19 one more point: There's one additional uncertainty
20 that we're not accounting for here because these
21 are only LNT results, and that's the uncertainty in
22 dose response. If we were to include that and add
23 that as an uncertainty, then it would broaden
24 things quite a lot.

25 CHAIRMAN STETKAR: That's clear, but I'm

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1 trying to hold us to within the constraints of what
2 was done.

3 MS. GHOSH: Right.

4 CHAIRMAN STETKAR: And given the fact
5 that the yellow and the other colors are all still
6 based on the mean of the weather, then my comment
7 still holds that most of the uncertainty comes from
8 the MELCOR part of the equation and not from the
9 MACCS part of the equation. If we were to add the
10 uncertainty in the weather to both, we would see a
11 broadening, a flattening, if you will, of these
12 curves, but they would flatten in a relative sense
13 the same way.

14 MR. BIXLER: That's right.

15 MS. GHOSH: Yes, I think that's right.

16 CHAIRMAN STETKAR: And that's why I ask
17 if you're just looking at the non-weather related
18 uncertainties in MACCS, evacuation times and dose
19 response correlations and things like that, it's
20 surprising that those uncertainties are relatively
21 modest if I look at an order of magnitude spread on
22 those curves.

23 MS. GHOSH: And I think we believe the
24 results, you know the -- a lot of the MACCS
25 modeling is tied to the habitability criterion,

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1 which kind of fixes the long-term dose rate that
2 people are able to incur. And that's set at 2 rem
3 the first year and then 500 millirem all subsequent
4 years. So once you get past the initial emergency
5 phase -- and we find again here that the long-term
6 dominates that the health risk is from people
7 either never having to evacuate because their dose
8 rates meet that criterion or coming back after that
9 dose rate is met. That kind of provides a backstop
10 in how much dose you can end up incurring over your
11 lifetime.

12 CHAIRMAN STETKAR: I get that. What I'm
13 challenging is have we adequately captured the
14 uncertainty in the emergency phase, the early part
15 of this stuff?

16 MR. BIXLER: For this particular
17 calculation the doses and health effects that would
18 potentially stem from the emergency phase are a
19 smaller contributor. They don't contribute 50
20 percent. I think on the average more like 25
21 percent to the whole. So variations in that really
22 don't have a gigantic impact on the final results
23 that we're plotting here.

24 CHAIRMAN STETKAR: Okay. Yes, I was
25 going to say I guess I can understand that in

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1 latent cancer.

2 MR. BIXLER: Yes, our releases are not
3 that early. There's time at least to start
4 evaluation.

5 CHAIRMAN STETKAR: Latent cancer, LNT, I
6 guess I can grudgingly accept that.

7 MEMBER BLEY: Kind of what you're looking
8 for I think is if in fact evacuation were greatly
9 delayed, would that have a big impact on early
10 fatalities?

11 CHAIRMAN STETKAR: Yes, exactly. Yes.

12 MEMBER BLEY: Or if you got caught.

13 CHAIRMAN STETKAR: Because you just get
14 such a -- under the LNT assumption you just get so
15 many people dosed from --

16 MEMBER BLEY: A little bit.

17 CHAIRMAN STETKAR: Well, re-habitability
18 dose --

19 MR. BIXLER: Yes.

20 CHAIRMAN STETKAR: -- in the long term is
21 that I guess it just swamps anything that you could
22 possibly get by dosing at the initial -- people
23 during the initial --

24 MS. GHOSH: Yes, so we don't talk in this
25 -- I think we don't have slides on the early

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1 fatality risk, but we did compute them. And we do
2 get a handful of non-zero numbers, which is -- it's
3 the model validation exercise so that we can
4 compute these small numbers. But I think there is
5 a non-evacuating cohort that's sitting there and
6 doesn't evacuate. And I think the only time they
7 do is -- we assume that if they're told that
8 they're sitting in a hot spot, eventually they get
9 out, but that happens at a later time when they've
10 already been sitting in the plume and so on.

11 CHAIRMAN STETKAR: Yes.

12 MS. GHOSH: We did vary the delays to
13 evacuation and how slow it would be, even taking
14 all of these things into consideration. And we did
15 have some releases that started on the earlier
16 side, given the ETEs for Surry, but I think for the
17 reasons Joe mentioned earlier; maybe you're about
18 to repeat them, we don't see that overlap where
19 we're getting -- we're able to get large doses in
20 the early phase to people.

21 MR. JONES: This is Joe Jones. What I
22 wanted to add was that as I mentioned earlier we
23 have depart times, but we have a cohort that is the
24 evacuation tail that Nate mentioned earlier. And
25 if you look at the depart time, which includes a

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1 delay to shelter and a delay to evacuation, and if
2 you look at the upper bound of that, they wouldn't
3 leave for almost 13 hours.

4 And if you look at the lower bound of the
5 speed, which is a half a mile an hour, you're
6 looking at almost 20 hours before some of these
7 people would be out of the area. And so we did
8 look at the results and found that there was no
9 relationship between these longer leaving people
10 and the consequences, which leads us to believe
11 it's the non-evacuees, as Tina just mentioned.

12 CHAIRMAN STETKAR: Okay. But the non-
13 evacuees are definitely sheltered?

14 MR. BIXLER: The non-evacuees are just
15 going about normal activities.

16 CHAIRMAN STETKAR: Yes, well, but 70
17 percent of the time, or whatever you did there,
18 they're inside?

19 MR. BIXLER: Yes.

20 CHAIRMAN STETKAR: In some sort of --

21 MR. BIXLER: Right around 80 percent of
22 the time we assume they're inside and the other
23 fraction outside. So, yes, that's true.

24 CHAIRMAN STETKAR: Okay.

25 MR. BIXLER: Okay. All right. This

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1 shows some sensitivity results for phrased
2 durations and for dose projection periods. Let's
3 see if I can read the small print here. There are
4 cases here with seven-day emergency phase. That's
5 kind of our standard calculation that we did for
6 this analysis. We looked at 15 and 30-day
7 emergency phases, so extending those to longer
8 durations. We look at a variation where we had a
9 six-month intermediate phase.

10 We haven't really talked too much about
11 the intermediate phase in MACCS, but intermediate
12 phase is between the emergency phase and the long-
13 term phase. And it's a period of time where the
14 only activity, the only action is relocation,
15 continued relocation of the public. The larger
16 actions, activities begin in the long-term phase,
17 and those include decontamination. So basically it
18 postpones for a period of time when you begin to
19 decontaminate.

20 MEMBER CORRADINI: That's a time window?
21 So I thought there was a definition for early,
22 intermediate and late. Is it a time window
23 definition or a dose, an expected dose definition?
24 That's what I don't remember.

25 MR. BIXLER: It's a time definition.

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1 MEMBER CORRADINI: So a few days is
2 early, intermediate is a few weeks, and then late
3 is --

4 MR. BIXLER: In this case six months.

5 MEMBER CORRADINI: Okay.

6 MR. BIXLER: We looked at a variation
7 with an intermediate phase of six months.

8 MEMBER CORRADINI: Okay.

9 MS. GHOSH: But our base case has no
10 intermediate phase. It had a zero duration for the
11 intermediate phase. So we're looking at the
12 relative importance of a six-month delay in when
13 you begin to decontaminate.

14 MEMBER CORRADINI: So --

15 MS. GHOSH: And --

16 CHAIRMAN STETKAR: Oh, go ahead. I had a
17 different question, but I'm not sure where to ask
18 it, so maybe I'll just try it and then Tina will me
19 to wait or whatever.

20 So this was done with what dispersion
21 model in MACCS?

22 MR. BIXLER: This is done with the
23 Gaussian plume segment model that I talked about
24 earlier and Pat showed the --

25 MEMBER CORRADINI: So as somewhere in the

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1 document said, you weren't looking at model
2 uncertainties. But now you guys have instituted --
3 you told me this, and I forgot what it's called --
4 from the military side, the three-dimensional --

5 MR. BIXLER: Oh, Lagrangian particle
6 tracking?

7 MEMBER CORRADINI: Yes, high-split,
8 right?

9 MR. BIXLER: High-split, yes.

10 MEMBER CORRADINI: Okay. But that has
11 not been looked at here as to how --

12 MR. BIXLER: No, that model was not
13 available and ready to use --

14 MEMBER CORRADINI: That's fine.

15 MR. BIXLER: -- for this work.

16 MEMBER CORRADINI: Would you expect
17 anything significantly different if I took a model
18 that took in the third dimension and how things
19 move around?

20 MR. BIXLER: I would expect some
21 differences, yes.

22 MEMBER CORRADINI: Both positive and
23 negative? Both higher and lower, I would assume?

24 MR. BIXLER: Yes, I think so. And I
25 don't feel confident that I know the answer to your

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1 question, but one thing that does happen when you
2 account for all three dimensions is you have
3 aerosol particles that will rise up into the
4 atmosphere, and usually the wind speeds are higher
5 as you get above the ground farther. So those will
6 travel faster.

7 And then some of them will come back down
8 near ground level again, but they'll arrive more
9 quickly than what you get with the Gaussian plume-
10 type model. So it does affect the timing of when
11 contaminants reach a location, but it also at the
12 same time affects the amount of dispersion you get
13 along the pathway, depending on the atmospheric
14 conditions and so forth. So the trade-off between
15 all those things I'm not real sure about how that
16 would come out, but for sure one thing that does
17 happen is the arrival time is typically earlier
18 with Lagrangian particle tracking than it is with
19 the Gaussian model.

20 MEMBER CORRADINI: Okay.

21 MEMBER BLEY: I have a very naïve
22 question.

23 MEMBER CORRADINI: I've still --

24 MEMBER BLEY: Oh, go on.

25 MEMBER CORRADINI: -- got just one

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1 quickie. So you said in your base case there was
2 no intermediate phase?

3 MR. BIXLER: Right.

4 MEMBER CORRADINI: Which mean
5 decontamination processes occurred earlier?

6 MR. BIXLER: Yes, that's right.

7 MEMBER CORRADINI: The reason I asked the
8 question about high-split is because I was guessing
9 that things moved faster. So you would probably
10 want -- not want -- it would be good if you could
11 start decontamination processes earlier rather than
12 letting it all sit there and drag people out.

13 MR. BIXLER: Yes, I think that's a
14 general -- that's a true statement regardless of
15 which atmospheric transport model you're using.

16 MEMBER CORRADINI: Okay.

17 MR. BIXLER: But just in general --

18 MEMBER CORRADINI: But the quantification
19 of that is done parametrically here?

20 MR. BIXLER: Yes.

21 MEMBER CORRADINI: That is, no
22 intermediate/intermediate?

23 MR. BIXLER: Right.

24 MEMBER CORRADINI: Okay.

25 MR. BIXLER: That's right.

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1 MEMBER CORRADINI: Thank you.

2 MS. GHOSH: Just a quick note. Just for
3 the record, we are implementing this high-split as
4 an alternative ATD module to use. And we do expect
5 some differences, but the reason we're comfortable
6 to comfortable to continue using the Gaussian plume
7 segment model for the typical applications we have
8 is that we do have a benchmarking study that had
9 been published to compare the results of using the
10 existing MACCS ATD module against these other
11 modules.

12 MEMBER CORRADINI: Yes, I wasn't
13 inferring that there was something way out of
14 whack, because we had done -- I think you're aware
15 of the student that came here that compared high-
16 split to RASCAL to MACCS, and they were all fairly
17 similar within assumed source terms.

18 MR. BIXLER: Yes, we did a benchmark
19 comparison some years back that is documented in a
20 NUREG/CR report. Don't recall the number of it
21 right off the bat, but something you can look up.
22 And in that we compared MACCS with RASCAL and
23 another variant at the time, which I think is more
24 like RASCAL is today called RATCHET that was also
25 being developed at PMML. And then the LODI code

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1 from Nareack, which the Lagrangian particular
2 tracking. So we were looking at all three types of
3 the most standard models that would be used for
4 APD: Gaussian plume, Gaussian puff and Lagrangian
5 particle tracking.

6 MEMBER CORRADINI: Okay.

7 MR. BIXLER: And from that study we found
8 that averaged over a year's worth of weather data
9 that the three tended to agree within about a
10 factor of two, and in some extreme cases about a
11 factor of three. And by the way, I probably should
12 have brought that up earlier when we were talking
13 about the distributions that we used for
14 dispersion. That was part of the thinking that
15 went into coming up with the factor that we did use
16 for that.

17 CHAIRMAN STETKAR: That is mentioned in
18 the report.

19 MR. BIXLER: Yes.

20 CHAIRMAN STETKAR: There's a paragraph
21 that -- it doesn't cite the codes, but it does -- I
22 tend to kind of glaze over on code comparisons
23 because in many cases they're tends to be a lot of
24 inbreeding in terms of the assumptions and boundary
25 conditions that are set in the codes.

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1 (Off microphone comment.)

2 CHAIRMAN STETKAR: Well, that I didn't
3 know. MR. BIXLER: Okay.

4 MS. GHOSH: Did Dr. Bley have a question?
5 I think I interrupted you.

6 MEMBER BLEY: No.

7 MS. GHOSH: No? Okay.

8 MR. BIXLER: Okay. So this shows two
9 families of curves, one set for 0 to 10 miles, a
10 10-mile radius circle, and the other one a 10 to
11 20-mile annular area. And for those two families
12 of curves all the results essentially fall on top
13 of each other with one exception, and that's the 0
14 to 10-mile case for the six-month intermediate
15 phase. When we introduced that, we actually ended
16 up with larger risks than our base case with no
17 intermediate phase.

18 I've thought about that trend, that it's
19 larger, and I can't really convince myself right
20 now that it being larger is a general result. I
21 think the fact that it ends up to be larger here
22 just is circumstantial, and if we considered a
23 different source term magnitude, it might have
24 ended up being smaller, or larger, or maybe almost
25 the same as before. So I don't think that's

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1 necessarily a general trend that you can conclude
2 that if you have -- in all cases if you have a six-
3 month intermediate phase that the risks go up. I
4 don't think that's the case.

5 MEMBER BLEY: Before you go I will ask my
6 question. I got a brain freeze here.

7 MR. BIXLER: Okay.

8 MEMBER BLEY: When we talk about risk, we
9 often mean different things. Here the latent
10 cancer fatality risk -- for instance, if it's 1E
11 minus 3, it means that within whatever area we're
12 talking about the average change of dying from
13 cancer is one chance in a thousand. Is that right?

14 MS. GHOSH: Given the accident itself.

15 MR. BIXLER: Yes.

16 MEMBER BLEY: The average.

17 MR. BIXLER: The increased chance from
18 the accident occurring.

19 MEMBER BLEY: Yes, from the accident.

20 MR. BIXLER: Obviously there's a
21 background risk of cancer, but the increase over
22 the background risk we're calculating to be one in
23 a thousand or one in ten thousand or something like
24 that. And the way that's calculated is it's the
25 number of fatalities within say 10 miles divided by

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1 the population within 10 miles. So it does account
2 for population distributions within that area.
3 It's not just averaged around the compass
4 uniformly.

5 MEMBER BLEY: Okay.

6 MR. BIXLER: Did you want to speak to
7 this one, Tina?

8 MS. GHOSH: Yes, sure. This is just a
9 super quick summary. When we looked at -- we
10 mentioned earlier we did a mini-UA or a joint
11 sensitivity analysis, whatever we want to call it,
12 to look at the effect of having multiple steam
13 generator tubes rupture, if you have an SGTR versus
14 just one. And we varied some of the most important
15 parameters contributing to SGTR to look at in
16 addition to sampling the number of tubes that would
17 rupture once you have a rupture in order to see
18 what the potential effects might be. And the range
19 there, we're spanning about 10 to the minus 5 to 10
20 to the minus 3 for the mean population weighted,
21 which is the same thing as individual. That's
22 another way to say conditional LCF risk.

23 And the second bullet I guess is kind of
24 obvious. The CCDFs overlap the part of the overall
25 CCDF in the UA where you see the SGTRs, but

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1 certainly it extends beyond that because you do get
2 higher consequences when you rupture more than one
3 tube. So I think that's all we were going to say
4 there.

5 MR. BIXLER: So this sort of summarizes
6 the figure that we saw earlier in the presentation.

7 MS. GHOSH: Okay. And so this is the
8 summary. I think these are my concluding remarks,
9 which none of this will be new. It's basically a
10 summary of what we've discussed today.

11 As I mentioned earlier, our uncertainty
12 analysis results here corroborate our original
13 SOARCA study conclusions. We find that a major
14 determinant of the source term magnitude and health
15 consequences in terms of what we looked at, the
16 individual latent cancer fatality risk, is whether
17 or not a steam generator tube rupture occurs. The
18 most influential input parameters that contribute
19 to accident progression, cesium release magnitude -
20 - and again, we care most about cesium with respect
21 to LCF risk, which is the main off-site health risk
22 we're seeing, since we don't really see early
23 fatality risk -- is the following set of
24 parameters:

25 The safety valve open area fraction, and

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1 we think in combination with a number of cycles
2 that are experienced by the safety valves, the tube
3 thickness for the reasons we talked about earlier,
4 the time at CYCLE, the containment leakage rate;
5 that's the D link parameter, the particle shape
6 factor and the groundshine shielding factor. And
7 we talked about all of these factors in terms of
8 why we understand why they're important to the
9 results.

10 In our study tube ruptures occurred in
11 about 10 percent of the realizations, and that
12 resulted in a one to two order of magnitude larger
13 release when you do get a tube rupture. In this
14 case there is always a thermal and pressure element
15 to the tube ruptures.

16 And just I guess FYI, when we did the
17 number of tubes joint sensitivity analysis, we did
18 have one realization with five tubes failing that
19 had not hot leg creep, which led to the highest
20 release fractions that we saw in any calculation,
21 either sensitivity or base UA that we --

22 (Simultaneous speaking.)

23 MEMBER BLEY: So I'm kind of back to
24 where we started, and that is one's impression when
25 you look at a slide like this is a generalization.

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1 And we can say this for the unmitigated short-term
2 station blackout scenario under the conditions that
3 were assumed.

4 MS. GHOSH: Right. Yes, everything is
5 predicated on the going in --

6 MEMBER BLEY: It's almost got to say that
7 at the --

8 MS. GHOSH: -- assumptions.

9 MEMBER BLEY: -- top for me. Once these
10 get loose and wander the world --

11 MS. GHOSH: Yes. No, I think that's a
12 good idea, right, a reminder at the top that this
13 is all for what we modeled.

14 CHAIRMAN STETKAR: It's also dangerous;
15 and I mentioned this earlier, but since you brought
16 it up there, the last bullet, when you're doing
17 sensitivity analysis just to say -- or do the
18 sensitivity analysis, and we had one realization
19 with five tubes failing, no hot leg creep rupture
20 and highest release fractions. Oh, my God. That
21 was just a sensitivity analysis. What's the actual
22 risk?

23 MS. GHOSH: Yes, the thing is --

24 CHAIRMAN STETKAR: And when you do
25 sensitivity analyses in isolation and just simply

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1 report results without providing any other context,
2 like what is the likelihood of that particular
3 scenario that's not modeled, it certainly leaves
4 you vulnerable --

5 MS. GHOSH: Yes, and I guess --

6 CHAIRMAN STETKAR: -- and open to a lot
7 of challenges.

8 MS. GHOSH: Right, and I don't remember
9 how much we summarize in that part of the report,
10 but we talked about earlier the fact that we
11 thought that only one tube rupturing was the most
12 likely scenario, which is why we included it in the
13 pot of the integrated UA. We don't think that's
14 very likely, but we wanted to understand what the
15 possibilities were, hence the sensitivity risk is
16 uncertainty analysis. But we can revisit how we've
17 written that up to see whether we should add some
18 context to that discussion.

19 We talked about this, too. In most of
20 the realizations iodine and cesium release
21 fractions were higher earlier in the transient due
22 to the design leakage sampling, but they were
23 significantly lower at 48 hours. And I think --
24 yes, and this is for the non-SGTR.

25 The median release of 48 hours is lower

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1 than the original SOARCA calculation in part due to
2 the higher pressurization in the original SOARCA
3 and that we had the containment rebar yield at 252
4 hours, which we didn't see in the new UA
5 calculations. And the early fatality risks we
6 compute as essentially zero. And the latent cancer
7 fatality risks were observed to be lower than the
8 original SOARCA calculation. We have lower source
9 terms in the UA, so that makes sense.

10 And actually we were just talking about
11 this. When we did the single realization analyses
12 and looked at just the MACCS epistemic uncertainty,
13 it looks like the distributions are more narrower
14 when you only consider the MACCS uncertain
15 parameters. In terms of an epistemic uncertainty
16 the MELCOR uncertainty seemed to have a larger
17 contribution to the overall consequence metric.
18 And then Nate mentioned this already, but this is
19 true when we're looking at a single dose response
20 model, but this would likely change if we were then
21 also to include uncertainties in the dose response
22 model itself.

23 And the last set of bullets. Yes, this
24 is just saying again the UA-calculated LCF risks
25 are low, a little bit lower than they were for the

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1 original SOARCA study. And the highest risk within
2 this case is the 0 to 10 miles, and they get lower
3 at longer distances. And most of the risk is from
4 the long-term exposure beyond the emergency phase.
5 Ninety-nine percent within the 10 miles, because
6 almost everybody's evacuating there. Eighty-four
7 percent beyond 10 miles.

8 I think that was it for the summary and
9 insights. And we were just going to wrap up with
10 next steps.

11 What are we doing next? We're planning
12 to finalize the report. We still have some updates
13 to do. And following this meeting we have some new
14 action items that we will put on the list, but
15 we're hoping by the end of September to have that
16 report finalized.

17 We're also trying to develop a product
18 that might be more useful going forward for
19 regulatory applications than the current 1,100
20 pages of documentation we have in the two
21 uncertainty analysis volumes. We want to create a
22 summary NUREG that would pull out what are the most
23 important things that we learned from the Peach
24 Bottom, Surry and Sequoyah uncertainty analyses?

25 And then we plan to contribute to

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1 identifying key sources of model uncertainty.
2 That's kind of language from the standards,
3 guidance for PRA in terms of the Level 2 and Level
4 3 portions of the Level 3 PRA.

5 CHAIRMAN STETKAR: On that, we've touched
6 on it a couple times, we've mentioned, you've
7 steadfastly resisted quantifying uncertainty in the
8 dose response models, among the three models. To
9 me that's a really important source of uncertainty,
10 maybe more important in terms of the overall
11 published results than anything else you might be
12 addressing in terms of -- I don't know, whether
13 it's a MACCS parameter or MAP parameter modeling
14 versus some MELCOR parameter modeling or some of
15 that other internal stuff. Do you plan to --

16 MS. GHOSH: Oh, hold on.

17 CHAIRMAN STETKAR: Yes, sorry. I'm
18 treading on hallowed ground there, I know. Is part
19 of the next steps to address that?

20 MS. GHOSH: I guess the only thing I can
21 say at this point is we've at least generated
22 results for these alternate dose models. This is a
23 research project. We have the liberty to do that.
24 We feel like we've done as much as we could. At
25 the end of the day right now NRC policy is still to

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1 use LNT. So any time we're talking about
2 regulatory applications, those sensitivity results
3 kind of get ignored. So I think we can have those
4 as qualitative discussion points, but --

5 CHAIRMAN STETKAR: To me some of the
6 dangers though of developing a summary NUREG report
7 with all of these insights and stuff that we've
8 learned -- within the context of what you've done
9 that might make sense, but people take that out of
10 that context.

11 MS. GHOSH: Yes, I would hope that we
12 would have a chapter in that NUREG that explains
13 the differences you get from the alternate dose
14 response models, because we have --

15 CHAIRMAN STETKAR: I would certainly hope
16 so, too.

17 MS. GHOSH: Yes, because we have
18 extensive information at this point from the
19 calculations that we have done. It's just that we
20 kept those separate from the rest of the
21 uncertainty analysis. We've still done a lot.
22 It's just it's not thrown into the pot along with
23 the other uncertainty so that we could demonstrate
24 the relative importance of that. But we've still
25 done a lot. I think we can certainly say a lot

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1 based on what we have done. So think it would be a
2 separate chapter for posterity to use as they can
3 or wish.

4 CHAIRMAN STETKAR: My only point is that
5 it's my personal opinion that it's very important
6 to address that in the same context or document or
7 whatever it is as all of these other insights that
8 you're talking about.

9 MS. GHOSH: Yes.

10 CHAIRMAN STETKAR: Because without that,
11 despite the fact that you're reluctant to try to
12 quantify it -- but without that information people
13 may start to focus on things that are much, much
14 less important to public health and safety than
15 perhaps grappling with what sort of models we
16 should be using for health effects on the public.

17 MS. GHOSH: Yes. Okay.

18 CHAIRMAN STETKAR: In deference to the
19 person who's sitting to my left who loves to noodle
20 with all of those other little things.

21 MEMBER REMPE: With respect to other
22 little things --

23 (Laughter.)

24 MEMBER REMPE: -- okay, so the Peach
25 Bottom was entirely analysis for SOARCA and the

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1 uncertainty was done entirely with 1.8.6. Are
2 there any other changes that -- we saw a lot of
3 changes with -- this is kind of an in-between case.
4 I assume Sequoyah we just will have the version 2.1
5 stuff. And are there any things we're missing from
6 the Peach Bottom because you had a new code and
7 didn't use it --

8 MS. GHOSH: Yes.

9 MEMBER REMPE: -- that you missing some
10 things?

11 MS. GHOSH: I think Nate and I are the
12 wrong people to ask. I don't know if Hossein is
13 here or if KC wants to comment on that.

14 MR. ESMAILI: Well, I don't think this is
15 going to answer your question because we haven't
16 done it, but 1.8.6 and 2.1 were not at some point
17 fundamentally different. This is the same code.
18 1.8.6 is the same -- 2.1 is the same code as 1.8.6.
19 Just the source for that was different.

20 And what we saw in the SOARCA calculation
21 is what's in Appendix A. It's that then we
22 converted the input deck, the 1.8.6 input deck from
23 five years ago. And we got essentially the same
24 type of results that we got in 1.8.6. Had we
25 continued with 1.8.6, we would have been probably

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1 seeing the differences because we are continuously
2 debugging the code, we are finding how to improve
3 the code, etcetera.

4 So if you're asking to go and convert the
5 Peach Bottom and run uncertainties, maybe we can
6 get some answers, but -- get some differences in
7 the answers, but we don't consider dose to be
8 greatly affected by which code versions, because
9 some of these cases that we have run the different
10 versions of the code essentially produce the same
11 type of results. Does that answer your question?

12 MEMBER REMPE: Sort of, yes.

13 MR. ESMAILI: Okay. But I just want --
14 and the thing is that the 2.1 we have added
15 additional capabilities. You brought up this CCI
16 modeling. We've improved the code. We have
17 debugged the code. So in that regard things might
18 change a little bit. Okay? But I don't think that
19 results are going to be drastically different.

20 MEMBER REMPE: Okay. The other question,
21 when you talk about the higher level insights from
22 looking at these uncertainty analyses, I'd like to
23 go back about my point about the CYCLE. In some
24 cases you're going to say this is important, but in
25 other cases you're going to say, well, we decided

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1 we learned enough, so it's not important for
2 Sequoyah, but it was -- it showed up a lot of times
3 in your regression analyses. And so I think you
4 might be opening yourself up to some criticism on
5 how to do that. But maybe you can wordsmith around
6 it. It's up to you all.

7 MS. GHOSH: Yes. That's a good point.
8 The time at CYCLE is also not something we can do
9 much about. That's a true aleatory uncertainty, we
10 don't know when the accident would occur. It's
11 more just if we have an understanding of how
12 different the results might be at a different point
13 of the CYCLE. And I think as we've discussed, as
14 long as we're not choosing the beginning of CYCLE
15 to do our base analysis, we're probably okay in
16 terms of that we haven't missed something big,
17 because the middle of CYCLE, end of CYCLE, close
18 enough. We shouldn't pick a point in the CYCLE
19 that is going to look very different from what you
20 can get from end of CYCLE or middle of CYCLE. But
21 it's certainly worth us spending more time to think
22 about how we explain the choices we made for what
23 we've included and not included.

24 MEMBER REMPE: And the results.

25 MS. GHOSH: Yes.

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1 DR. SHACK: You've mentioned several
2 times you get some realizations that get you to the
3 rebar yield.

4 MS. GHOSH: Yes.

5 DR. SHACK: Did you ever get anywhere
6 until you got to the two percent global strain?

7 MS. GHOSH: Yes, we didn't. I think Kyle
8 just looked at this. Yes, we did not. Yes.

9 I think I was on the fourth bullet. Just
10 two other quick notes. We also have some MACCS
11 input parameter guidance that's under development,
12 and we anticipate that this work would contribute
13 to the guidance that we're developing as well in
14 terms of what uncertainties to look at, what's
15 important.

16 And we also have an appendix that's under
17 development for -- it's an appendix on severe
18 accident consequence analysis that supports cost-
19 benefit analyses. This is in relation to the
20 Agency's cost-benefit analysis guidance update.
21 And we expect that essentially the summary NUREG
22 that we're developing and the insights that we've
23 gotten would contribute to that work as well.

24 CHAIRMAN STETKAR: How does that
25 contribute to regulatory analyses for issues that

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1 are not focused solely on a complete station
2 blackout, a loss of all AC and DC power that is not
3 mitigated, which is the only thing that you've ever
4 thought about? So if I'm looking at regulatory
5 analyses that might extend out into health effects
6 from LOCAs, for example, this is completely
7 irrelevant as best as I can tell because you've not
8 looked at that.

9 MS. GHOSH: This is one source of
10 information that we would draw from. I mean, our
11 task is to survey kind of everything that's out
12 there and be able to say something. Depending on
13 the problem you're modeling, how can you draw from
14 what has already been done?

15 CHAIRMAN STETKAR: No, this is quite
16 obviously my concern of extrapolating too far and
17 generalizing too far from what has been an awful
18 lot of work done on a one specific completely
19 square, completely black, fully defined scenario.

20 MS. GHOSH: Yes. And, no, I think it's a
21 very fair point, and we have to put some hard
22 thinking into what is applicable, when is it
23 applicable and being able to characterize that for
24 sure.

25 CHAIRMAN STETKAR: The danger being is

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1 very few other people besides you appreciate what
2 has been done, but more importantly appreciate what
3 hasn't been done. And they want to pick things up
4 and say, whoa, the Agency's SOARCA analyses show
5 that these issues are completely unimportant, so we
6 don't need to make any regulatory decisions about
7 those issues --

8 MS. GHOSH: Right.

9 CHAIRMAN STETKAR: -- because they're
10 completely unimportant to risk.

11 MS. GHOSH: Yes, so --

12 CHAIRMAN STETKAR: Health risk.

13 MS. GHOSH: Right. So maybe that's part
14 of the guidance that has to be developed as to
15 understand the applicability of -- depending on
16 what you're trying to do. We're in the very early
17 stages of that. At this point we're trying to
18 capture the current state of practice, which is not
19 represented at all in our guidance documents, which
20 are rather old. I know that the rulemaking groups
21 in the technical bases have come and briefed you.

22 CHAIRMAN STETKAR: Yes.

23 MS. GHOSH: A lot of that that -- what
24 was done, it's not documented anywhere. I mean,
25 what is documented is not even stated practice,

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1 forget trying to push the --

2 (Simultaneous speaking.)

3 CHAIRMAN STETKAR: Yes, it seems to be
4 kind of ad hoc on a case-by-case basis in many
5 cases.

6 MS. GHOSH: Yes. That's how a lot of
7 these things progress, right? I mean, the need
8 arises and then you create a new state of practice
9 and kind of advance the thinking forward. We're
10 trying to capture that now in our documents that
11 are outdated. But it's a good question. Thank
12 you.

13 MEMBER CORRADINI: So, are you waiting
14 for our questions now are you going to go --

15 (Simultaneous speaking.)

16 CHAIRMAN STETKAR: No. No, I'm trying to
17 get to a point there's a diminishing returns here
18 on --

19 MEMBER CORRADINI: Sure. So I have
20 questions.

21 MS. GHOSH: I think the slides are done.
22 The last slide was just the references of our
23 growing SOARCA library. And the Peach Bottom
24 uncertainty analysis has been with publication
25 since the end of September. And we have our

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1 fingers crossed that sometime this month it will be
2 out. But that's just a list of references.

3 MEMBER CORRADINI: So I had a question.
4 Or do you want to wait to go to the outside world
5 first?

6 CHAIRMAN STETKAR: What I'm going to do
7 is if there are no other questions directly related
8 to the presentation material, I will go ask for
9 public comments and then we'll go around the table
10 and wrap up. If you have a question that's related
11 to the presentation material, please speak up.

12 MEMBER CORRADINI: So if this were TRACE
13 and you were doing an uncertainty, would you do
14 anything differently? You said one of the biggest
15 contributions I thought you said at the very end
16 was it's not the results since this is one sequence
17 for one reactor. Now you're going to do three
18 reactors with one sequence, all unmitigated, but
19 yet you developed a methodology. Right? That's
20 what I thought I heard you say. So is this
21 methodology different how -- what TRACE is doing
22 for their uncertainty analysis, or have you even
23 looked?

24 (No audible response.)

25 MEMBER CORRADINI: I mean, it's all one

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1 agency. It's all one happy family. So I assume
2 the uncertainty analysis here ought to be somehow
3 similar to --

4 MS. GHOSH: I think at the very -- it
5 depends on what level you want that question
6 answered.

7 MEMBER CORRADINI: I'm not trying to be
8 flip. I'm actually being serious in the sense that
9 I do think you've developed a -- I mean, to put it
10 another way, you ask for 1,200 calculations, you
11 hit the go button, you got 904. So that's pretty
12 good considering MELCOR is hundreds of thousands of
13 God-knows-what, 4-TREN, maybe even 4-TREN-90, I'm
14 not sure, and it worked. So that's pretty
15 phenomenal.

16 So my question is is the process you're
17 using, the methodology translatable to what the
18 others are doing in uncertainty world, or are they
19 so different that you can't learn from each other,
20 or --

21 MS. GHOSH: No, no. I think it's very
22 similar. In fact, if you -- I don't know if
23 anybody from industry is here, but if you look at
24 what EPRI is doing or other people, the general
25 Monte Carlo approach to getting a distribution of

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1 results based on what you want to describe for your
2 uncertainties, it's a pretty standard method. So I
3 would say at a high level, yes, they're very
4 similar approaches. I think the basic steps of
5 what you would ideally want to do any time you want
6 to consider uncertainty are the same.

7 We're working on getting more
8 coordination amongst all the groups who are doing
9 different things on uncertainty across the Agency.
10 I think some of that will come out as we're
11 developing some of the more practical products.
12 And we have had some coordination, but we're
13 improving in that area. But I think that a high
14 level the answer is, yes, the basic process is the
15 same that you'd want to follow.

16 MEMBER CORRADINI: I'll stop for now.

17 CHAIRMAN STETKAR: Any other questions
18 related to the presentation?

19 (No audible response.)

20 CHAIRMAN STETKAR: If not, I have one
21 more observation on the infamous valve data. If
22 you look at table 20; this is just taking notes,
23 and do the recovered plus non-recovered, you can
24 get to the 17 out of 773.

25 MR. BIXLER: Is that for Kyle or for all

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1 of us?

2 CHAIRMAN STETKAR: That's for Kyle.

3 MEMBER CORRADINI: I observed that
4 before.

5 CHAIRMAN STETKAR: Huh?

6 MEMBER CORRADINI: I observed that
7 before. Weren't you paying attention to Dr. Shack?

8 CHAIRMAN STETKAR: I was not.

9 (Laughter.)

10 With that, if there are no other
11 questions, what I'd like to do is get the bridge
12 line open. I don't know if there are any members
13 of the public on the bridge line.

14 PARTICIPANT: We have one request.

15 CHAIRMAN STETKAR: We have? Okay. Good.
16 So let's get the bridge line open and see if
17 there's anyone out there.

18 While we're doing that, if there's anyone
19 in the room who would like to make a comment,
20 please come up to the microphone and do so.

21 I'm starting to hear pops and crackles,
22 so there's some indication the bridge line is open.

23 Anyone out there, could you please do me
24 a favor and just say hello so that we confirm that
25 it's open?

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1 MS. GRAY: Hello.

2 CHAIRMAN STETKAR: Thank you. Good. I
3 always have to apologize for this. It's the only
4 way we can confirm it's open.

5 Now, if there's anyone on the bridge line
6 who'd like to make a comment, please identify
7 yourself and speak.

8 MS. GRAY: Yes, hello. Can you hear me?

9 CHAIRMAN STETKAR: Yes, we can.

10 MS. GRAY: My name is Erica Gray and I'm
11 calling from Richmond, Virginia. And I have, well,
12 a couple of comments or questions.

13 I'd like to start with I attended an
14 aging reactor meeting about a week or two back and
15 it was stated that a lot of reactors no longer have
16 capsules available. In dealing with Surry are the
17 capsules available for the surveillance program?

18 CHAIRMAN STETKAR: We'll note that
19 question. It's not relevant to the topic of
20 today's meeting, but we'll note that question for
21 the record.

22 MS. GRAY: The meeting was long. I'm not
23 sure if you covered surveillance of dealing with
24 the reactor core and the embrittlement issue.

25 CHAIRMAN STETKAR: No, that's not part of

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1 this particular research project because of the
2 nature of the accident scenario that's being
3 modeled here. As I said, certainly we'll note for
4 the record, but I can at least respond that it's
5 germane to other issues that we're certainly
6 following as the ACRS, but not particularly today's
7 discussions.

8 MS. GRAY: Okay. Well, I did want to
9 mention, I know there was talk about the tubing,
10 the steam generator tubing.

11 CHAIRMAN STETKAR: Yes.

12 MS. GRAY: And I agree that obviously in
13 particular with Surry they should go on the data
14 that's available. I was able to pull up data for
15 Unit 1 and 2. Of course the most latest data was
16 from Unit 1 showing that there was, I don't know,
17 111 tubes that have already been plugged. And Unit
18 2 I think I couldn't pull anything earlier -- or
19 later than 2010, which showed 94. And it seemed
20 like there was a lot of issues with Unit 2 having
21 foreign material inside of them. So just to say
22 that I think obviously going on data that's present
23 at the reactors themselves is probably important to
24 do.

25 But I also wanted to state and talk not

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1 about modeling and dispersal of gaseous cesium or
2 other radionuclides. Well, as a citizen, I mean,
3 I'm very concerned because I think that there's
4 very well-known knowledge out there that we were
5 able to detect cesium all the way to Vermont with
6 the Fukushima disaster. So I'm hoping that these
7 dispersion models will really be complete and a lot
8 more detailed.

9 I can't think of anything else at the
10 moment that I'd like to mention, but I do believe
11 there is definitely going to be issues in running
12 these facilities for 80 years. Thank you.

13 CHAIRMAN STETKAR: Great. Thank you
14 very, very much.

15 Are there any other members of the public
16 on the bridge line who'd like to make a comment?

17 (No audible response.)

18 CHAIRMAN STETKAR: If not, we'll re-close
19 the bridge line from your end so that we don't hear
20 the pops and crackles that tend to come across.
21 You'll still be able to hear our closing remarks.

22 And as we usually do at the end of a
23 Subcommittee meeting, I'd like to go around the
24 table and ask each person at the table for any
25 final comments or observations and at least -- and

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1 I'm sorry, Bill, I'm going to have to exclude from
2 this, but the members, whether or not you think we
3 should bring this subject to the Full Committee.

4 So I will start, starting at Dr. Rempe,
5 I'll start with Dr. Ballinger.

6 (Laughter.)

7 MEMBER REMPE: I was ready to push my
8 button.

9 (Laughter.)

10 CHAIRMAN STETKAR: Turn your mic on.

11 MEMBER BALLINGER: I mean, I don't have
12 anything more to add other than the conversation
13 that we've had all day.

14 As far as bringing this before the Full
15 Committee, I think in a significantly abbreviated
16 length, yes.

17 CHAIRMAN STETKAR: Dick?

18 MEMBER SKILLMAN: Tina, to you and your
19 team, thank you. This has been a huge amount of
20 work, it's obvious. Very informative. Thank you.

21 Whether to bring it to the whole
22 Committee, I agree with Dr. Ballinger, in an
23 abbreviated form. I think it's important enough to
24 get it in front of the Full Committee, yes, sir.
25 Thank you.

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1 CHAIRMAN STETKAR: Okay. Dr. Corradini,
2 sir?

3 MEMBER CORRADINI: Thanks to the staff
4 and their contractors. I think they did an
5 excellent job. I guess at this point it's
6 kind of still a work in progress. I'm not sure we
7 want to bring it to the Full Committee and write a
8 letter because I'm not sure what the purpose of
9 writing a letter would be for. So I guess I would
10 hold off a bit until we see a little bit more
11 results in Subcommittee format before we would do
12 that.

13 I do think though -- at least my
14 observation at this point is that there's the
15 methodology part. That's the reason I asked the
16 last question, which you've settled on now a
17 methodology that if asked again you would know
18 exactly how you want to attack the problem, or at
19 least better attack the question. But since this
20 is just one sequence with now the second reactor,
21 I'm not exactly sure what I'd do with it. So I
22 kind of would challenge the staff to say, okay, now
23 what do you guys want to do with it from a results
24 standpoint before it comes in front of the Full
25 Committee and we write a letter about it, because

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1 I'm not sure how we attack it.

2 CHAIRMAN STETKAR: Be careful, because
3 it's not one sequence with a second reactor. It is
4 a different sequence --

5 (Simultaneous speaking.)

6 MEMBER CORRADINI: I'm sorry. I'm sorry.
7 Excuse me. Excuse me. It's a different sequence -
8 -

9 CHAIRMAN STETKAR: Peach Bottom was a
10 long-term station, but ---

11 (Simultaneous speaking.)

12 MEMBER CORRADINI: I apologize.

13 CHAIRMAN STETKAR: -- because the timing
14 is different.

15 MEMBER CORRADINI: But a single sequence
16 with a different reactor. So I guess I'd ask the
17 staff the question of how one would use the results
18 at this point to go further; and I can think of
19 some things, but my only thought is until that's
20 discussed maybe in a Subcommittee it would be
21 inappropriate to come to the Full Committee and
22 write a letter on something.

23 CHAIRMAN STETKAR: Okay. Dennis?

24 MEMBER BLEY: Yes, I appreciate what a
25 formidable task you took on to do this, and I'm

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1 very pleased that you've done this formidable task.
2 We were critical of SOARCA early on for not doing
3 this kind of work and I think it's important. I
4 think we learned quite a bit from this effort and I
5 hope that it will support the Level 3 work. I
6 don't have any additional things to add beyond the
7 comments I made during the session, but
8 congratulations on a lot of very good work here.

9 I would at least I think weigh in at
10 least for the summary report on the insights from
11 the three analyses. That would be a better place
12 for us to go to the Full Committee.

13 CHAIRMAN STETKAR: Okay. Bill, I'll skip
14 you for a moment.

15 And, Joy?

16 MEMBER REMPE: I agree with my colleagues
17 that we should thank you for your efforts. Yes, we
18 picked here and there on the report things that
19 needed to be changed, but in general I thought the
20 quality of the report was very good for a draft
21 report. And so, I think you did a good job in that
22 way. And I also thought the way you responded to
23 the questions today indicates some depth of
24 knowledge that's nice to see. And so I appreciate
25 that.

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1 With respect to bringing it to the Full
2 Committee, I wholeheartedly agree with Mike and
3 Dennis that we shouldn't write a letter yet, but
4 I'm also thinking of how long it's been since we
5 had anything on SOARCA to the Full Committee. Even
6 for the Subcommittee it's been a long time. And
7 so, it might be worthwhile, just an update, because
8 the Committee is changing faces. And so by the
9 time you bring it to the Full Committee to write a
10 letter, there are going to be people who don't know
11 what SOARCA is. And so, I think it might be good
12 to -- and those of us who were here for writing the
13 letter may have forgotten what it is. So I don't
14 think it would hurt to have an information meeting.
15 That's again something that we can discuss more.

16 MEMBER BALLINGER: Again, I'm not
17 advocating writing the letter, just exactly what we
18 did.

19 MEMBER SKILLMAN: Yes, that's what I
20 said, too, I think.

21 MEMBER BALLINGER: I'm not advocating
22 writing a letter. I'm just voting --

23 (Simultaneous speaking.)

24 CHAIRMAN STETKAR: First of all, the
25 Subcommittee, nobody can decide whether the

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1 Committee's going to write a letter. We can only
2 recommend whether or not it should come to the Full
3 Committee. The Committee then decides whether or
4 not a letter is warranted. So discussing whether
5 or not the ACRS issues a letter on it in this forum
6 is irrelevant.

7 MEMBER BALLINGER: The two people on your
8 left and right did suggest not writing the letter.

9 CHAIRMAN STETKAR: It doesn't make any
10 difference. They're only two members of the
11 Committee.

12 MEMBER BALLINGER: He ignores us all the
13 time.

14 (Laughter.)

15 CHAIRMAN STETKAR: Okay. Joy, anything
16 else?

17 MEMBER REMPE: No.

18 CHAIRMAN STETKAR: Bill, last but not
19 least?

20 DR. SHACK: One of the things you can
21 carry over to other uncertainty analyses I think is
22 the story board concept, which I think was a great
23 improvement over what we did with Peach Bottom. If
24 nothing else it presents everything up in a way
25 that I can suddenly look at it and criticize it,

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1 disagree with it.

2 (Laughter.)

3 DR. SHACK: So I think you've made a
4 substantial contribution there in a way to document
5 an uncertainty analysis, as well as the other
6 things you've done with sort of the mechanics of
7 how to do an uncertainty analysis. So that's very
8 good. As I say, my technical point I've made
9 before. Congratulations on an enormous piece of
10 work.

11 CHAIRMAN STETKAR: And I'll close. Yes,
12 congratulations. The documentation here, the
13 technical justification, as I said, I'll echo Bill,
14 I might not necessarily agree with all of the
15 distributions, but I understand for the most part
16 now the background and the rationale behind them.
17 I understand the basic process. And I think this
18 is, from that perspective, a tremendous improvement
19 over the Peach Bottom report. And I think you
20 deserve congratulations for that. It's a
21 tremendous improvement.

22 Regarding going to the Full Committee,
23 I'm personally kind of torn. I think that an
24 information briefing would be very useful. I think
25 that perhaps such an information briefing would be

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1 even more useful. We have new members coming on
2 the ACRS, well, in an indeterminate time. It will
3 probably be three or four or five months from now.

4 MEMBER BLEY: Maybe in time for that
5 summary review.

6 (Laughter.)

7 CHAIRMAN STETKAR: Well, depends on what
8 you're timing is for -- you mentioned this spring
9 for Sequoyah.

10 MS. SANTIAGO: Right.

11 CHAIRMAN STETKAR: The Subcommittee.

12 MS. SANTIAGO: We have two things coming
13 up, which would be the Sequoyah --

14 CHAIRMAN STETKAR: Well, you --

15 MS. SANTIAGO: Oh, I'm sorry.

16 CHAIRMAN STETKAR: Yes, actually that's -

17 -

18 (Simultaneous speaking.)

19 MS. SANTIAGO: Is it?

20 CHAIRMAN STETKAR: Yes.

21 MS. SANTIAGO: Okay. So we do want to
22 come and brief you on the Sequoyah analysis.

23 CHAIRMAN STETKAR: And the timing of that
24 would be?

25 MS. SANTIAGO: It's probably April or

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1 May.

2 CHAIRMAN STETKAR: April or May? Okay.

3 MS. SANTIAGO: And that depends on --

4 (Simultaneous speaking.)

5 CHAIRMAN STETKAR: I'm assuming -- yes.

6 But I won't hold you, but I'm trying to get a sense

7 of --

8 MS. SANTIAGO: Well, and we want to go to
9 the public, because I think in the past the ACRS
10 Subcommittee recommended to us to go to the public
11 meeting and then come and inform you about any
12 comments that we got from --

13 CHAIRMAN STETKAR: Right. Right.

14 MS. SANTIAGO: -- members of the public.

15 CHAIRMAN STETKAR: Right.

16 MS. SANTIAGO: So that's why I'm saying
17 April or May.

18 CHAIRMAN STETKAR: And I'm assuming that
19 the compilation of insights from the three studies
20 would be delayed. We're probably looking at the
21 end of the calendar year for that.

22 MS. SANTIAGO: Right. We're looking to
23 try and get the draft reports to the Commission in
24 September.

25 CHAIRMAN STETKAR: The three draft --

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1 MS. SANTIAGO: Well, the summary report
2 was not --

3 MS. GHOSH: Would be later, yes. Right.

4 MS. SANTIAGO: -- would be later than
5 that.

6 CHAIRMAN STETKAR: Yes.

7 MS. SANTIAGO: Just so that we have some
8 time to really think and --

9 MS. GHOSH: We're still finishing
10 Sequoyah.

11 CHAIRMAN STETKAR: Well --

12 MS. GHOSH: There's only so much we can
13 do at the same time.

14 CHAIRMAN STETKAR: Okay. We'll have to
15 discuss it.

16 MS. SANTIAGO: So we were expecting
17 eventually to come brief the Subcommittee on
18 Sequoyah.

19 CHAIRMAN STETKAR: Yes.

20 MS. SANTIAGO: And then we thought
21 perhaps we'd go to the Full Committee with both
22 analyses for the Sequoyah and this Surry
23 uncertainty analysis.

24 CHAIRMAN STETKAR: Well, they probably
25 have to be all three of them. I think that the

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1 Committee -- this is my own personal opinion, that
2 the Committee ought to have in front of it the
3 three uncertainty analyses, recognizing that it's
4 an evolutionary process --

5 MS. SANTIAGO: Right.

6 CHAIRMAN STETKAR: -- but not focusing
7 only on the two pressurized water reactors.

8 MEMBER REMPE: You mentioned you were
9 going to have something, public comment on
10 Sequoyah. I hope you come let us see it before it
11 goes for public comment like you have done on this
12 document. Is that a true statement? I mean, you
13 mentioned you hoping to have it out for public
14 comment.

15 MS. SANTIAGO: Yes, in the past; and I'll
16 go back and re-look at our process, we actually
17 went and had a public meeting and had the licensee
18 do a fact check on the inputs and --

19 MEMBER REMPE: Has this --

20 CHAIRMAN STETKAR: That's a good idea.

21 (Simultaneous speaking.)

22 MEMBER REMPE: -- for public comment
23 already before we saw it today?

24 MS. SANTIAGO: For the Surry uncertainty
25 analysis, no.

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1 CHAIRMAN STETKAR: But the Surry SOARCA
2 has.

3 MS. SANTIAGO: Correct.

4 MEMBER REMPE: Right. Oh, okay. I
5 thought you meant the --

6 MS. SANTIAGO: For Sequoyah --

7 MEMBER REMPE: The Sequoyah --

8 MS. SANTIAGO: -- we're doing it in --

9 MEMBER REMPE: -- uncertainty analysis or
10 the --

11 MS. SANTIAGO: -- concert, in parallel.

12 MEMBER REMPE: Okay.

13 CHAIRMAN STETKAR: It's only one for --

14 MS. SANTIAGO: Right.

15 CHAIRMAN STETKAR: Effectively one for
16 Sequoyah.

17 MS. SANTIAGO: Because the Committee
18 recommends --

19 MS. GHOSH: That was your advice, do it
20 all at the same time.

21 CHAIRMAN STETKAR: Is it going to be one
22 report?

23 MS. GHOSH: Yes.

24 MS. SANTIAGO: Yes.

25 CHAIRMAN STETKAR: Okay. Even better.

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1 So you don't have the --

2 MS. SANTIAGO: Yes. Okay.

3 CHAIRMAN STETKAR: -- SOARCA thing and
4 the UA thing.

5 MS. SANTIAGO: So if you want us to
6 come --

7 CHAIRMAN STETKAR: No.

8 MS. SANTIAGO: Okay.

9 MS. GHOSH: Okay.

10 CHAIRMAN STETKAR: I think that we follow
11 what we've been doing. I think that we certainly
12 want to have any public input and certainly the
13 licensee's input for fact checking some reasonable
14 mature document at the time before it comes to us
15 at the Subcommittee. Even at the Subcommittee
16 level, because otherwise you get into this kind of
17 endless -- not endless loop, but nested loop where
18 we ask questions. You say, well, we haven't
19 checked that. We have to go back to TVA and ask
20 the people at Sequoyah. And they come back. And
21 it isn't productive.

22 MEMBER BLEY: But you're looking to send
23 it to the Commission in September?

24 CHAIRMAN STETKAR: In September. I think
25 the ACRS would like to be able to weigh in in that

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1 time frame. And that would be useful in our
2 guesstimates in terms of when our new members will
3 be coming on board, because they probably can't
4 spell SOARCA yet. So it would be good getting them
5 up to speed also. So we're probably looking at a -
6 - we don't have Full Committee meetings in August,
7 so we might be targeting the July time frame for
8 maybe a Full Committee briefing, with or without a
9 letter. I mean, we can do that with the Sequoyah
10 Subcommittee meeting earlier than that, in April or
11 something.

12 MS. SANTIAGO: But I do want to say we
13 deeply appreciate all the comments that we get from
14 the Committee members, because on this particular
15 analysis it's fairly complex, intricate and
16 technical and we spent the last 18 months debating
17 amongst a lot of experts in our field as well. And
18 so we do appreciate the comments that you've made.
19 And also that we don't want people to take what
20 we've done out of context. And so, we still have
21 to think about some of these things.

22 So I do want to also thank the team. And
23 as you say this team has been together pretty much
24 for five years since we started the original SOARCA
25 analyses, and it's made it good in a lot of ways.

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1 And we're trying to grow other staff so that they
2 have the background and knowledge that we've
3 developed over the course of five years.

4 Unfortunately, we may have some new folks
5 and lose some folks that have been with us for that
6 five years, so we -- in fact, I asked Tina
7 yesterday do we have to give another little summary
8 brief on SOARCA, because we hadn't been here for
9 two years. And I forget things after a while, so I
10 think it's a great time to really introduce new
11 members if you're going to have new members --

12 CHAIRMAN STETKAR: Yes.

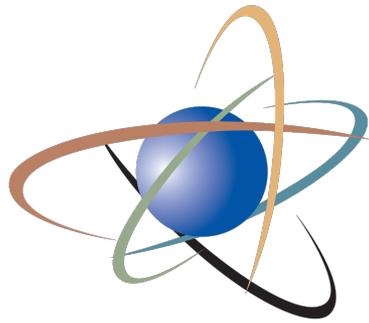
13 MS. SANTIAGO: -- and give them that
14 background and that continuity that you have. So
15 thank you again for all your support.

16 CHAIRMAN STETKAR: And with that, unless
17 anyone has anything else, we are adjourned.

18 (Whereupon, the above-entitled matter
19 went off the record at 5:00 p.m.)

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U.S. NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

State-of-the-Art Reactor Consequence Analyses (SOARCA) Surry Uncertainty Analysis (UA)

ACRS Subcommittee Briefing
February 2, 2016

Tina Ghosh, PhD

NRC Office of Nuclear Regulatory Research, Accident Analysis Branch

Randy Gauntt, PhD and Nathan Bixler, PhD
Sandia National Laboratories



Core Team Members and Advisors

- MELCOR and severe accident progression: Randy Gauntt, Kyle Ross, Scott Weber, Jeff Cardoni (SNL); KC Wagner (dycoda); Ed Fuller, Hossein Esmaili, Don Helton (NRC)
- MELMACCS: Nate Bixler, Doug Osborn (SNL)
- MACCS, consequence analysis and emergency response: Nate Bixler, Joe Jones, Doug Osborn (SNL)
- UA methodology: Cedric Sallaberry, Dusty Brooks, Aubrey Eckert-Gallup, Jon Helton, Matthew Denman (SNL); Tina Ghosh, Trey Hathaway (NRC)

Outline

- Objectives
- Overview and overall conclusions
- MELCOR model enhancements
- Parameter development
- MELCOR parameters
- MACCS parameters
- MELCOR analysis results
- MACCS consequence analysis results
- Summary and insights

Objectives of the Uncertainty Analysis

- Develop insight into overall sensitivity of results and conclusions to uncertainty in model inputs.
- Identify the most influential input parameters contributing to variations in accident progression, source term, and offsite consequence results.
- “Complement and support” the NRC’s Site Level 3 PRA project and post-Fukushima activities including Tier 3 items. (Staff Requirements Memorandum SECY-12-0092)

Overview

- Analysis of uncertainty in the Surry SOARCA unmitigated short term station blackout (STSBO)
- Focus on epistemic (state-of-knowledge) uncertainty in input parameter values, and limited aleatory uncertainty
 - Aleatory (random) uncertainty due to weather handled in the same way as the SOARCA study
 - Time-at-cycle (burn-up) and stochastic nature of safety valve failure investigated (aleatory aspects of some input parameters)
- The Surry MELCOR model was updated
 - It had been 5 years since SOARCA base case was developed
 - MELCOR 2.1 had been released (1.86 was used for the SOARCA original analysis)
 - Updated “base case” documented in report

Overview (continued)

- Investigated uncertainty in MELCOR and MACCS inputs
- Key uncertain input parameters were identified
- Uncertainty in these parameters was propagated in a two-step Monte Carlo simulation:
 - A set of source terms generated using MELCOR model
 - A distribution of consequence results generated using MACCS model
- 1003 successful MELCOR Monte Carlo “realizations” completed to 48 hours were each coupled with a successful MACCS realization
 - Of 1200 originally run, incomplete MELCOR realizations were attributable to numerical simulation issues

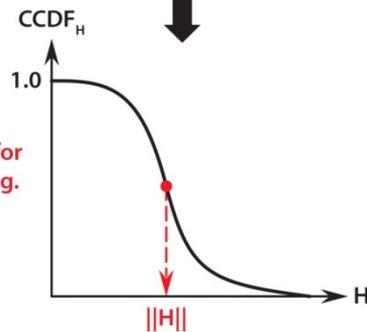
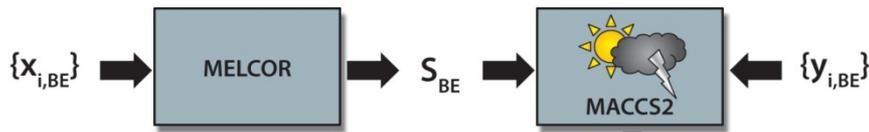
Overview (continued)

- Results reported with regard to figures of merit investigated:
 - MELCOR: Cesium and Iodine release to the environment by 48 hours, in-vessel hydrogen production, and timing of initial fission product release to the environment
 - MACCS: Individual early and latent cancer fatality (LCF) risk
- Results analyzed with statistical regression based methods, scatter plots, and phenomenological investigation of selected individual realizations
 - An individual realization is a single run (or “realization”) selected from the set generated in the Monte Carlo simulation



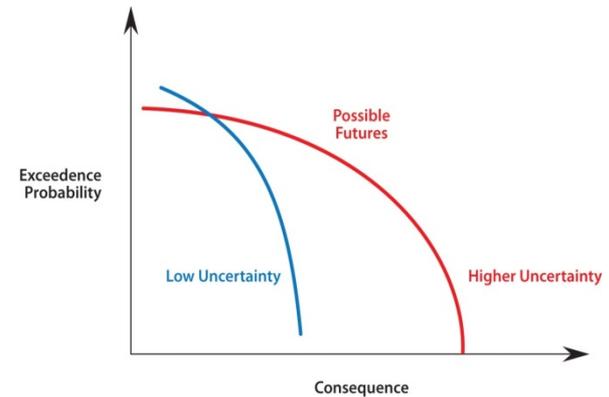
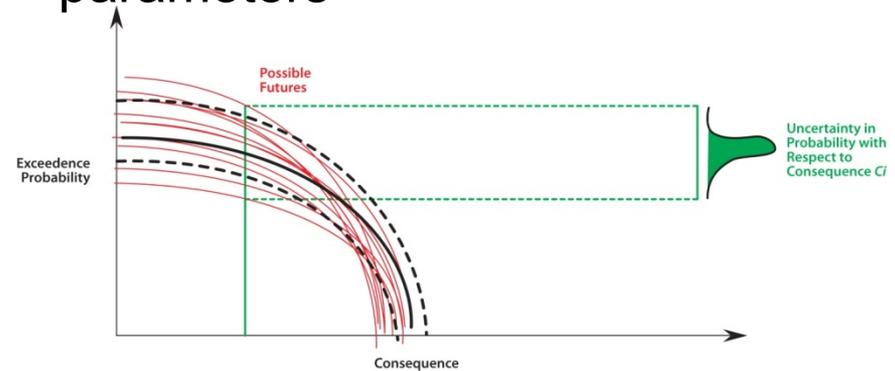
Uncertainty Analysis

Base calculations include weather variability in the consequences



$||H||$ is the mean consequence for a specific accident sequence, e.g. latent cancer fatalities

Probabilistic UA includes both the weather variability and the uncertainty in the epistemic input parameters



Multiple regression techniques were implemented

- Regression techniques included:
 - Rank regression,
 - Quadratic regression,
 - Recursive partitioning, and
 - Multivariate adaptive regression splines (MARS)
- Use of multiple approaches to post-process and analyze Monte Carlo results provided better explanatory power with regard to which input parameters are most important to uncertainty in results
 - Demonstrated in the Peach Bottom UA

Overall Conclusions

- Surry UA corroborates SOARCA study conclusions
 - Public health consequences from severe nuclear accident scenarios that were modeled are smaller than previously calculated, and very small in absolute terms
 - Delayed releases calculated provide time for emergency response actions such as evacuating or sheltering
 - Long-term phase dominates health effect risks because emergency response is faster than progression to release
 - “Essentially zero” early fatality risk projected

Overall Conclusions (2)

- A major determinant of source term magnitude and health consequences is whether or not a steam generator tube rupture (SGTR) occurs
- Mean, individual, LCF risks assuming a linear-no-threshold (LNT) dose response, conditional on the occurrence of an accident, estimated in this UA of the Surry unmitigated STSBO¹ are very low, lower than the risk evaluated in the original SOARCA study, which was 9×10^{-5} within 10 miles, and lower at longer distances.

¹ Frequency STSBO – 1×10^{-6} to 2×10^{-6} pry; STSBO with SGTR – 1×10^{-7} to 8×10^{-7} pry (NUREG/CR-7110 Vol 2, pg. 2-3).



MELCOR Model Enhancements

MELCOR Model Enhancements

- MELCOR 1.86 was used for the original Surry SOARCA study.
- MELCOR 2.1 became available in 2010
 - MELCOR code enhancements continued.
 - Version 1.86 is no longer maintained.
- Given the evolution of the code, it was determined reasonable to correct known errors and implement additional model enhancements to improve the analysis.

Surry MELCOR Model Enhancements

- A few Surry model enhancements are described below:
 - Enabled optional molten core concrete interaction (MCCI) modeling input to take advantage of recent code enhancements/corrections that add realism;
 - Increased the steam generator nodalization (see next slide);
 - Included hot tube modeling in the SGTR logic;
 - Redefined the ignition criteria for H₂/CO deflagrations;
 - Extended hot leg nozzle creep rupture modeling to consider the stainless steel cladding.

Surry MELCOR Model Corrections

- A few Surry model corrections are described below.
- Corrected errant vapor pressure coefficients for control rod materials silver, indium, and cadmium.
- Corrected the containment concrete.
 - The Surry SOARCA analysis used a limestone aggregate. Research in the UA identified the aggregate to be basaltic.
- Main steamline drains were found not isolating in Surry SOARCA and were fixed.
- Developed a current Surry core inventory to facilitate time-at-cycle sampling: the Surry SOARCA analysis had implemented a high burnup core inventory.

Example: Increased steam generator tube nodalization

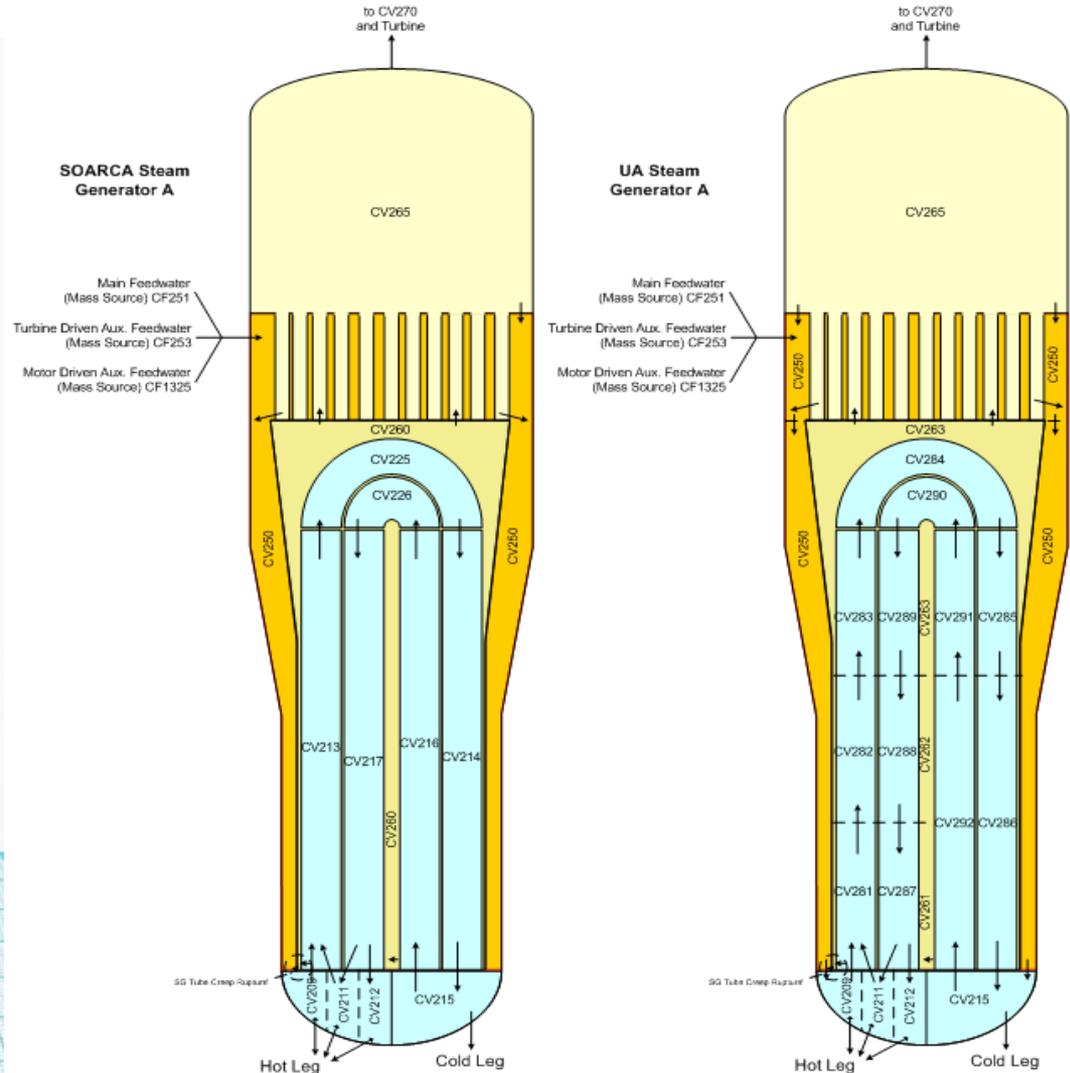
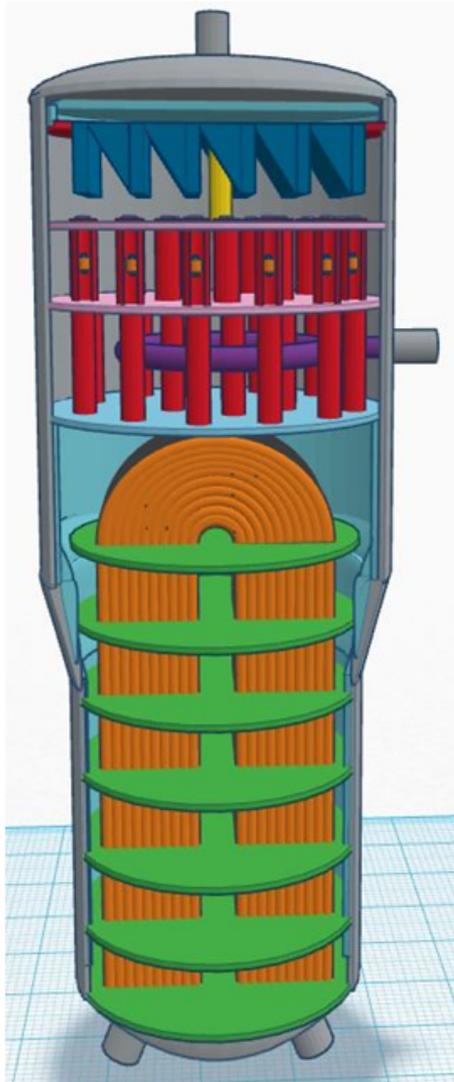


Figure 3-3 Comparison of NUREG/CR 7110 Vol 2 and UA steam generator nodalizations

Parameter Development

Implemented a Process for Choosing Parameters and Establishing Distributions

- Involved staff from SNL and NRC with expertise in MELCOR and MACCS modeling for SOARCA
- Subject matter experts (SMEs) provided support in reviews of data and parameters
- Reviewed parameters used in Peach Bottom UA
- Performed a systematic review of phenomenological areas (sequence, in-vessel and ex-vessel accident progression, containment behavior, chemical form and aerosol deposition)
- Reviewed the phenomenological topics covered in the MELCOR Reference Manual
- Reviewed a comprehensive MACCS parameter list

Process (continued)

- An initial list of candidate parameters was then developed.
- Implemented a ‘storyboard’ process
 - Required analysts to document justification and rationale for each parameter
 - Iterative and involved joint NRC reviews
- Focused on:
 - confirming the parameter representations appropriately reflect key sources of uncertainty, and
 - ensuring model parameter representations (i.e., probability distributions) are reasonable and have a defensible technical basis.

Process (continued)

- During the course of the project (typically storyboard reviews), some parameters were omitted from further consideration and others were added for the analysis.
- Some parameters were exploratory
 - Little basis for the uncertainty distribution, but analysts had an interest in gaining some insights
- MELCOR and MACCS parameters that were considered but not included are listed in the report.

Diagram of the code information flow

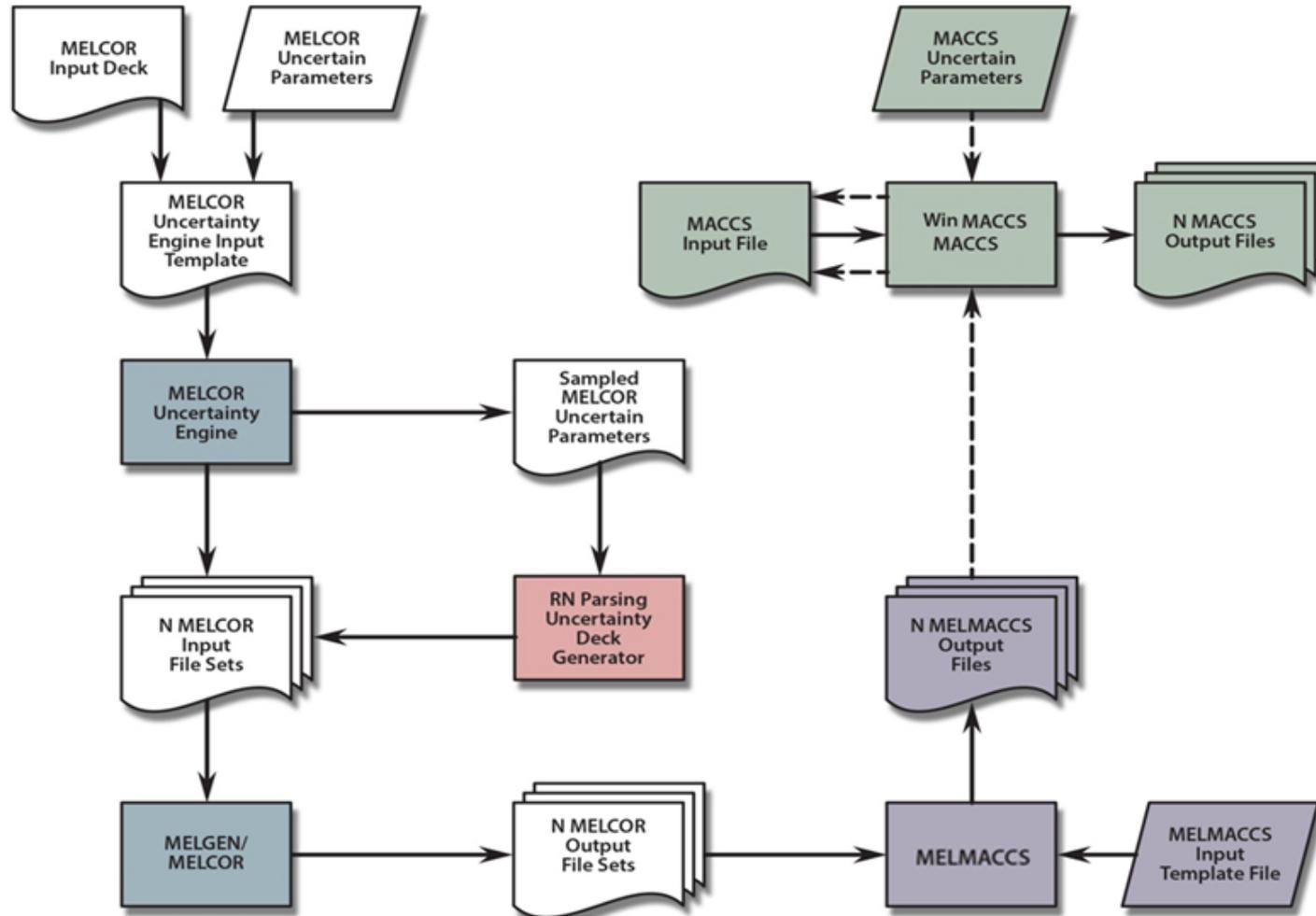
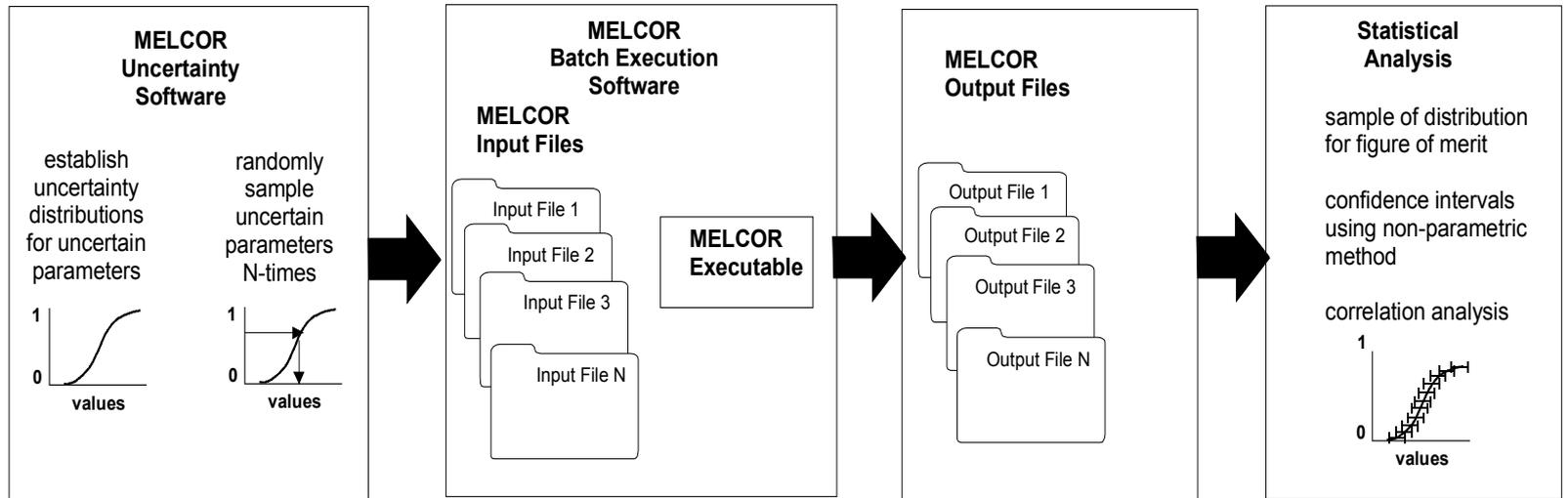


Figure 3-1 Diagram of code information flow

MELCOR uncertainty application



- Define uncertain parameter distributions
- MELCOR Uncertainty software samples distributions
- MELCOR Uncertainty software incorporates “n” sets of sampled parameters into “n” MELCOR input files

- Batch Execution software runs “n” MELCOR input files on server system

- MELCOR output files are manually retrieved from server system

- MELCOR output files are post processed

Figure 3-2 Melcor uncertainty application

MELCOR Parameters

Sequence

- Primary SV stochastic FTC
- Primary SV stochastic FTO
- Primary SV FTC due to passing water
- Secondary SV stochastic FTC
- SV open area fraction
- Primary SV FTC due to overheating
- Reactor coolant pump seal leakage (RCPSL)
- Normalized temperature of hottest SG tube
- SG tube thickness (mm)

In-Vessel Accident Progression

- Zircaloy melt breakout temperature**
- Molten clad drainage rate**
- Radial molten debris relocation time constant (RDMTC)
- Radial solid debris relocation time constant (RDSTC)
- Time in the fuel cycle of the accident (BOC, MOC, or EOC)
- Decay Heat (DEV_DECAY_HEAT)
- Melting temperature of the eutectic formed between UO_2 and ZrO_2

** indicates parameter was uncertain in the Peach Bottom UA

MELCOR Uncertain Parameters (continued)

Ex-vessel Accident Progression

- Hydrogen ignition criteria (H₂ LFL)
- SGTR location (for decontamination factor per ARTIST)

Containment Behavior

- Containment design leakage rate (DLEAK)
- Containment fragility curve (CFC)
- Containment convection heat transfer coefficient

Chemical Forms of Iodine and Cesium

- CHEMFORM iodine**
- CHEMFORM cesium**

Aerosol Transport and Deposition

- Dynamic Shape Factor (PARTSHAPE)

** indicates parameter was uncertain in the Peach Bottom UA

Safety Valves

- In most cases, a failure to close (FTC) occurs on the lowest set-point safety valve (SV) and the system transitions from state 1 to state 4.
- If failure to open (FTO) occurs, or a FTC with a sufficiently small open area, the system transitions from cycling on the lowest set point (state 1) to cycling on the middle, then highest set point SVs (states 2 and 3).
- Should all 3 valves FTO, State 5 (no relief) develops.

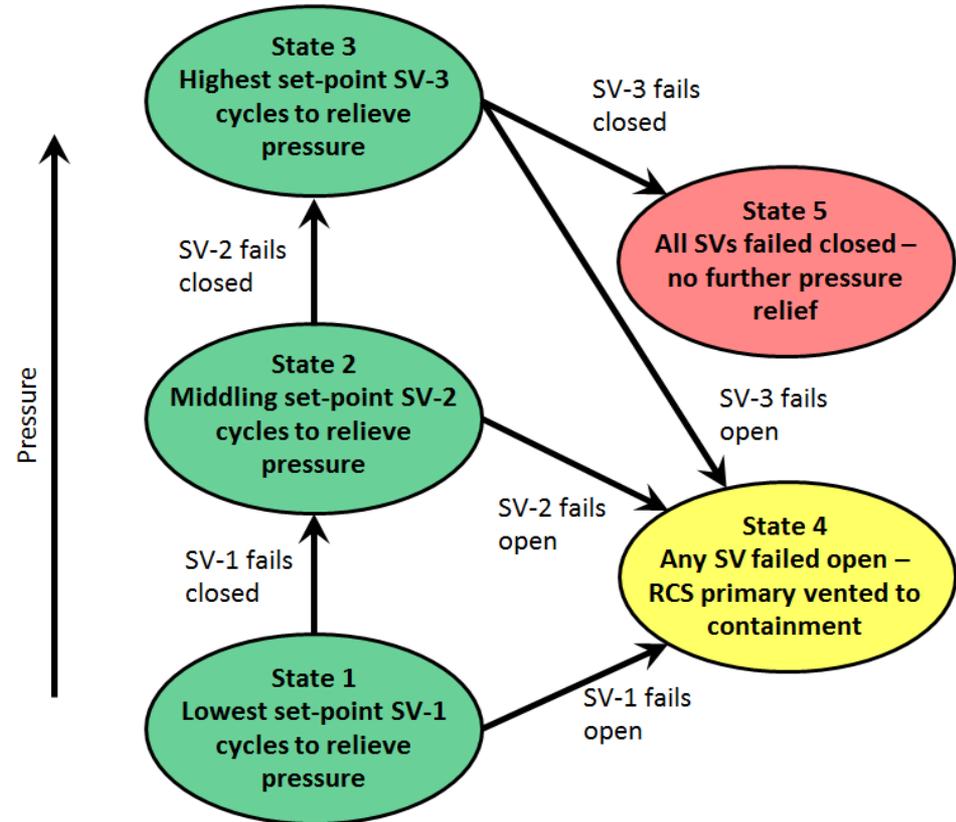


Figure 4-1 Possible transitions in the 3-SV pressurizer pressure relief system considering both FTO and FTC valve conditions

Safety Valves

- Truncated at 1,000 cycles based on professional judgment that an SV would likely not cycle more than a few hundred times prior to failure
- Note the very low possibility that all 3 valves would fail to open was identified, but was never sampled in the 1003 realizations

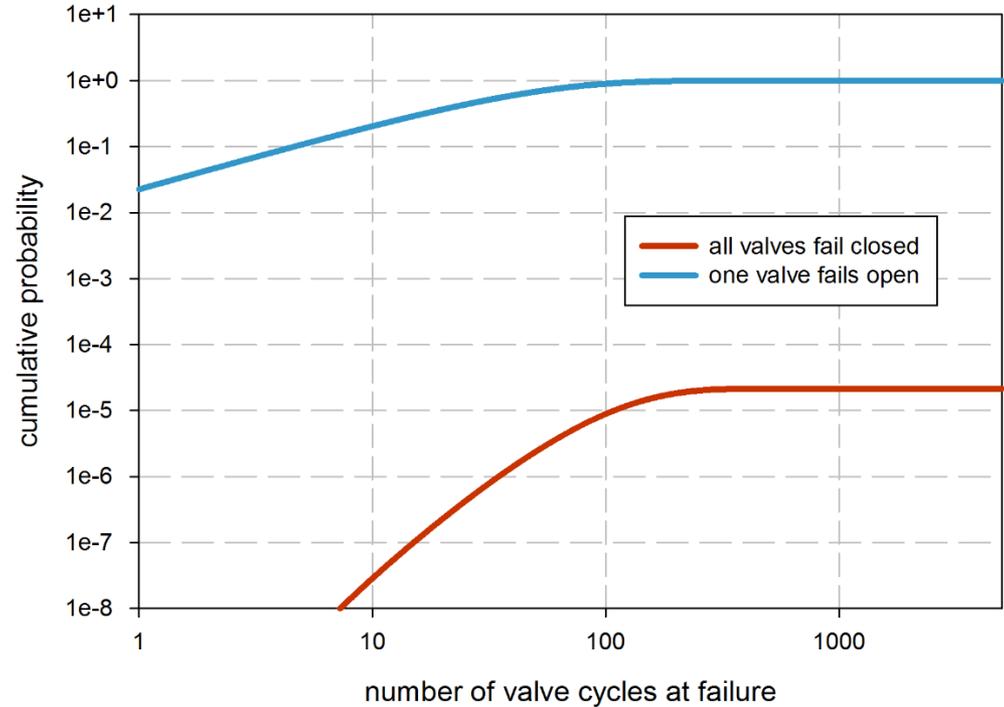


Figure 4-2 Cumulative distribution function (CDF) for the number of cycles at after which any single SV will have failed open compared to the CDF for the number of cycles after which all 3 valves failed closed

Safety Valves

Uncertain Parameter	Distribution type	Distribution Parameters	Lower Bound	Upper Bound
Primary SV stochastic FTC (-)	Beta ¹	$\alpha : 17.5$ $\beta : 756.5$	0	1
Primary SV stochastic FTO (-)	Beta ¹	$\alpha : 0.5$ $\beta : 773.5$	0	1
Primary SV FTC due to passing water (-)	Beta ¹	$\alpha : 0.5$ $\beta : 4.5$	0	1
Secondary SV stochastic FTC (-)	Beta ¹	$\alpha : 17.5$ $\beta : 756.5$	0	1
SV open area fraction (-)	Uniform	-	0.01	1
Primary SV thermal failure to close (K)	Beta	$\alpha : 5$ $\beta : 10.7615$	811	1422

- From Table 4-1 MELCOR sampled parameters.

Decay Heat (Cycle)

- CYCLE represents the time at cycle and was varied between beginning, middle, and end of cycle (BOC, MOC, and EOC).
- Cycle determines the radionuclide inventory which is the source of decay heat
 - Baseline decay heat curves were developed for each time at cycle.
- For each realization, variation from the base decay heat curve was sampled.
- Cycle directly affects the MELCOR source term calculation through decay heat and directly affects the MACCS consequence analysis through fission product inventory
 - CYCLE is the only parameter that has this dual status.

Decay Heat

- The baseline BOC, MOC, and EOC decay power curves are shown with respect to the time considered for the STSBO scenario.
- The times of shutdown in cycle 20 were chosen to be 7 days for BOC, 200 days for MOC, and 505 days for EOC.

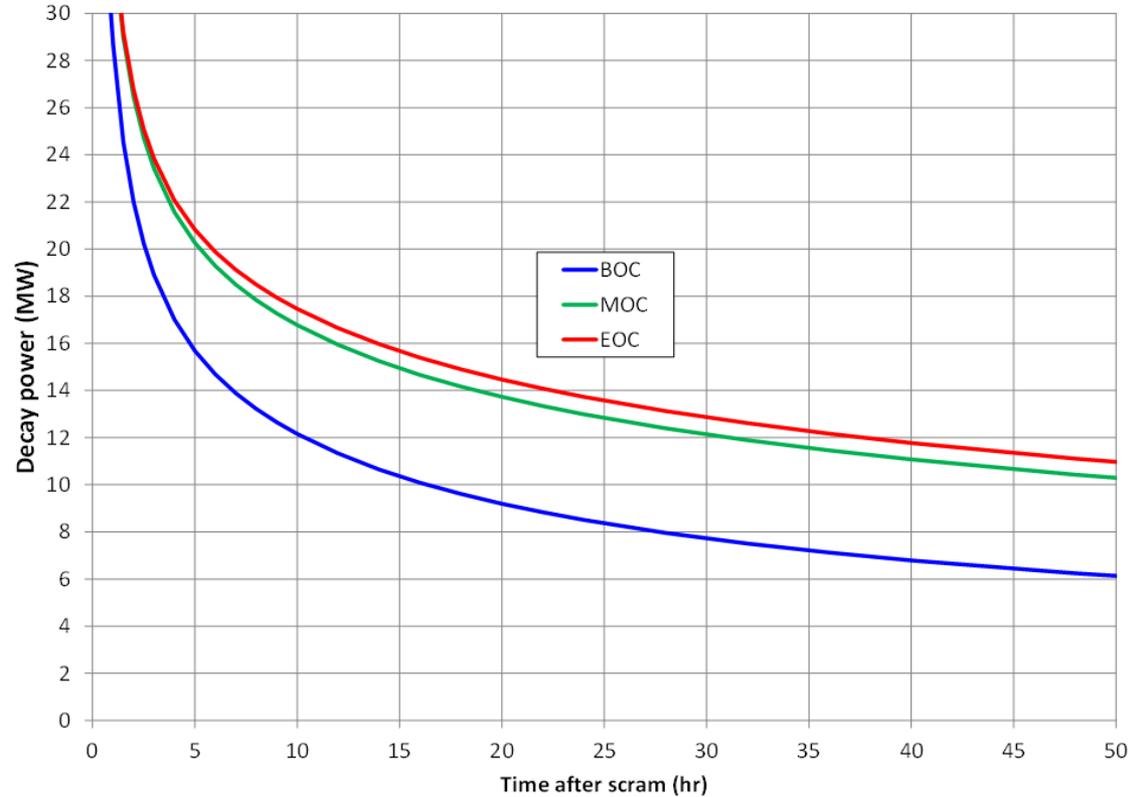


Figure 4-21 BOC, MOC, and EOC decay power curves

Containment Fragility Curve

- The containment failure curve was modified -- original Surry SOARCA (top) and the UA curve (bottom).
- Data points shown reflect leak rate data collected from 1:6 scale experiments
 - Developed with a simple NRC method to reconcile scale and idealized nature of experiment.
- The 3 calculated pressures were all reduced 15 percent in SOARCA for conservatism because of the above approach.
- Both curves use 3 of the same points, based on scaled containment testing at Sandia. However, the UA includes the liner yield point, which results in the enhanced failure leakage not initiating until much higher containment pressures.
- The 4th data point, liner yield, shown at 1% volume / day was adopted directly (pressure and leak rate) from experimental data, also with the pressure reduced 15 percent.

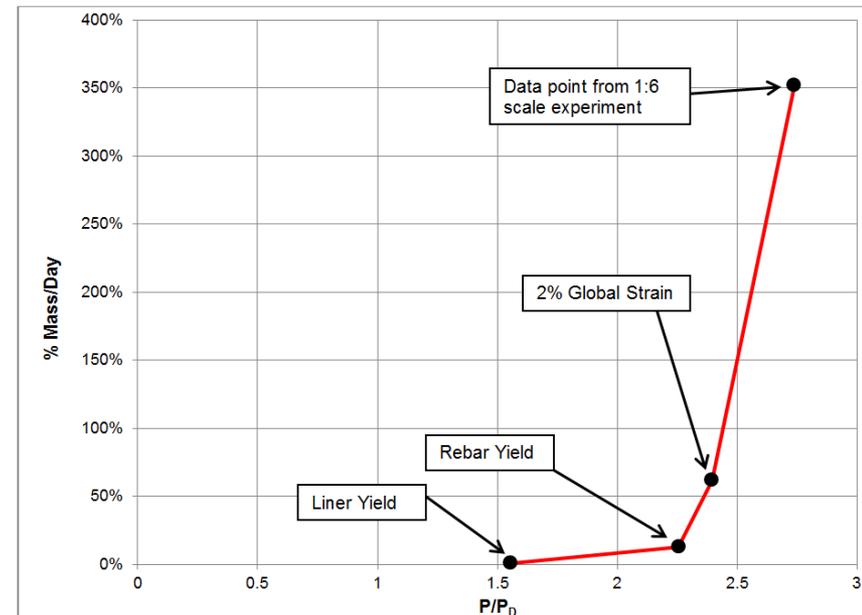
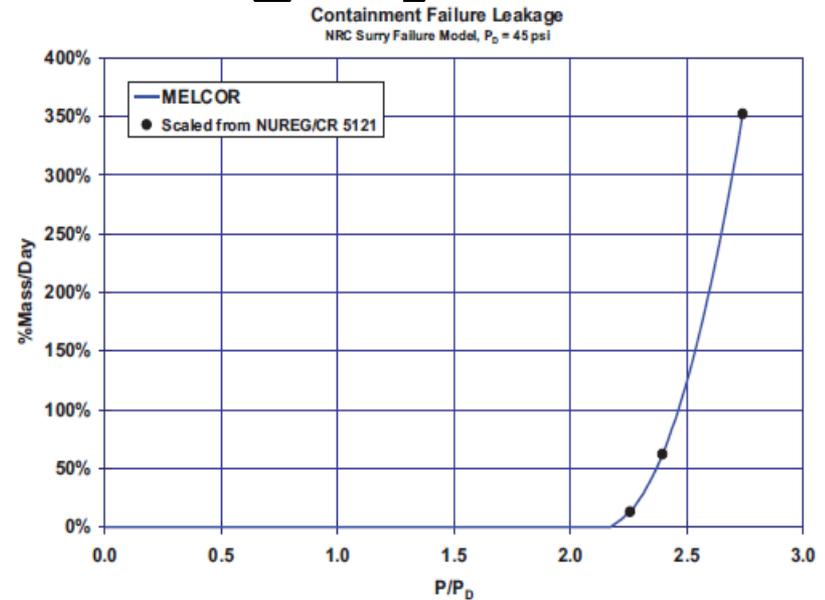


Figure 4-34 Containment functional failure leakage 31

Containment Fragility Curve

- The Surry SOARCA study neglected the liner yield point; thus overpressure leakage before rebar yield was assumed to be subsumed by design leakage, and early enhanced leakage was assumed insignificant for calculation of integral releases.
- The effect, combined with other sampled parameters such as time at cycle and nominal leakage, is that in the UA realizations containment pressure remains lower for a longer time period.

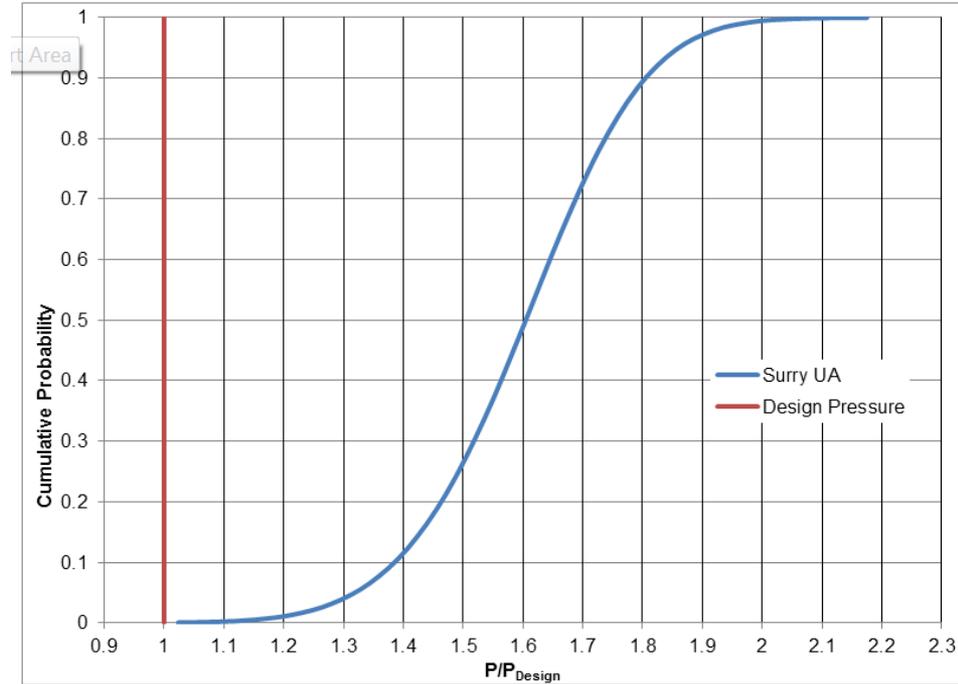


Figure 4-35 CDF for containment overpressure ratio for liner yield

Hydrogen Ignition Criteria

- Hydrogen ignition criteria accounts for the ignition location for a hydrogen deflagration and the corresponding flammability limit (volume percent of hydrogen) to represent uncertainty in the direction of propagation from the ignition source for upward, horizontal, and downward propagation.

H2-LFL Uncertainty Parameter Distribution (Propagation Direction)

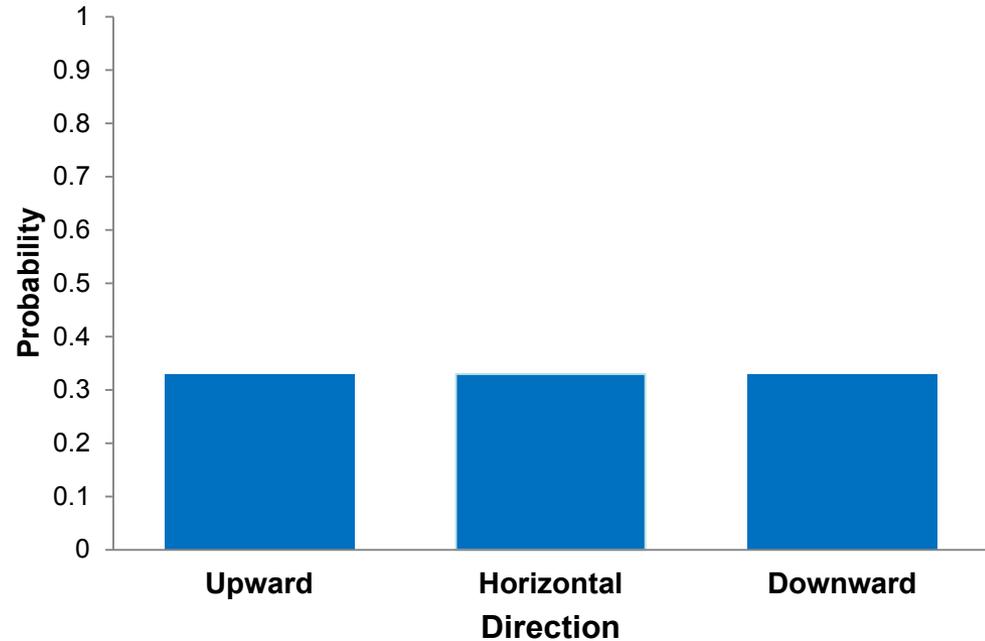


Figure 4-28 Uncertainty distribution for ignition propagation direction

Hottest Steam Generator Tube

- Normalized SG tube temperature is represented by this parameter, which along with the MELCOR-calculated hot leg and cold tube temperatures is used to determine the time-dependent hottest tube temperature applied to the single tube model.

$$T_n = \frac{T_{ht} - T_{ct}}{T_h - T_{ct}}$$

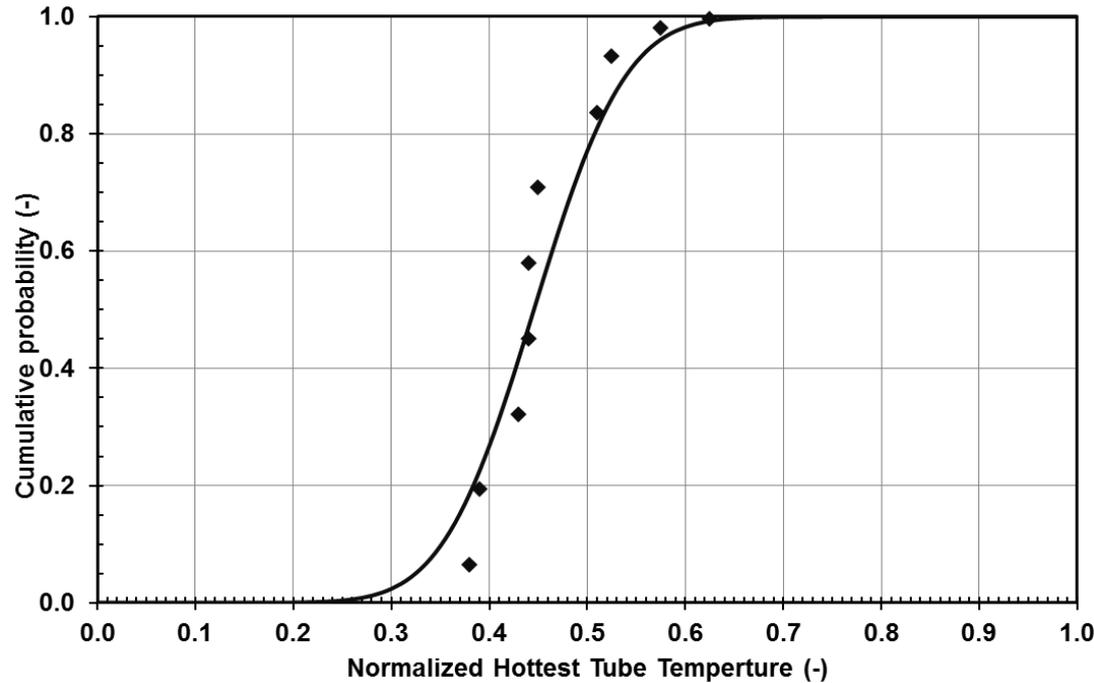


Figure 4-12 CDF of normalized hottest tube temperature

MELCOR Modeling

- Updated MELCOR base case.
- 1003 successful realizations in Monte Carlo simulation.
- Regression analyses performed for figures of merit identified in table below.

Output Parameter Data set used based on occurrence of SGTR												
Cycle	Cs_frac			I_frac			H2_Prod			Release Timing		
	SGTR	Non-SGTR	Both	SGTR	Non-SGTR	Both	SGTR	Non-SGTR	Both	SGTR	Non-SGTR	Both
All	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
BOC		✓	✓		✓	✓		✓	✓			
MOC		✓	✓		✓	✓		✓	✓			
EOC		✓	✓		✓	✓		✓	✓			

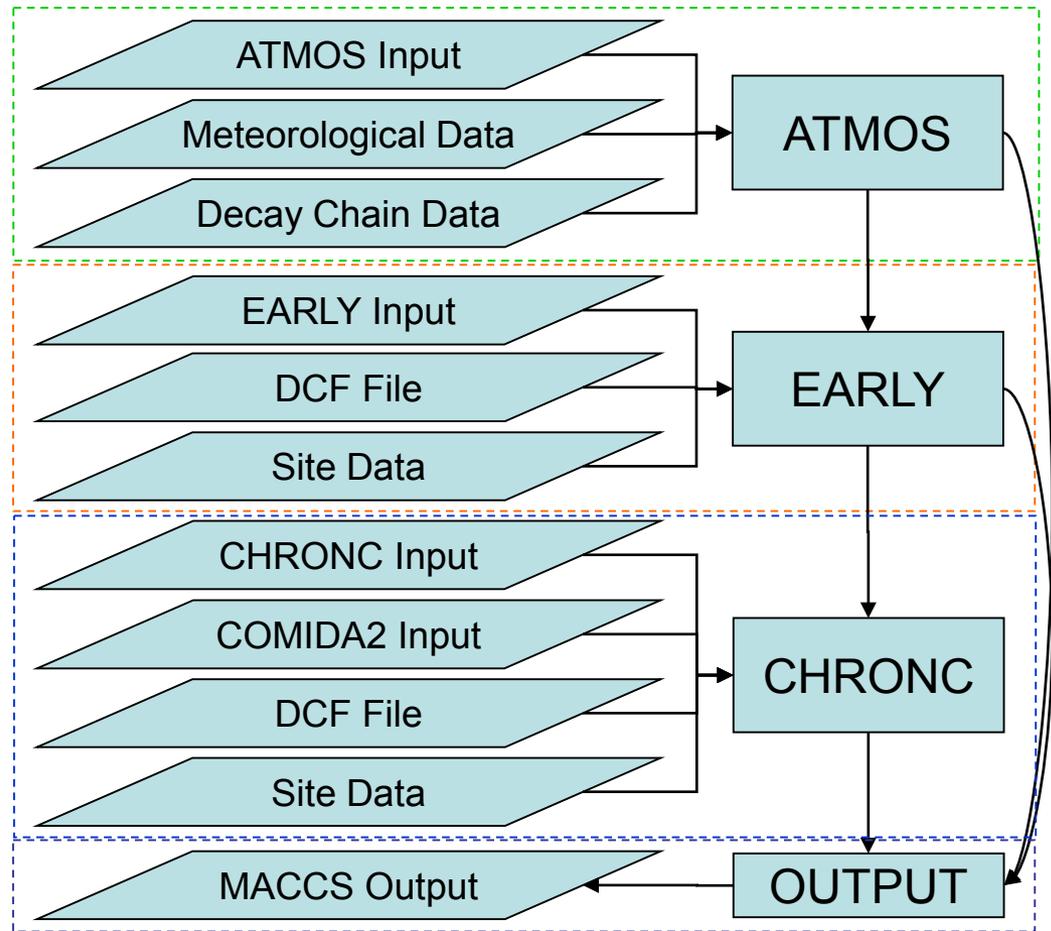
Table 6-1 MELCOR regression analyses completed



MACCS Consequence Analysis

MELCOR Accident Consequence Code System (MACCS)

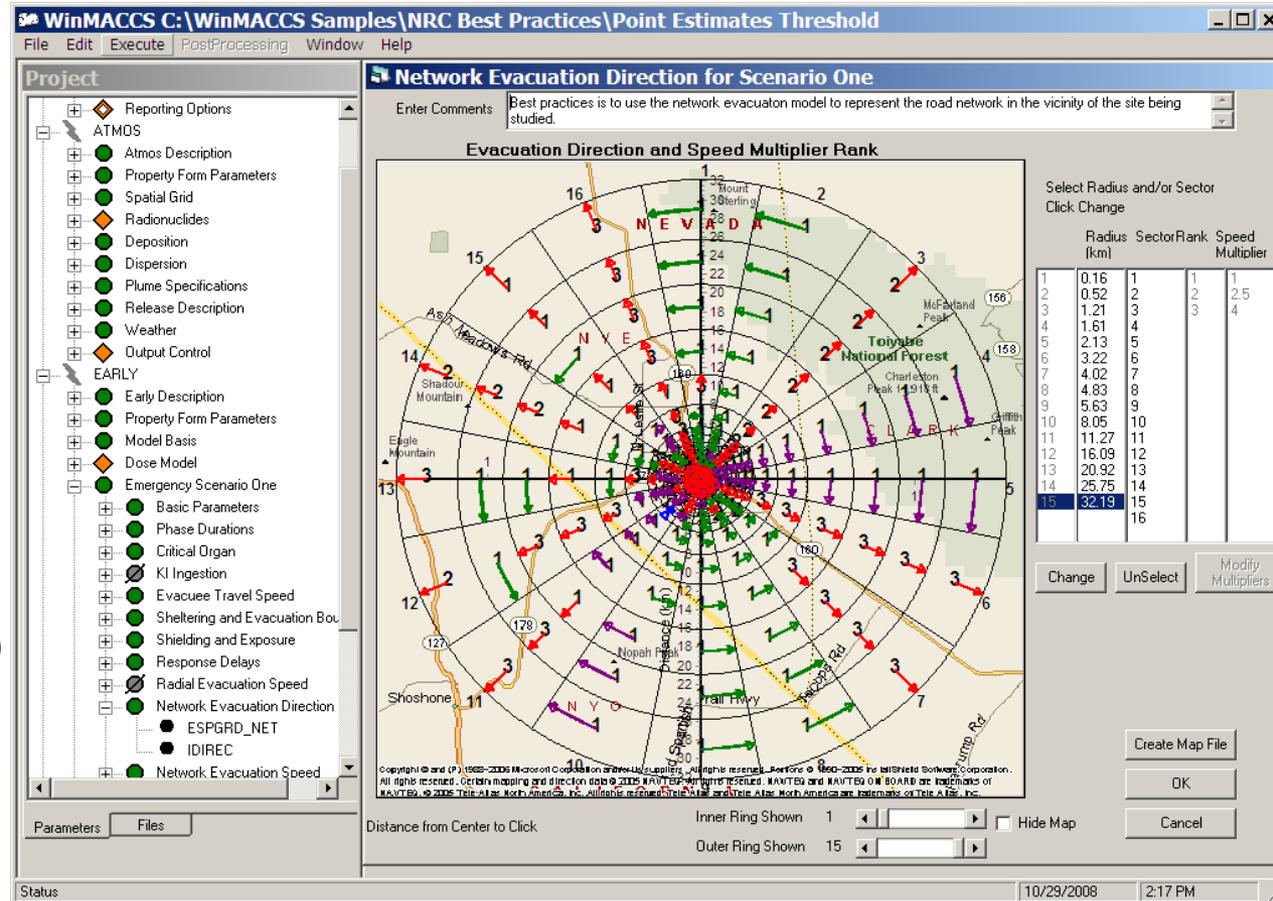
- Tool used to assess the risk and consequence associated with a hypothetical release of radioactive material to the atmosphere.
- Dispersion based on Gaussian plume segment model (with provisions for meander and surface roughness effects)
- Multiple Plumes (i.e. up to 200)
- Radioactive decay and ingrowths
- Models aleatory (random) uncertainty due to weather



MACCS model structure data and data flow

MACCS models realistic response

- Models evacuation, shelter, and KI protective actions
- Evacuation speeds and direction developed from site specific evacuation time estimate (ETE)
- 6 cohorts modeled for Surry (also Peach Bottom)
- Unique response characteristics for each cohort
- MACCS also models relocation of the public.
- Relocation implemented, typically beyond the EPZ, for hotspot and normal dose criteria and for habitability criteria



MACCS input screen showing radial directions and speed reduction multipliers (sample site, not Surry)



MACCS Parameters

MACCS Uncertain Parameter Groups

Deposition

- Wet Deposition (CWASH1)
- Dry Deposition Velocities (VDEPOS, m/s)

Dispersion

- Crosswind Dispersion Linear Coefficient (CYSIGA)
- Vertical Dispersion Linear Coefficient (CZSIGA)

Shielding factors

- Groundshine Shielding Factors (GSHFAC)
- Inhalation Protection Factors (PROTIN)

Latent Health Effects

- Dose and dose rate effectiveness factor (DDREFA)
- Lifetime Cancer Fatality Risk Factors (CFRISK)

- Long Term Inhalation Dose Coefficients

Early Health Effects

- Early Health Effects LD₅₀ Parameter (EFFACA)
- Early Health Effects Exponential Parameter (EFFACB)
- Early Health Effects Threshold Dose (EFFTHR)

MACCS Uncertain Parameter Groups (continued)

Emergency Response

- Evacuation Delay (DLTEVA)
- Evacuation Speed (ESPEED)
- Hotspot Relocation Time (TIMHOT)
- Normal Relocation Time (TIMNRM)
- Hotspot Relocation Dose (DOSHOT)
- Normal Relocation Dose (DOSNRM)

Aleatory Uncertainty

- Weather trials

Groundshine Shielding Factors (GSHFAC)

- Values of GSHFAC are important because doses received from groundshine are directly proportional to these factors and groundshine is usually the most important of the long-term dose pathways.
- Uncertainty exists in factors that affect GSHFAC, such as indoor residence time, housing shielding value, and degree of departure from the infinite flat plane assumptions.

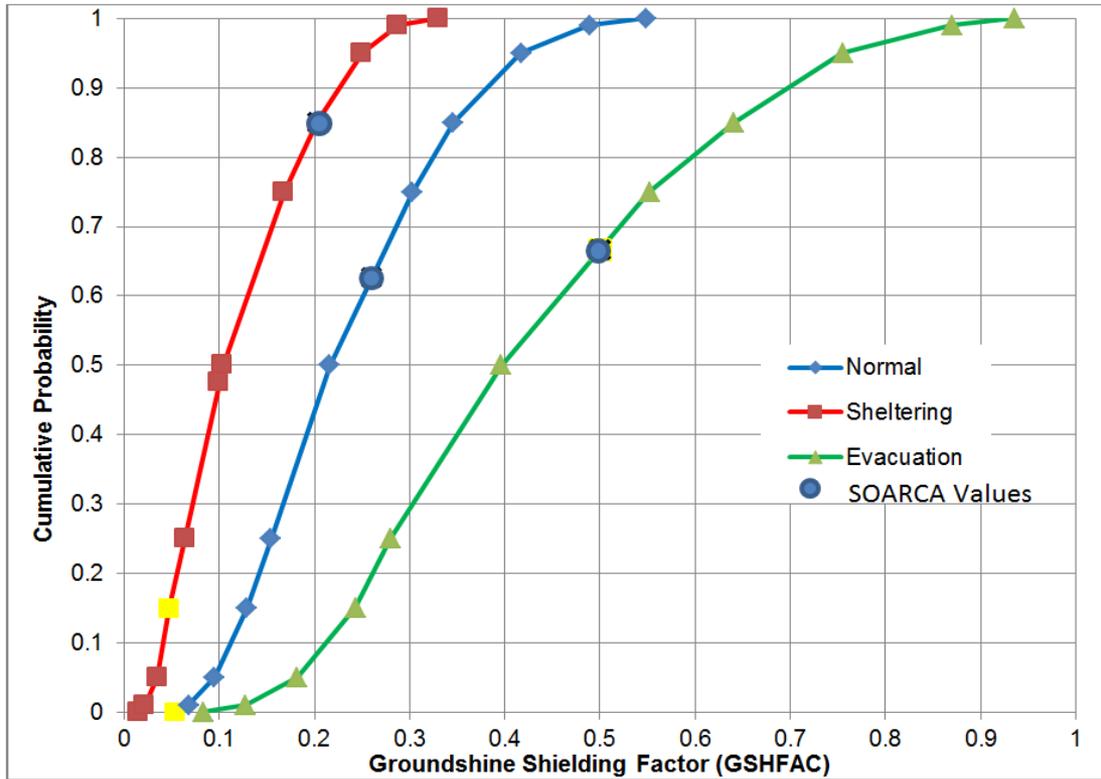


Figure 4-45 Cumulative distribution functions of GSHFAC for normal activity, sheltering, and evacuation based on expert elicitation data

Lifetime Cancer Fatality Risk Factors (CFRISK)

- Risk factors (CFRISK) are based on a 50-year lifetime dose commitment to specified target organs (risk/Sv).
- Probability of a lifetime cancer fatality is calculated separately for each cancer syndrome related to each target organ.
- Based on the technical approach described in BEIR V.

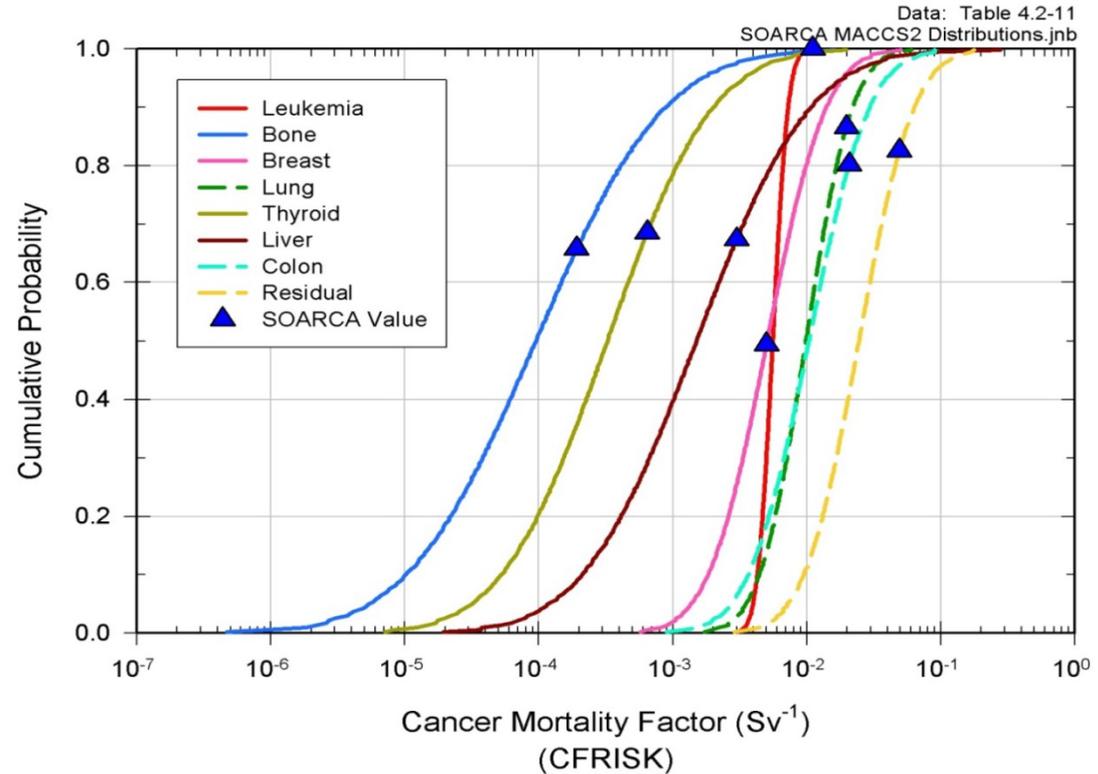


Figure 4-54 Cumulative distribution functions for CFRISK for each of the organs included in the analysis

Dose and Dose Rate Effectiveness Factor (DDREFA)

- In MACCS, doses received during the emergency phase are divided by DDREFA when the committed dose is less than 0.2 Sv.
- Doses received during the long-term phase are assumed to be controlled by the habitability criterion to be well below 0.2 Sv, so these doses are always divided by DDREFA in the calculation of latent health effects.

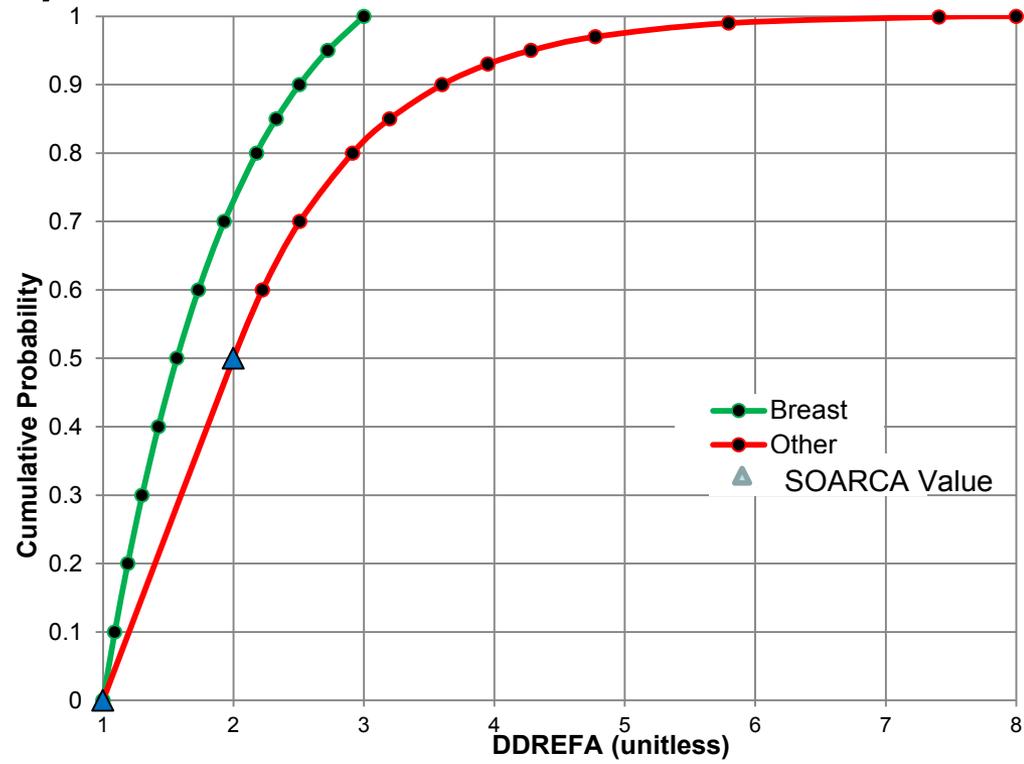


Figure 4-53 Cumulative distribution functions of DDREFA for breast and other cancer types



Dry Deposition Velocity (VDEPOS)

- Dry deposition velocities are established by aerosol bins to represent the dependence of deposition velocity on particle size.
- Dry deposition is the only mechanism for deposition onto the ground for more than 90 percent of the hours of the year at Surry.
- Long-term exposures usually contribute more than 50 percent of the overall exposure, thus deposition is important because deposited material is the only source of exposure during the long term.

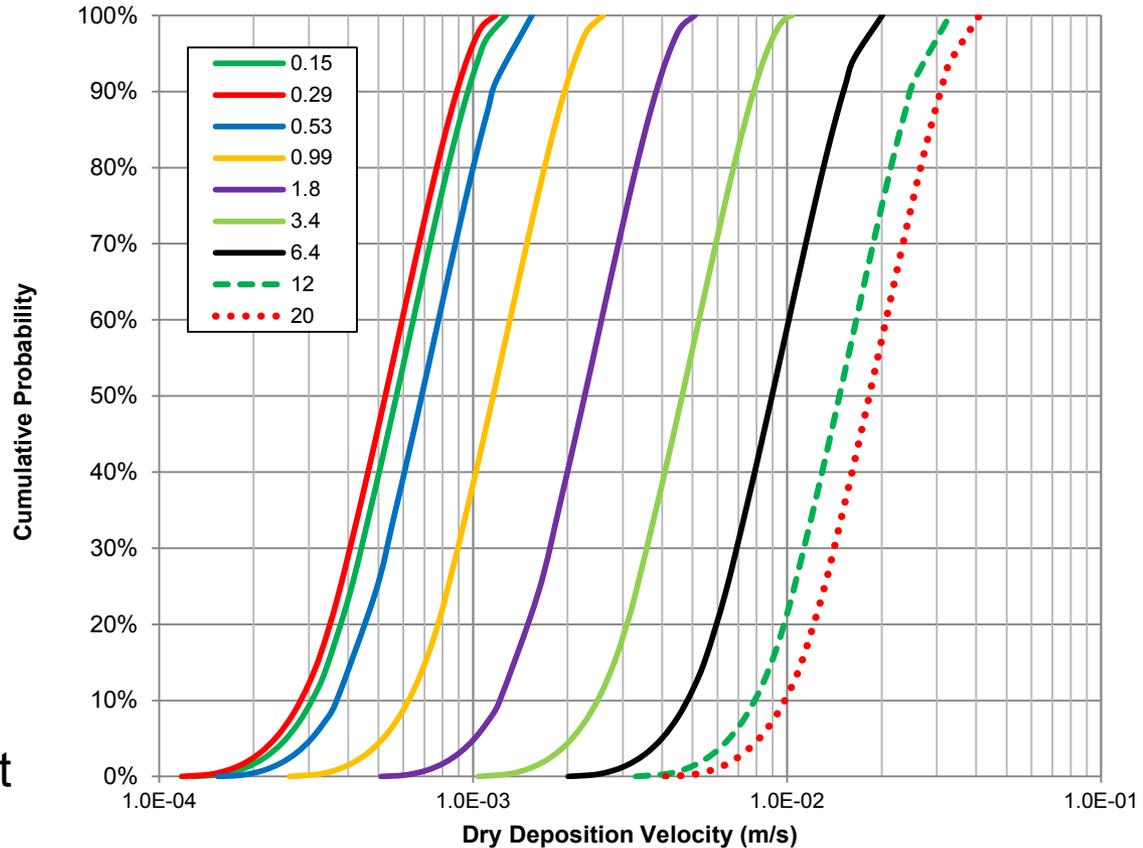


Figure 4-44 CDF of dry deposition velocities for mass median diameters representing MACCS aerosol bins

Note: The Peach Bottom UA indicated that dry deposition velocity is the most important parameter of all those considered for individual latent cancer risk

Crosswind Dispersion Linear Coefficient (CYSIGA)

- Medians of expert data were chosen as medians of SOARCA UA distributions, but they were made narrower to reflect that sampled values would be used to represent a year of weather data
- CZSIGA is the vertical dispersion linear coefficient and is treated similarly.

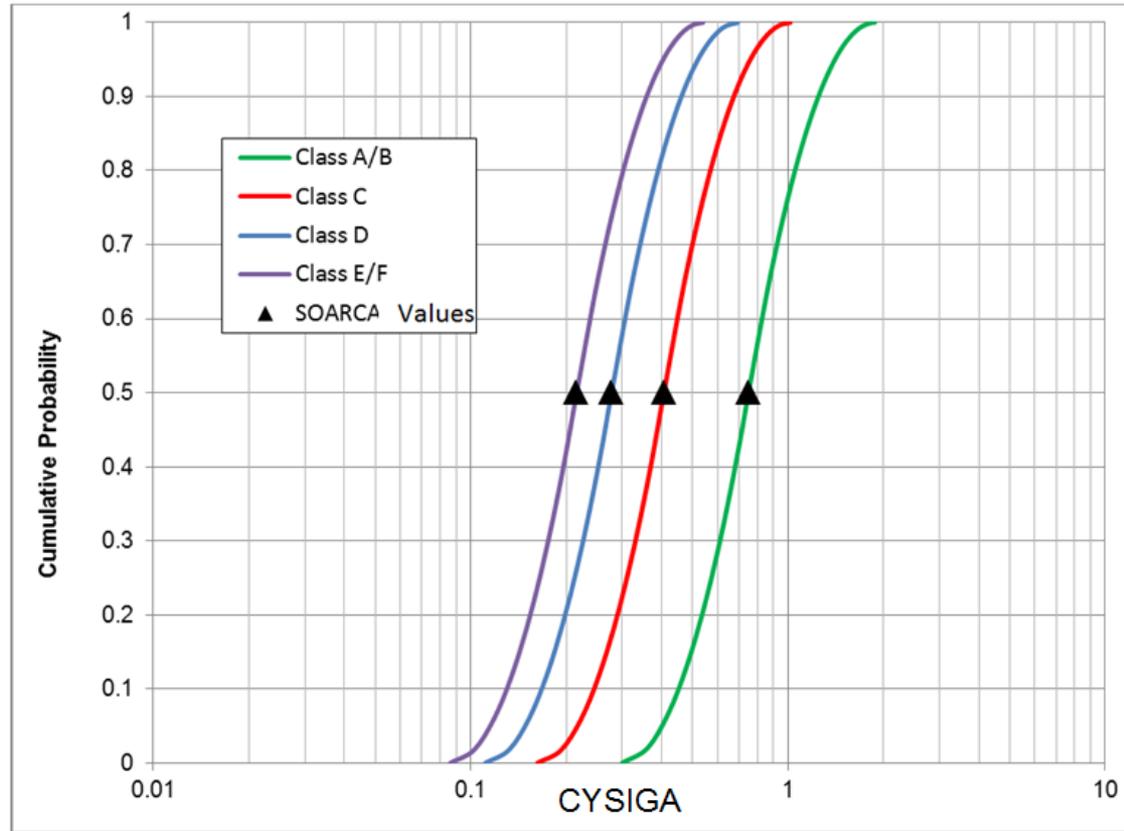


Figure 4-57 CDFs of CYSIGA for individual stability classes

Weather

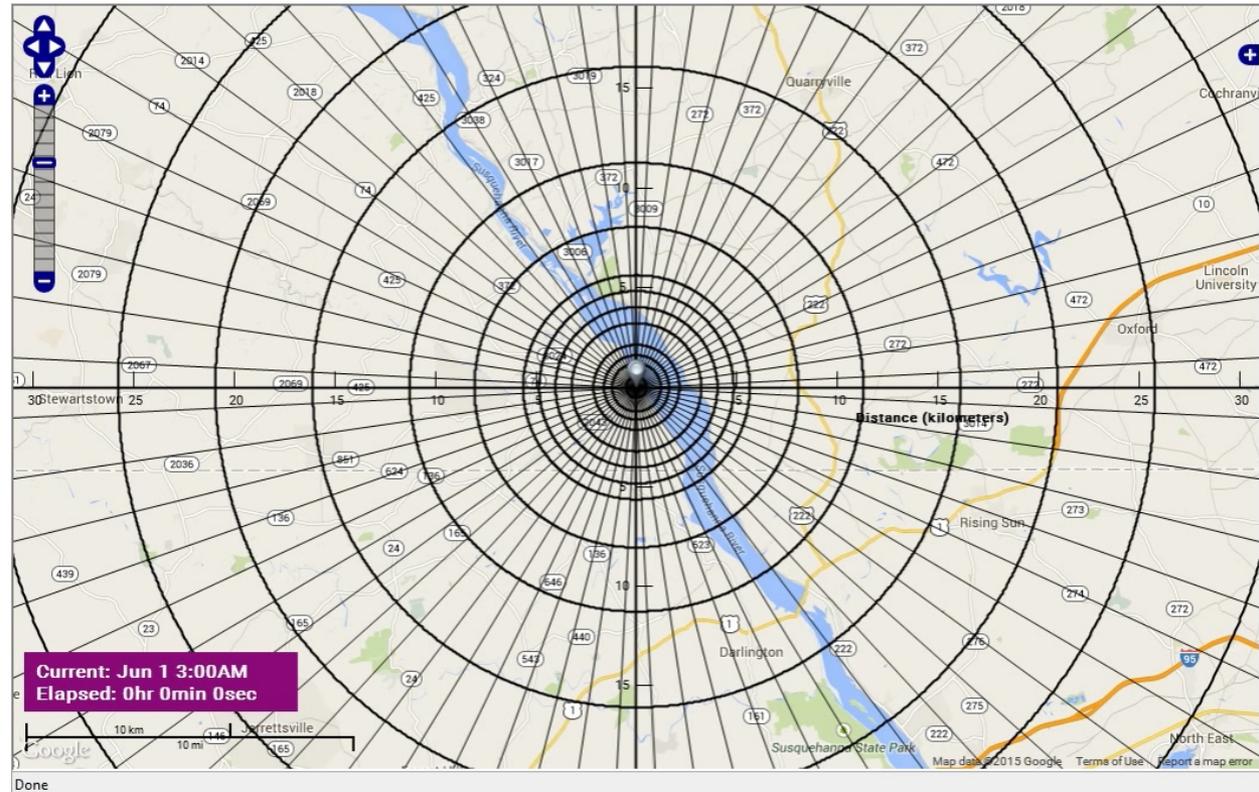
- Weather-binning approach in MACCS was implemented.
- Consists of 16 predefined bins for combinations of stability class and wind speed and 20 user-defined bins for rain occurring before the plume travels 32 km (20 miles).
- Probability of weather in each weather bin is proportional to the number of hours of data that go into that bin, and thus the weather bins are not equally probable.

	Rain Bins					
Rain Distance (miles)	Rain Intensity (mm/hr)					
	0 - 2	2 - 4	4 - 6	> 6		
< 2 miles	Bin 17	Bin 18	Bin 19	Bin 20		
2 - 3.5 miles	Bin 21	Bin 22	Bin 23	Bin 24		
3.5 - 7 miles	Bin 25	Bin 26	Bin 27	Bin 28		
7 - 13 miles	Bin 29	Bin 30	Bin 31	Bin 32		
13 - 20 miles	Bin 33	Bin 34	Bin 35	Bin 36		
> 20 miles	Not a rain bin – use wind speed and stability class binning					
	Wind Speed and Stability Class Bins					
Stability Class	Wind Speed u (m/s)					
	0 - 1	1 - 2	2 - 3	3 - 5	5 - 7	> 7
A/B	Bin 1			Bin 2		
C/D	Bin 3	Bin 4	Bin 5	Bin 6	Bin 7	Bin 8
E	Bin 9	Bin 10	Bin 11	Bin 12		
F/G	Bin 13	Bin 14	Bin 15	Bin 16		

Table 4-16 Rain bins and wind speed and stability class bins.

Weather Illustrations

- Illustration showing how plume segments move with wind shifting from northwest to northeast
- Each segment has its own width depending on the amount of dispersion that has occurred as it experiences varying weather conditions
- Each segment has a unique length depending on wind speed



Video display of plume segments

Evacuation Speed (ESPEED)

- Represents the speed for each of the evacuating cohorts for the duration of the middle phase (most congested period of travel within the EPZ).
 - Cohort 1 (0-10 public)
 - Cohort 2 (10-20 shadow)
 - Cohort 3 (schools)
 - Cohort 4 (special facilities)
 - Cohort 5 (evacuation tail)
 - Cohort 6 (non-evacuating)
- Triangular distribution was used to represent uncertainty because there is confidence in the mode derived from the ETE report.

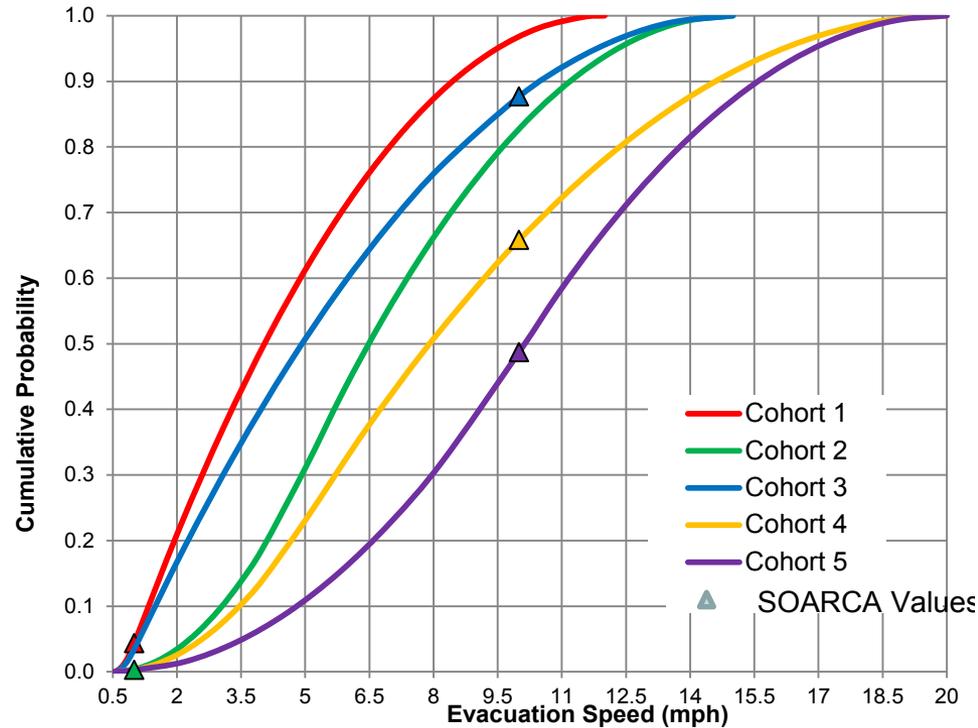


Figure 4-61 CDFs of ESPEED for each cohort



Hotspot Relocation Time (TIMHOT)

- TIMHOT is the estimated time needed to relocate residents from areas that exceed the hotspot dose threshold (DOSHOT).
- MACCS implements by removing the entire affected population from the dose equation at the time specified by TIMHOT after plume arrival.
- Actual relocation would occur over a period of time, thus an average value was developed for the affected population.
- Normal relocation time (TIMNRM) is applied similarly with a longer time period to account for a larger affected area.

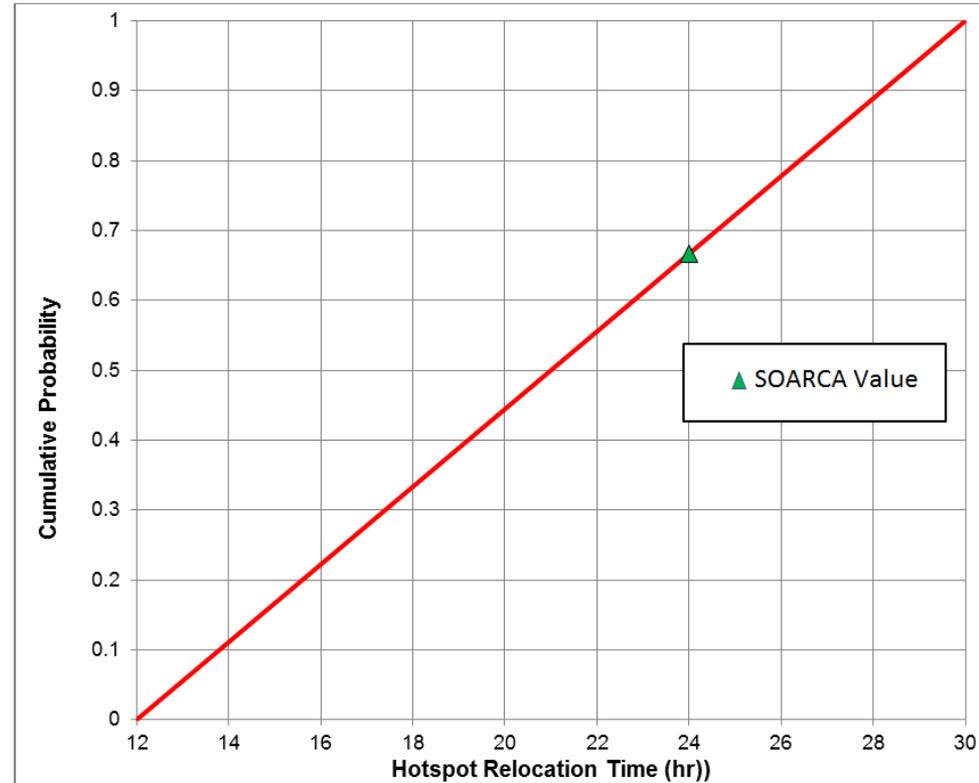


Figure 4-63 CDF of TIMHOT

Hotspot Relocation Dose (DOSHOT)

- DOSHOT is projected dose used to initiate hotspot relocation. Surry SOARCA modeled 5 rem over 7 days.
- If the total dose to individuals exceeds DOSHOT, affected people are relocated (i.e., removed from the analysis) at a user specified hotspot relocation time (TIMHOT).
- Normal Relocation Dose (DOSNRM) is applied similarly with a lower dose threshold. Surry SOARCA modeled 1 rem over 7 days.

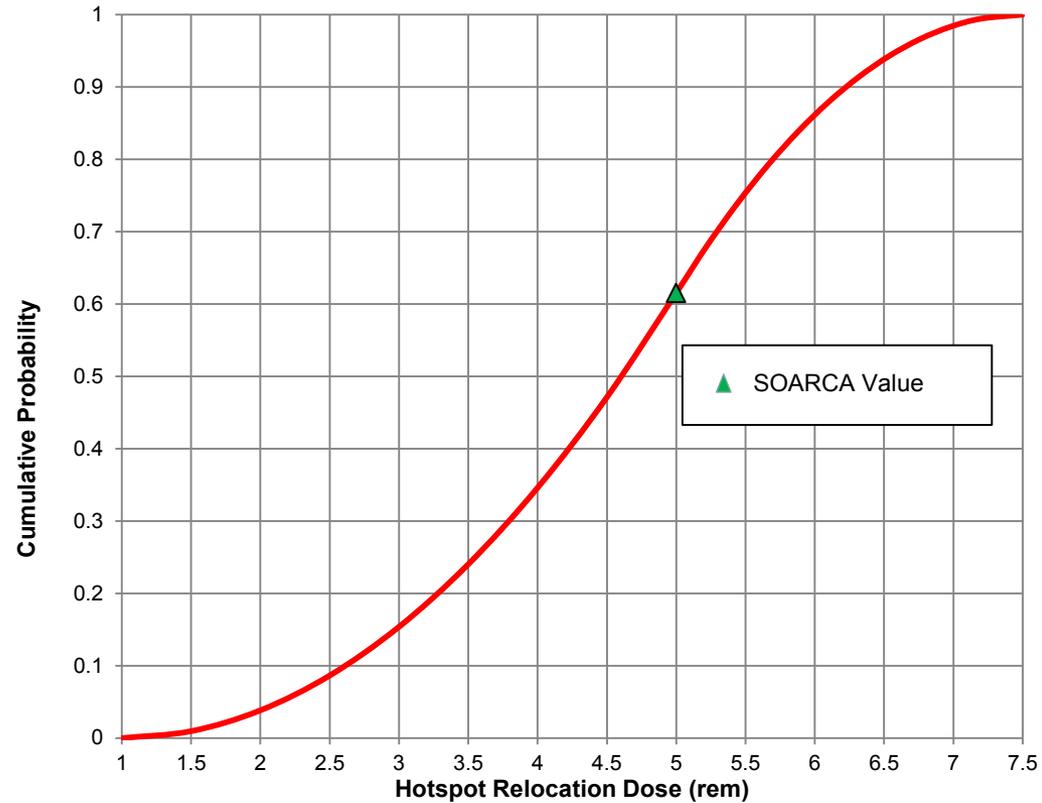


Figure 4-64 CDF of DOSHOT

MELCOR Analysis Results

MELCOR Modeling

- For review: 1003 successful Monte Carlo realizations
- Regression analyses: one for all realizations, one for just SGTR realizations, and one for non-SGTR realizations. Additional regressions were done for the three times at cycle independently (BOC, MOC, and EOC) identified in table below.

Output Parameter												
Data set used based on occurrence of SGTR												
Cycle	Cs_frac			I_frac			H2_Prod			Release Timing		
	SGTR	Non-SGTR	Both	SGTR	Non-SGTR	Both	SGTR	Non-SGTR	Both	SGTR	Non-SGTR	Both
All	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
BOC		✓	✓		✓	✓		✓	✓			
MOC		✓	✓		✓	✓		✓	✓			
EOC		✓	✓		✓	✓		✓	✓			

Table 6-1 MELCOR regression analyses completed

Overview of MELCOR Results

- An SGTR occurred in 10% of realizations, and a hot leg nozzle rupture occurred in 93% of realizations
- In every realization that an SGTR occurred, a hot leg nozzle rupture also occurred
- Prior to core damage, the secondary side depressurized through main steamline leakage and safety valve FTC
- An SV on the RCS primary side (on the pressurizer) failed to close in 68% of realizations
- The steel containment liner yielded/tore in 74% of realizations
- Containment rebar yielded in 7% of realizations.

Cesium Release Fraction to Environment

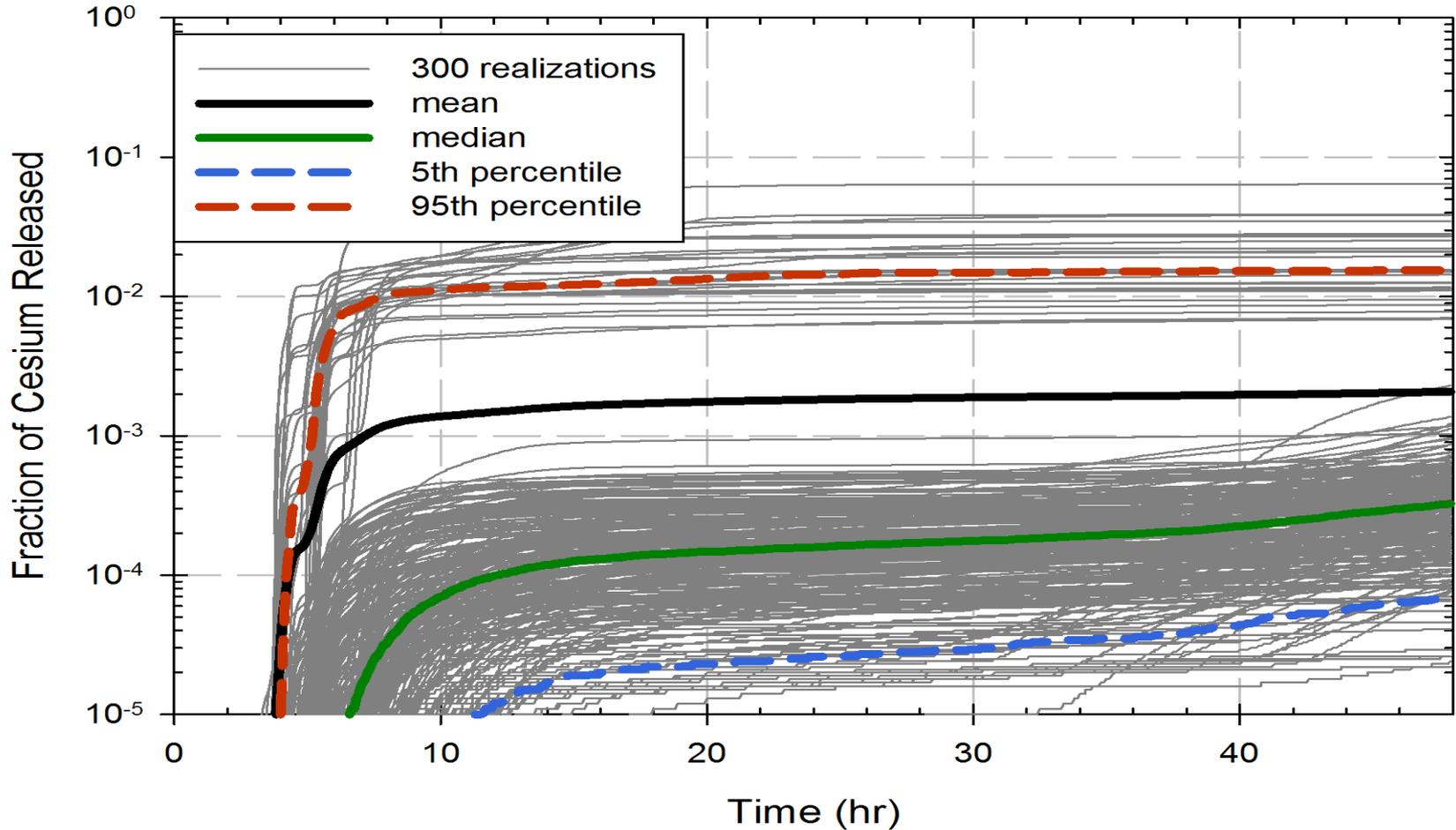
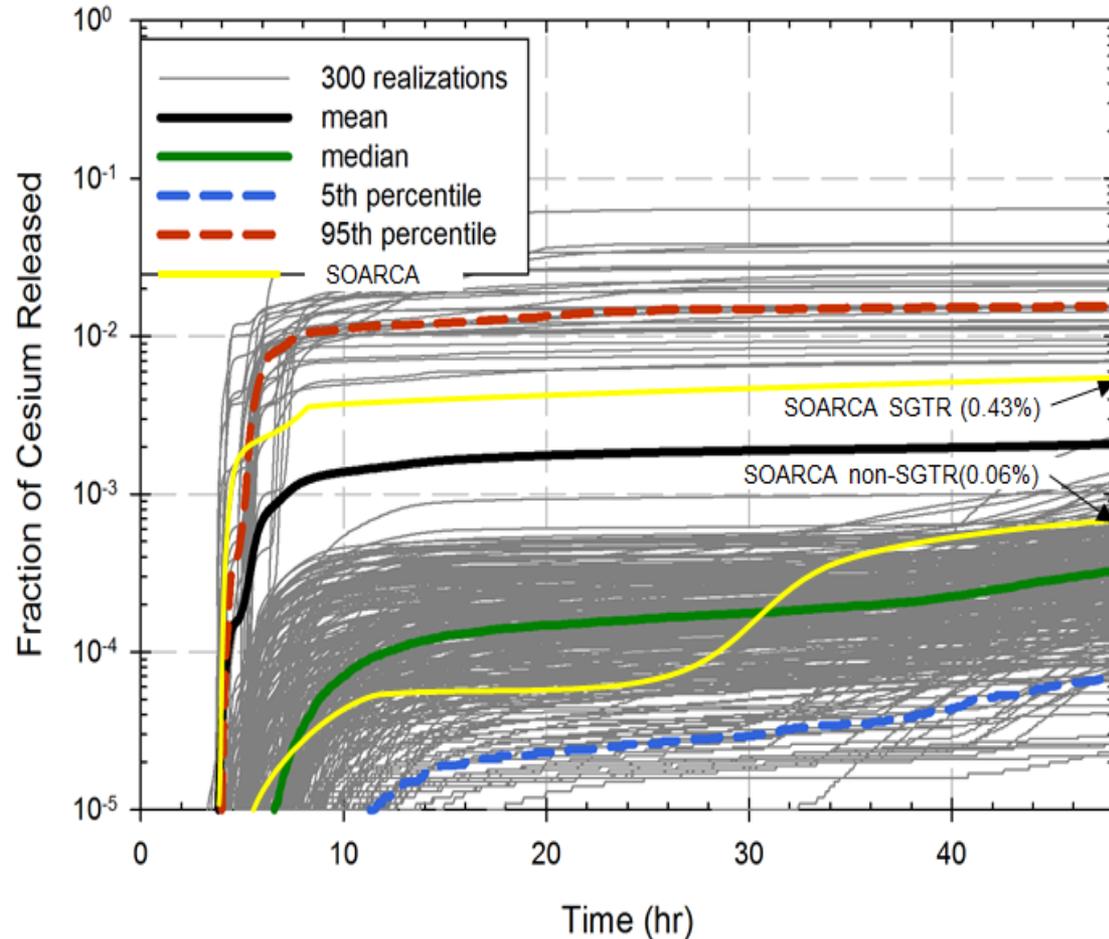


Figure 6-13 Cesium release fractions over 48 hours with mean, median, 5th and 95th percentiles (which are calculated at each point in time)

Cesium Release Fractions

- UA cesium environmental release fractions are equal to or lower than the Surry SOARCA calculation except when an SGTR occurs.
- The early UA non-SGTR median release is higher than SOARCA due to nominal leakage sampling (0.1%-1%) in the UA.
- SOARCA release was higher than the UA non-SGTR median release at 48 hour due to higher pressurization (limestone concrete) and resultant containment rebar yield at 25.5 hour.
- The UA SGTR results are higher than SOARCA due to addition of size-dependent aerosol capture.



Cesium release fractions over 48 hours with mean, median, 5th and 95th percentiles

Cesium Regression Analysis for non-SGTR Realizations

- Design leakage was identified by each regression technique as the largest contributor to uncertainty.
- The next two parameters, time at cycle and shape factor, explain the majority of the remaining uncertainty that is explained by the regression models. There is some uncertainty that is not explained by the regression models.

Final R ²	Rank Regression		Quadratic		Recursive Partitioning		MARS		Main Contr.*	Conjoint Contr.*
	0.67		0.79		0.83		0.68			
Input	R ² contr.	SRRC	S _i	T _i	S _i	T _i	S _i	T _i		
<i>DLEAK</i>	0.35	0.58	0.29	0.34	0.25	0.48	0.35	0.35	0.258	0.077
<i>CYCLE</i>	0.15	0.42	0.19	0.29	0.12	0.30	0.20	0.20	0.135	0.073
<i>PARTSHAPE</i>	0.05	0.23	0.12	0.16	0.09	0.33	0.18	0.21	0.085	0.081
<i>CFC</i>	0.04	-0.20	0.07	0.12	0.03	0.20	0.11	0.12	0.050	0.060
<i>DEV_DEC_HEAT</i>	0.02	-0.15	0.04	0.07	0.05	0.23	0.05	0.06	0.031	0.061
<i>CHEMFORMCS</i>	0.03	-0.16	0.03	0.06	0.00	0.05	0.04	0.04	0.020	0.022
<i>SVOAFRAC</i>	0.01	-0.12	0.00	0.05	0.01	0.10	0.01	0.04	0.006	0.044
<i>SC1132</i>	0.01	0.07	0.00	0.02	0.00	0.02	0.01	0.03	0.004	0.015
<i>TUBTHICK</i>	0.00	0.03	0.01	0.00	0.00	0.02	---	---	0.003	0.006
<i>CONDENS</i>	0.00	-0.06	0.00	0.02	0.00	0.02	0.01	0.01	0.003	0.011
<i>SGTRLOC</i>	0.01	0.07	0.00	0.01	---	---	0.00	0.01	0.002	0.003
<i>RDSTC</i>	0.00	0.06	---	---	0.00	0.02	0.00	0.01	0.001	0.005
<i>SC1131</i>	0.00	-0.04	0.00	0.00	0.00	0.02	---	---	0.001	0.004
<i>RCPSL</i>	0.00	0.08	---	---	0.00	0.01	0.00	0.01	0.001	0.003
<i>SRVFAILT</i>	---	---	---	---	---	---	0.00	0.01	0.000	0.001
<i>SV_STATUS</i>	---	---	0.00	0.06	---	---	0.00	0.00	0.000	0.016
<i>SG_B_SV_cycl</i>	---	---	0.00	0.01	0.00	0.01	---	---	0.000	0.008
<i>TUBETEMP</i>	---	---	0.00	0.01	0.00	0.01	---	---	0.000	0.006
<i>CHEMFORMI2</i>	---	---	---	---	---	---	0.00	0.00	0.000	0.000

* highlighted if main contribution larger than 0.02 or conjoint contribution larger than 0.1

Table 6-4 Regression analysis of cesium release fraction in non-SGTR realizations.

Cesium Regression Analysis for SGTR Realizations

- Safety valve open area fraction (SVOAFRAC) is a partial indicator for the open fraction of both the primary and secondary SV system at 48 hours.
 - The number of safety valve cycles is also thought to be important, though not shown in regression results
- Sampling thickness of hottest SG tube (TUBTHICK) effectively also samples stress multiplier on the creep equation.

Final R ²	Rank Regression		Quadratic		Recursive Partitioning		MARS		Main Contr.*	Con-joint Contr.*
	0.54		1.00		0.81		0.54			
	R ² contr.	SRRC	S _i	T _i	S _i	T _i	S _i	T _i		
SVOAFRAC	0.13	0.58	0.30	0.75	0.39	0.71	---	---	0.188	0.234
TUBTHICK	0.21	-0.27	0.00	0.02	0.07	0.14	0.36	0.36	0.115	0.023
SV_STATUS	---	---	0.04	0.12	---	---	0.33	0.33	0.072	0.026
CYCLE	0.08	0.34	0.00	0.02	0.06	0.12	0.22	0.22	0.062	0.024
PARTSHAPE	0.12	0.36	0.00	0.00	0.05	0.09	0.09	0.09	0.052	0.011
CHEMFORMCS	---	---	---	---	0.06	0.27	---	---	0.015	0.058
DLEAK	---	---	0.04	0.59	---	---	---	---	0.014	0.184
SC1141	---	---	0.00	0.00	0.01	0.06	---	---	0.004	0.013
SV_WTR_CYC	---	---	0.01	0.09	---	---	0.00	0.00	0.003	0.028
SGTRLOC	---	---	0.01	0.03	---	---	---	---	0.003	0.009
H2LFL	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.002	0.001
SC1131	---	---	0.00	0.00	0.01	0.01	0.00	0.00	0.002	0.002
RDSTC	---	---	0.00	0.00	---	---	---	---	0.001	0.000
SRVFAILT	---	---	0.00	0.01	---	---	0.00	0.00	0.000	0.004
CONDENS	---	---	0.00	0.00	---	---	0.00	0.00	0.000	0.002
RDMTC	---	---	---	---	0.00	0.02	0.00	0.00	0.000	0.006
RCPSL	---	---	---	---	0.00	0.00	0.00	0.01	0.000	0.001
SC1132	---	---	---	---	---	---	0.00	0.01	0.000	0.001
SV_NBCYC	---	---	---	---	---	---	0.00	0.00	0.000	0.001
DEV_DEC_HEAT	---	---	---	---	---	---	0.00	0.00	0.000	0.000
TUBETEMP	---	---	---	---	---	---	0.00	0.00	0.000	0.000

Table 6-9 Regression analysis of cesium release fraction for SGTRs.

Iodine Release Fraction to Environment

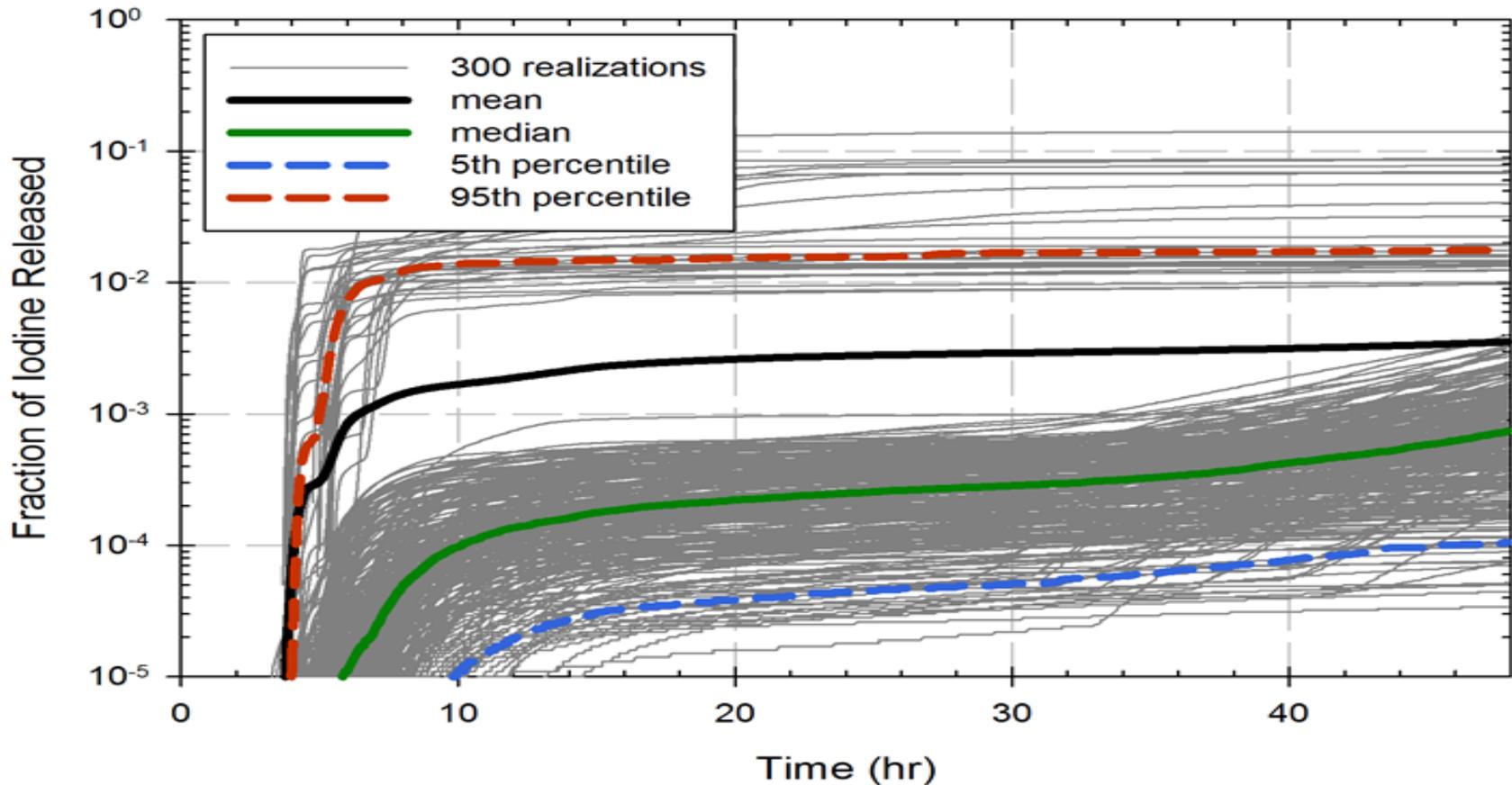


Figure 6-1 Iodine release fractions over 48 hours with mean, median, 5th and 95th percentiles (which are calculated at each point in time)

Iodine Regression Analysis – non-SGTR realizations

- CYCLE determines timing of fuel heat-up, which in turn causes initial radionuclide releases, and later in the accident progression, the rate of containment pressurization.
- The set of most important variables to iodine and cesium release are consistent.

Final R ²	Rank Regression		Quadratic		Recursive Partitioning		MARS		Main Contr.*	Conjoint Contr. *
	0.77		0.92		0.88		0.82			
Input	R ² contr.	SRRC	S _i	T _i	S _i	T _i	S _i	T _i		
<i>CYCLE</i>	0.51	0.69	0.39	0.50	0.37	0.60	0.40	0.40	0.380	0.102
<i>CFC</i>	0.04	-0.21	0.09	0.15	0.08	0.25	0.12	0.16	0.074	0.080
<i>DLEAK</i>	0.11	0.32	0.08	0.11	0.04	0.10	0.09	0.09	0.073	0.029
<i>CHEMFORMI2</i>	0.03	0.18	0.06	0.10	0.09	0.29	0.11	0.17	0.063	0.089
<i>DEV_DEC_HEAT</i>	0.03	-0.18	0.06	0.11	0.03	0.16	0.08	0.11	0.043	0.063
<i>PARTSHAPE</i>	0.02	0.15	0.04	0.06	0.02	0.11	0.07	0.11	0.034	0.041
<i>SC1132</i>	0.00	0.07	0.01	0.02	0.00	0.01	0.01	0.03	0.005	0.011
<i>SV_STATUS</i>	0.00	0.09	0.02	0.09	---	---	---	---	0.004	0.023
<i>CONDENS</i>	0.01	-0.07	0.01	0.01	---	---	0.00	0.01	0.004	0.003
<i>SV_NBCYC</i>	---	---	---	---	0.00	0.00	0.01	0.01	0.002	0.000
<i>SRVFAILT</i>	---	---	0.00	0.01	0.00	0.01	0.00	0.00	0.002	0.005
<i>SGTRLOC</i>	0.00	0.05	0.00	0.02	0.00	0.02	---	---	0.002	0.009
<i>RDSTC</i>	0.00	0.04	---	---	0.00	0.01	---	---	0.001	0.001
<i>CHEMFORMCS</i>	---	---	0.00	0.01	---	---	0.00	0.01	0.001	0.005
<i>SG_B_SV_cycl</i>	---	---	---	---	---	---	0.00	0.01	0.001	0.001
<i>TUBETEMP</i>	---	---	0.00	0.01	0.00	0.01	---	---	0.001	0.005
<i>RCPSL</i>	0.00	0.06	---	---	---	---	---	---	0.001	0.000
<i>RDMTCT</i>	---	---	---	---	---	---	0.00	0.00	0.000	0.000
<i>TUBTHICK</i>	0.00	0.03	---	---	0.00	0.00	---	---	0.000	0.000
<i>SVOAFRAC</i>	0.00	-0.08	0.00	0.01	0.00	0.02	---	---	0.000	0.009
<i>SC1131</i>	0.00	-0.03	0.00	0.02	---	---	0.00	0.01	0.000	0.009
<i>SV_WTR_CYC</i>	---	---	---	---	0.00	0.01	0.00	0.00	0.000	0.003

* highlighted if main contribution larger than 0.02 or conjoint contribution larger than 0.1

Table 6-3 Regression analysis of iodine release fraction for non-SGTR realizations

Hydrogen Production

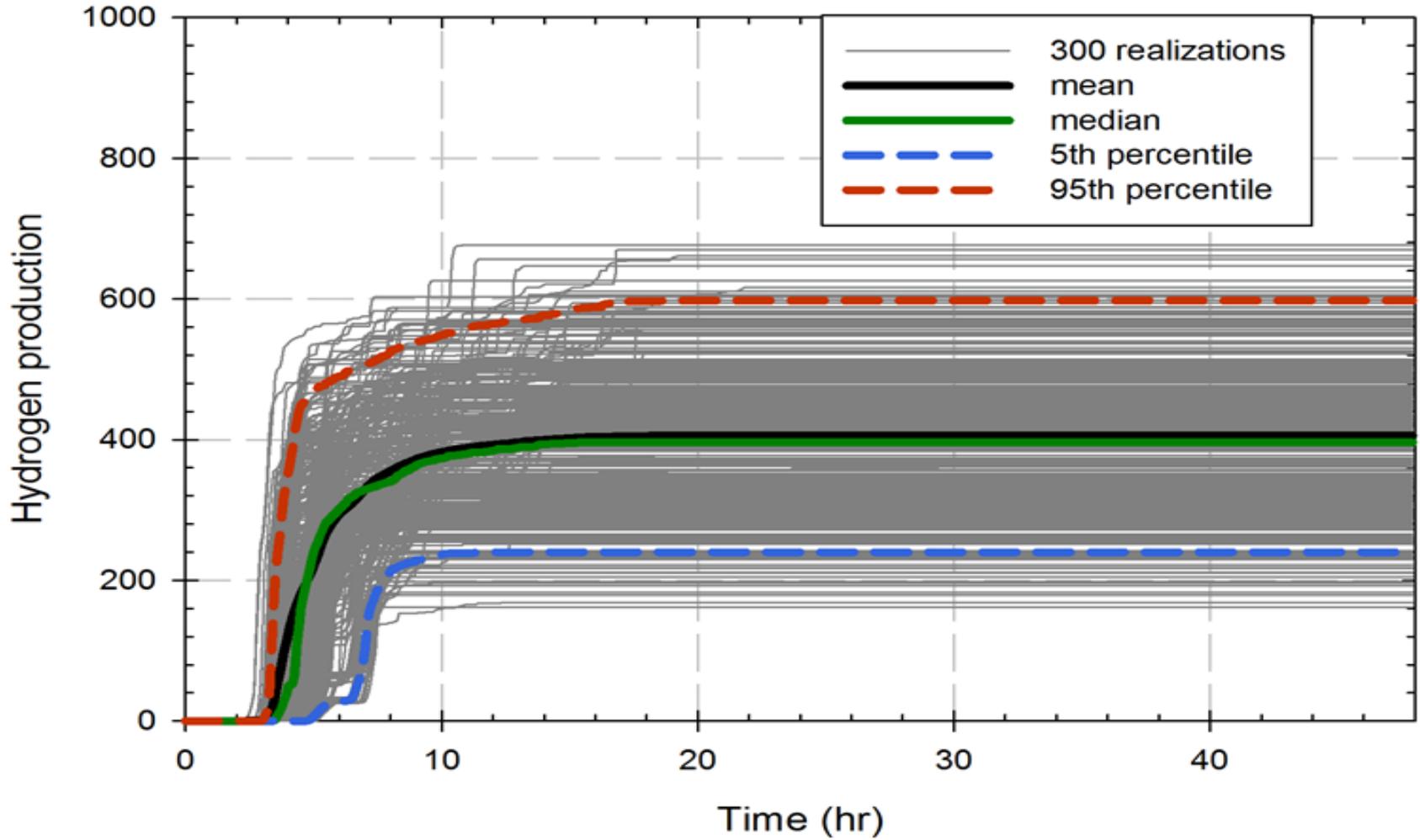


Figure 6-24 Total Hydrogen production over 48 hours with mean, median, 5th and 95th percentiles.

Hydrogen Production Regression Analysis

- Regression results for hydrogen uncertainty are essentially the same, regardless as to whether or not there is an SGTR.
- Depressurization (SVOAFRAC) and effective melt temperature remain as the most important parameters.

	Rank Regression		Quadratic		Recursive Partitioning		MARS		Main Contr.*	Conjoint Contr. *
Final R ²	0.54		0.73		0.88		0.71			
Input	R ² contr.	SRRC	S _i	T _i	S _i	T _i	S _i	T _i		
SVOAFRAC	0.03	0.23	0.52	0.54	0.31	0.45	0.54	0.54	0.266	0.046
SC1132	0.16	0.41	0.19	0.22	0.19	0.42	0.20	0.24	0.151	0.087
CYCLE	0.08	0.32	0.14	0.16	0.17	0.31	0.14	0.13	0.106	0.047
SV_STATUS	0.25	0.30	0.04	0.04	---	---	0.03	0.03	0.076	0.000
SC1131	---	---	0.01	0.04	0.02	0.18	0.01	0.06	0.010	0.066
SV_NBCYC	0.01	-0.13	0.01	0.00	0.00	0.05	0.02	0.02	0.007	0.015
RCPSL	0.00	0.06	0.02	0.05	---	---	0.02	0.01	0.007	0.007
DLEAK	---	---	0.01	0.01	---	---	---	---	0.001	0.000
RDSTC	---	---	0.00	0.01	0.00	0.01	0.00	0.00	0.001	0.004
SGTRLOC	0.00	0.07	---	---	---	---	0.00	0.00	0.001	0.000
SC1141	---	---	0.00	0.01	0.00	0.01	0.00	0.00	0.001	0.006
CHEMFORMI2	---	---	---	---	0.00	0.03	0.00	0.01	0.001	0.010
DEV_DEC_HEAT	---	---	---	---	0.00	0.01	---	---	0.001	0.004
SG_B_SV_cycl	---	---	---	---	0.00	0.01	0.00	0.00	0.001	0.003
TUBETEMP	---	---	---	---	0.00	0.02	0.00	0.00	0.000	0.006
TUBTHICK	---	---	---	---	0.00	0.01	0.00	0.00	0.000	0.003
CFC	---	---	---	---	---	---	0.00	0.01	0.000	0.001
PARTSHAPE	---	---	0.00	0.01	---	---	---	---	0.000	0.001
CONDENS	---	---	0.00	0.00	---	---	---	---	0.000	0.000
RDMTC	---	---	---	---	0.00	0.01	---	---	0.000	0.004
H2LFL	---	---	---	---	0.00	0.01	---	---	0.000	0.003
SV_WTR_CYC	---	---	---	---	0.00	0.01	---	---	0.000	0.003

* highlighted if main contribution larger than 0.02 or conjoint contribution larger than 0.1

Table 6-5 Regression analysis of hydrogen production in non-SGTR realizations



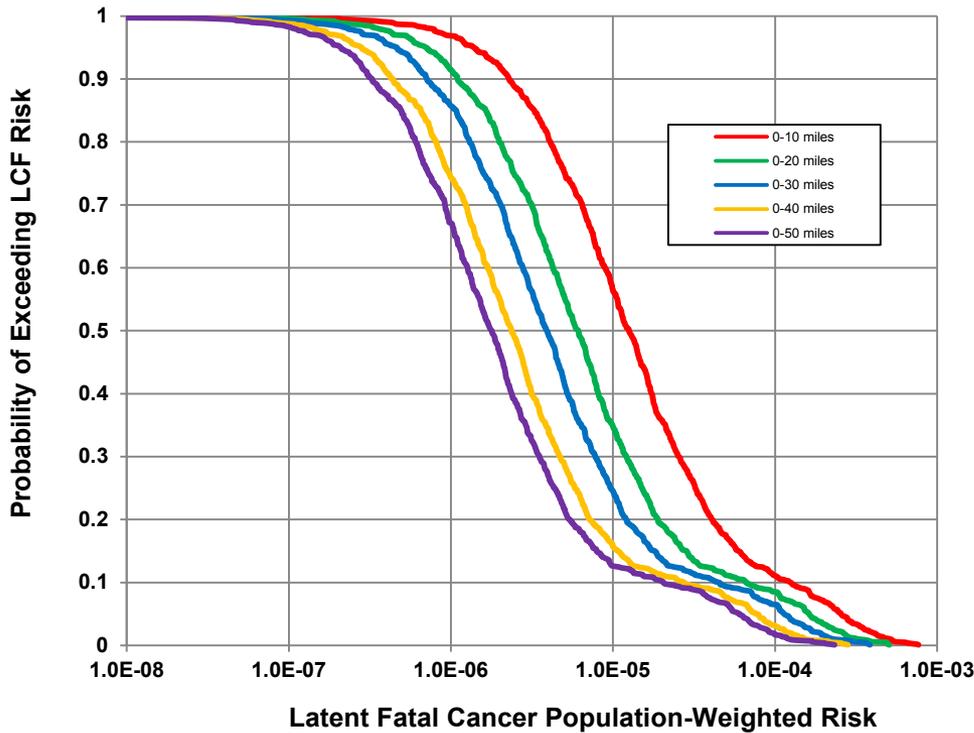
- An analysis of selected realizations was also performed to evaluate physical effects that impact environmental release fractions, particularly containment failure, that might occur beyond 48 hours.
- Extended the MELCOR calculations for 9 individual MELCOR realizations to 72 hours.
- For cases in which rebar yield was reached, the pressure tends to level off (to a plateau) and then gradually decrease as leakage more than compensates for steam generation and heating of the atmosphere.
- There are marked increases in cesium and iodine environmental release at the point of liner yield (or rebar yield if reached), with some increases of an order of magnitude from 48 to 72 hours.

MACCS Analysis Results

Note that results and draft report are in the process of being updated

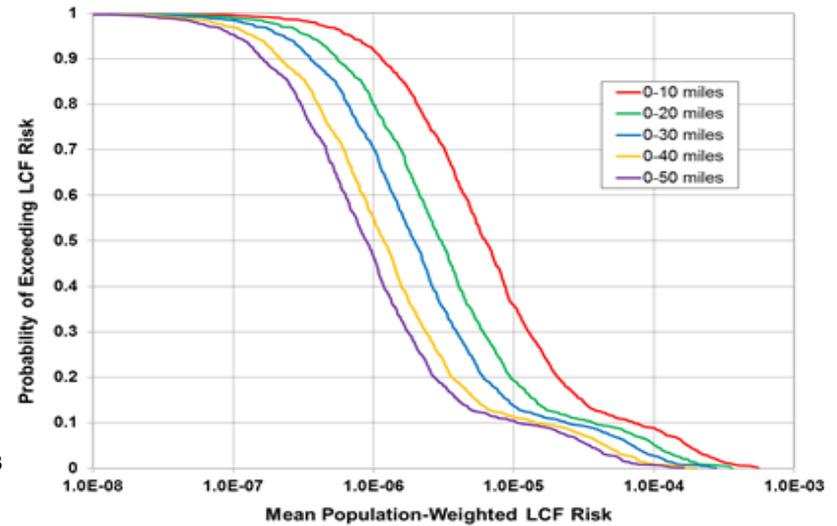
Preliminary Individual LCF Risk Consequence Results

Mean (over weather), individual, LCF risk (based on LNT) per event, 0-10 miles



New LCF Risk results

0-10 miles LCF Risk	Difference - higher
Mean	1.6x
Median	2x
5 th percentile	2x
95 th percentile	1.5x



Old LCF Risk results

Consequence Regression Analyses, LNT (10 mile, All RIs)

- The most important parameter is tube thickness.
- Second most important is the SV open area fraction.
- The third most important input parameter is the time at cycle.
- Fourth is groundshine shielding factor for normal activity during the emergency phase, GSHFAC.2, which is fully correlated with the groundshine shielding factor for the long-term phase.
- The top two parameters largely control whether an SGTR occurs, which has a dominant effect on consequences. Both parameters have large conjoint contributions which imply that there is some synergistic influence on LCF risk from TUBTHICK and SVOAFRAC in conjunction with each other or other parameters.

	Rank Regression		Quadratic		Recursive Partitioning		MARS		Main Contr.*	Conjoint Contr.*
Final R ²	0.54		0.60		0.86		0.74			
Input	R ² contr.	SRRC	S _i	T _i	S _i	T _i	S _i	T _i		
TUBTHICK	0.04	-0.20	0.33	0.53	0.30	0.86	0.35	0.80	0.189	0.309
SVOAFRAC	0.03	-0.18	0.23	0.40	0.09	0.55	0.11	0.45	0.082	0.250
CYCLE	0.18	0.44	0.01	0.02	0.01	0.01	0.02	0.02	0.050	0.005
GSHFAC.2	0.13	0.35	0.02	0.05	0.00	0.00	0.01	0.03	0.038	0.011
DLEAK	0.08	0.26	0.01	0.04	0.01	0.01	0.00	0.01	0.022	0.010
CFRISK.8	0.02	0.15	0.02	0.05	0.00	0.06	0.02	0.08	0.011	0.037
SV_STATUS	---	---	0.04	0.04	---	---	---	---	0.006	0.000
DDREFA.8	0.01	-0.12	0.00	0.02	0.00	0.05	0.00	0.03	0.004	0.025
CYSIGA.1	0.02	-0.13	---	---	---	---	---	---	0.004	0.000
TUBETEMP	---	---	0.02	0.02	0.00	0.00	0.01	0.03	0.004	0.006
DEV_DEC_HEAT	0.01	-0.09	0.00	0.03	0.00	0.03	0.01	0.02	0.004	0.015
VDEPOS.1	0.01	0.09	0.01	0.01	0.00	0.04	---	---	0.003	0.011
CFRISK.7	0.01	0.09	---	---	---	---	---	---	0.002	0.000
CFC	0.01	-0.09	---	---	---	---	0.00	0.01	0.002	0.001
CFRISK.6	0.01	0.07	---	---	---	---	0.00	0.02	0.002	0.003
PROTIN.2	---	---	---	---	0.01	0.09	---	---	0.001	0.023
CHEMFORMCS	0.01	-0.06	---	---	---	---	---	---	0.001	0.000
SGTRLOC	0.00	0.06	0.00	0.01	---	---	---	---	0.001	0.002
CFRISK.2	---	---	0.00	0.03	---	---	---	---	0.001	0.005
LA.140_I.9	---	---	0.00	0.04	0.00	0.03	0.00	0.01	0.000	0.018
PARTSHAPE	---	---	0.00	0.01	0.00	0.01	---	---	0.000	0.004
CHEMFORMI2	---	---	---	---	0.00	0.02	0.00	0.01	0.000	0.009

* highlighted if main contribution larger than 0.02 or conjoint contribution larger than 0.1

Table 6-24 Mean, individual, LCF risk (based on LNT) regression results within a 10-mile circular area for all realizations.

Consequence Regression Analyses, LNT (10 mile w/o SGTR)

- The most important parameter is the time during the fuel cycle at which the accident occurs, CYCLE.
- Second is the groundshine shielding factor for normal activity during the emergency phase, GSHFAC.2, which is fully correlated with the groundshine shielding factor for the long-term phase.
- The third most important input parameter is the containment leakage path length, DLEAK, which is inversely proportional to containment leakage rate.

Final R ²	Rank Regression		Quadratic		Recursive Partitioning		MARS		Main Contr.*	Conjoint Contr. *
	0.73		0.83		0.84		0.59			
Input	R ² contr.	SRRC	S _i	T _i	S _i	T _i	S _i	T _i		
CYCLE	0.27	0.52	0.14	0.23	0.18	0.55	0.30	0.30	0.179	0.128
GSHFAC.2	0.19	0.44	0.22	0.38	0.18	0.54	0.25	0.27	0.166	0.152
DLEAK	0.12	-0.33	0.06	0.20	0.03	0.16	0.09	0.09	0.062	0.077
CFRISK.8	0.03	0.16	0.04	0.07	0.02	0.14	0.07	0.07	0.030	0.040
CYSIGA.1	0.03	-0.18	0.02	0.02	0.01	0.04	0.04	0.05	0.019	0.012
VDEPOS.1	0.02	0.12	0.02	0.06	0.01	0.24	0.03	0.07	0.017	0.081
PARTSHAPE	0.01	0.09	0.01	0.03	0.00	0.04	0.05	0.06	0.012	0.018
CFRISK.7	0.01	0.12	0.02	0.03	0.00	0.02	0.03	0.03	0.012	0.007
CFC	0.02	-0.13	0.02	0.03	0.00	0.02	0.02	0.02	0.010	0.009
DEV_DEC_HEAT	0.01	-0.08	0.02	0.04	0.00	0.04	0.02	0.04	0.010	0.021
CFRISK.6	0.01	0.09	0.02	0.07	0.00	0.04	0.01	0.01	0.009	0.023
DDREFA.8	0.01	-0.11	0.01	0.03	0.01	0.03	---	---	0.006	0.014
CHEMFORMCS	0.01	-0.09	---	---	---	---	0.02	0.03	0.005	0.001
GSHFAC.3	---	---	0.02	0.07	---	---	---	---	0.005	0.014
CFRISK.4	0.01	0.09	---	---	---	---	---	---	0.002	0.000
CFRISK.3	---	---	---	---	---	---	0.01	0.02	0.001	0.003
SV_NBCYC	---	---	0.00	0.02	---	---	0.00	0.00	0.001	0.005
SGTRLOC	0.00	0.04	0.00	0.03	---	---	0.00	0.00	0.000	0.009
CFRISK.1	---	---	---	---	0.00	0.12	---	---	0.000	0.033
DLTEVA_5.12	---	---	---	---	0.00	0.04	---	---	0.000	0.011
ZR.95_I.9	---	---	---	---	0.00	0.03	---	---	0.000	0.008

* highlighted if main contribution larger than 0.02 or conjoint contribution larger than 0.1

Table 6-30 Mean, individual, LCF risk (based on LNT) regression results within a 10-mile circular area for realizations that do not involve SGTR.

Consequence Regression Analyses, LNT (50 mile, All Rlzs)

	Rank Regression		Quadratic		Recursive Partitioning		MARS		Main Contr.*	Conjoint Contr.*
Final R ²	0.37		0.60		0.86		0.59			
Input	R ² contr.	SRRC	S _i	T _i	S _i	T _i	S _i	T _i		
TUBTHICK	0.04	-0.21	0.26	0.43	0.35	0.89	0.47	0.88	0.194	0.269
SVOAFRAC	0.02	-0.14	0.21	0.37	0.08	0.55	0.12	0.53	0.071	0.247
GSHFAC.2	0.12	0.34	0.02	0.06	0.00	0.05	---	---	0.033	0.022
DLEAK	0.07	0.24	0.01	0.08	---	---	---	---	0.018	0.014
CYCLE	0.05	0.23	0.00	0.01	0.00	0.02	0.01	0.01	0.014	0.006
SV_STATUS	---	---	0.04	0.11	---	---	---	---	0.008	0.013
CFRISK.8	0.01	0.13	0.01	0.04	0.00	0.04	---	---	0.005	0.016
DDREFA.8	0.02	-0.12	0.00	0.02	0.00	0.01	0.00	0.01	0.004	0.009
DEV_DEC_HEAT	0.01	-0.09	0.01	0.06	---	---	---	---	0.004	0.009
CFRISK.6	0.01	0.06	0.01	0.11	0.00	0.01	0.00	0.00	0.003	0.022
CFRISK.7	0.01	0.11	---	---	---	---	---	---	0.003	0.000
SV_NBCYC	---	---	0.01	0.04	---	---	0.00	0.01	0.002	0.007
PARTSHAPE	0.00	0.05	0.00	0.02	0.01	0.02	0.00	0.01	0.002	0.008
CYSIGA.1	0.01	-0.09	---	---	---	---	---	---	0.002	0.000
PROTIN.2	---	---	0.01	0.01	0.00	0.03	---	---	0.002	0.007
CWASH1.	0.01	0.08	---	---	---	---	---	---	0.002	0.000
CHEMFORMI2	---	---	---	---	0.01	0.01	0.00	0.02	0.002	0.003
CFC	0.01	-0.07	---	---	---	---	---	---	0.001	0.000
CHEMFORMCS	0.01	-0.06	---	---	---	---	---	---	0.001	0.000
VDEPOS.1	---	---	0.00	0.03	---	---	---	---	0.001	0.004
CFRISK.2	---	---	0.00	0.05	0.00	0.03	0.00	0.00	0.001	0.019
CE.143_ICh.9	---	---	---	---	0.00	0.00	0.00	0.00	0.001	0.000

* highlighted if main contribution larger than 0.02 or conjoint contribution larger than 0.1

Table 6-26 Mean, individual, LCF risk (based on LNT) regression results within a 50-mile circular area for all realizations.

Consequence Regression Analyses, LNT (50 mile w/o SGTR)

- The most important parameter is the time during the fuel cycle at which the accident occurs, CYCLE.
- The second most important input parameter is the groundshine shielding factor for normal activity during the emergency phase, GSHFAC.2.
- The third most important input parameter is containment design leakage.

	Rank Regression		Quadratic		Recursive Partitioning		MARS		Main Contr.*	Conjoint Contr.*
Final R ²	0.72		0.84		0.82		0.67			
Input	R ² contr.	SRRC	S _i	T _i	S _i	T _i	S _i	T _i		
CYCLE	0.29	0.54	0.14	0.23	0.18	0.55	0.28	0.28	0.185	0.128
GSHFAC.2	0.16	0.41	0.19	0.30	0.18	0.56	0.22	0.26	0.155	0.144
DLEAK	0.12	-0.34	0.06	0.20	0.03	0.16	0.10	0.11	0.065	0.077
CFRISK.8	0.03	0.16	0.04	0.06	0.01	0.11	0.06	0.07	0.027	0.037
PARTSHAPE	0.01	0.09	0.02	0.02	0.00	0.03	0.05	0.07	0.015	0.013
CYSIGA.1	0.03	-0.15	0.01	0.02	0.01	0.03	0.03	0.03	0.014	0.009
CFC	0.02	-0.13	0.02	0.09	0.01	0.06	0.02	0.02	0.013	0.035
DEV_DEC_HEAT	0.01	-0.08	0.01	0.09	0.01	0.03	0.02	0.04	0.011	0.031
CFRISK.6	0.01	0.09	0.03	0.08	---	---	0.02	0.06	0.011	0.023
VDEPOS.1	0.01	0.09	0.02	0.03	0.01	0.22	0.01	0.05	0.010	0.070
CFRISK.7	0.01	0.12	---	---	0.00	0.06	0.02	0.03	0.008	0.017
CHEMFORMCS	0.01	-0.08	0.01	0.02	0.00	0.04	0.02	0.03	0.007	0.016
DDREFA.8	0.01	-0.11	---	---	0.01	0.08	0.01	0.02	0.006	0.021
GSHFAC.3	---	---	0.02	0.07	---	---	---	---	0.006	0.014
CFRISK.4	0.01	0.10	---	---	---	---	0.01	0.01	0.003	0.001
RCPSL	---	---	0.01	0.13	---	---	---	---	0.003	0.034
CFRISK.3	---	---	---	---	---	---	0.01	0.04	0.002	0.006
CWASH1.	0.01	0.07	---	---	---	---	---	---	0.001	0.000
SGTRLOC	---	---	0.00	0.02	---	---	---	---	0.001	0.004
CM.242_I.CH.9	---	---	---	---	0.00	0.05	---	---	0.001	0.013
CFRISK.1	---	---	---	---	0.00	0.08	---	---	0.001	0.020
PROTIN.2	---	---	0.00	0.02	---	---	---	---	0.000	0.005

* highlighted if main contribution larger than 0.02 or conjoint contribution larger than 0.1

Table 6-32 Mean, individual, LCF risk (based on LNT) regression results within a 50-mile circular area for realizations without an SGTR.

MACCS Uncertainty Analysis on MELCOR Single Realizations

- MACCS parameters-only Monte Carlo simulation run with three MELCOR source terms.
- The results show that the Surry UA CCDFs span the results for the single MELCOR realizations, with the exception of the upper end of the curves for the large source term (Large ST).
- This shows that there are low probability combinations of input parameters that can produce larger consequences than any of those in the set of 1003 realizations.

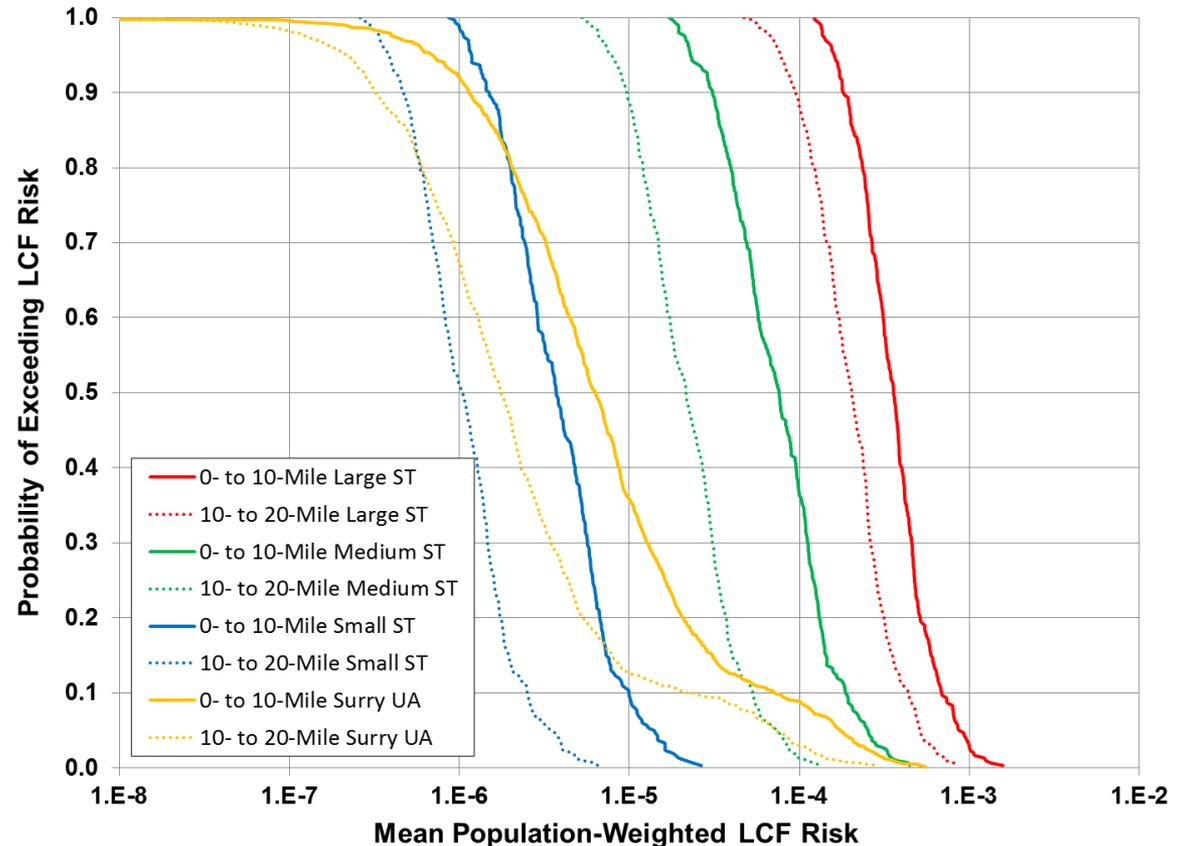


Figure 6-123 CCDF of mean, population-weighted LCF risk (based on LNT dose response) within two annular areas centered on the Surry site for three single realizations and for the base Surry uncertainty analysis results

Sensitivity Results for Phase Durations and Dose Projection Period

- The Figure shows results are all essentially the same with one exception, the risks for the 0- to 10-mile distance interval are noticeably larger for the case when the intermediate phase is 6 months than when its duration is 0 (no intermediate phase).
- The increase in risk for the 0- to 10-mile interval indicates that less decontamination occurs when the intermediate phase is included and that more individuals receive a larger dose when they return home than receive a smaller dose.

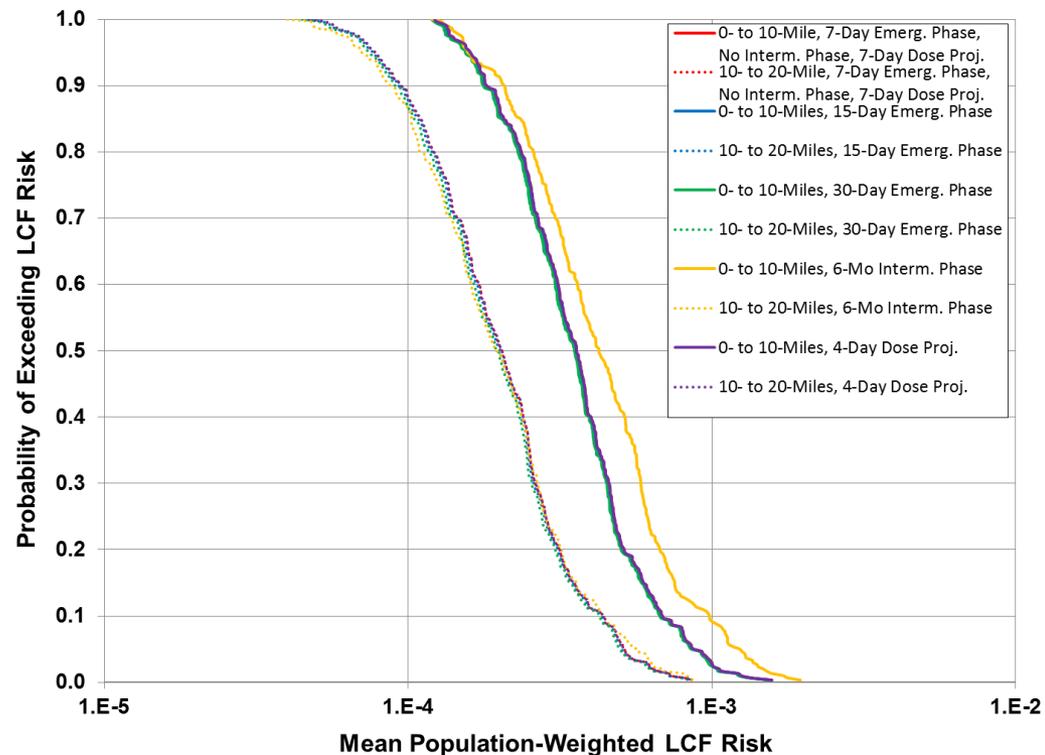


Figure 6-124 CCDF of mean, population-weighted LCF risk (based on LNT dose response) within two annular areas centered on the Surry site for four sensitivity cases and for the Large Source Term case

Evaluation of Multiple Tube Ruptures

- The CCDFs for the SG tube UA span the range of 10^{-5} to more than 10^{-3} mean, population-weighted, conditional LCF risk (per event.)
- The CCDFs for the SG tube UA overlap the portion of the Surry UA CCDFs representing a single SGTR (probability of exceedance below 0.1), but also extend beyond them at the upper end of the range. This is because the source terms are larger when multiple SGTRs occur in a realization.

Summary and Insights

- Surry UA corroborates SOARCA study conclusions.
- A major determinant of source term magnitude and health consequences is whether or not a steam generator tube rupture (SGTR) occurs.
- The most influential input parameters contributing to accident progression, cesium release magnitude, and individual LCF risk were found to be:
 - SV open area fraction and the number of cycles experienced by SVs
 - SG tube thickness
 - Time at cycle (BOC, MOC, or EOC)
 - Containment leakage rate
 - Dynamic particle shape
 - Groundshine shielding factor
- SGTRs occurred in about 10% of the Monte Carlo realizations and had release fractions 1 to 2 orders of magnitude larger than realizations without an SGTR.
- SGTRs always included a thermal *and* pressure element.
- In the number of SG tubes joint sensitivity analysis, one realization with 5 tubes failing had no hot leg creep leading to the highest release fractions.

Summary and Insights

- In most of the Monte Carlo realizations, iodine and cesium environmental release fractions were higher early in the transient than the Surry SOARCA calculation; but all were significantly lower at 48 hours (except that cesium was equal in a few realizations).
- The UA non-SGTR median release at 48 hr is lower than SOARCA due to higher pressurization (limestone concrete) and resultant containment rebar yield at 25.5 hr in SOARCA.
- Early fatality risks for this scenario are essentially zero.
- The LCF risk was observed lower than the Surry SOARCA calculation and is attributable to the lower source terms from the UA.

Summary and Insights

- The consequence analysis showed that the mean population-weighted LCF risk distribution is much narrower when only uncertain consequence parameters are considered than when both source-term and consequence parameters are considered in the analysis. It appears the results are more heavily influenced by uncertainties in source term than by uncertain consequence parameters, just as they were for the Peach Bottom UA.
 - This is true when a single dose-response model (LNT) is used, but uncertainties in risks created by uncertainties in the dose-response model are large and most likely would have altered this conclusion if dose response had been included as part of the integrated UA.
- Mean (over epistemic uncertainty and weather variability) individual LCF risks assuming LNT dose response, conditional on an the occurrence of an accident, estimated in this UA are very low, lower than the risk evaluated in the original SOARCA study, which was 9×10^{-5} within 10 miles, and lower at longer distances.
 - The primary reason for this reduction in estimated risk is attributed to refinements in the MELCOR model
- Most of the risks (99% within 10 miles and about 84% beyond 10 miles from the plant) are from long-term exposure following the emergency phase.

Next Steps

- Finalize NUREG/CR report documenting SOARCA Surry Uncertainty Analysis by September 2016.
- Develop summary NUREG report on insights from the SOARCA Peach Bottom, Surry, and Sequoyah Uncertainty Analyses.
- Contribute to identifying key sources of model uncertainty in the level-2 and level-3 portions of Level 3 PRA.
- Contribute to MACCS input parameter guidance under development.
- Contribute to appendix under development on severe accident consequence analysis supporting cost-benefit analyses.

References

- NUREG-1935, State-of-the-Art Reactor Consequence Analyses (SOARCA) Report (November 2012)
- NUREG/BR-0359, Modeling Potential Reactor Accident Consequences, Rev. 1 (December 2012)
- NUREG/CR-7110, Vol. 1, SOARCA Project Peach Bottom Integrated Analysis, Rev. 1, (May 2013)
- NUREG/CR-7110, Vol. 2, SOARCA Project Surry Integrated Analysis, Rev. 1 (August 2013)
- NUREG/CR-7008, MELCOR Best Practices as Applied in the SOARCA Project (August 2014)
- NUREG/CR-7009, MACCS Best Practices as Applied in the SOARCA Project (August 2014)
- NUREG/CR-7155, SOARCA Project Uncertainty Analysis of the Unmitigated Long-Term Station Blackout of the Peach Bottom Atomic Power Station (expected February 2016)
- SECY-12-0092, “State-of-the-Art Reactor Consequence Analyses – Recommendation for Limited Additional Analysis” (July 2012)
 - Staff recommended “UA for a severe accident scenario at Surry”



Questions?

Acronyms

BEIR	Biological Effects of Ionizing Radiation	PWR	Pressurized water reactor
BOC	Beginning of cycle	RCPSL	Reactor coolant pump seal leakage
CDF	Cumulative distribution function	RCS	Reactor coolant system
CCDF	Complementary CDF	RN	Radionuclide
EOC	End of cycle	RPV	Reactor pressure vessel
EPZ	Emergency planning zone	SGTR	Steam generator tube rupture
ETE	Evacuation time estimate	SME	Subject matter expert
FTC	Failure to open	SNL	Sandia National Laboratories
FTO	Failure to close	SOARCA	State-of-the-Art Reactor Consequence Analyses
KI	Potassium iodide	STSBO	Short term station blackout
LCF	Latent cancer fatality	SV	Safety valve
LHS	Latin Hypercube Sampling	UA	Uncertainty Analysis
LNT	Linear no threshold		
MACCS	MELCOR Accident Consequence Code System		
MCCI	Molten concrete core interaction		
MOC	Middle of cycle		

Backup Slides

Iodine Release Fractions to Environment

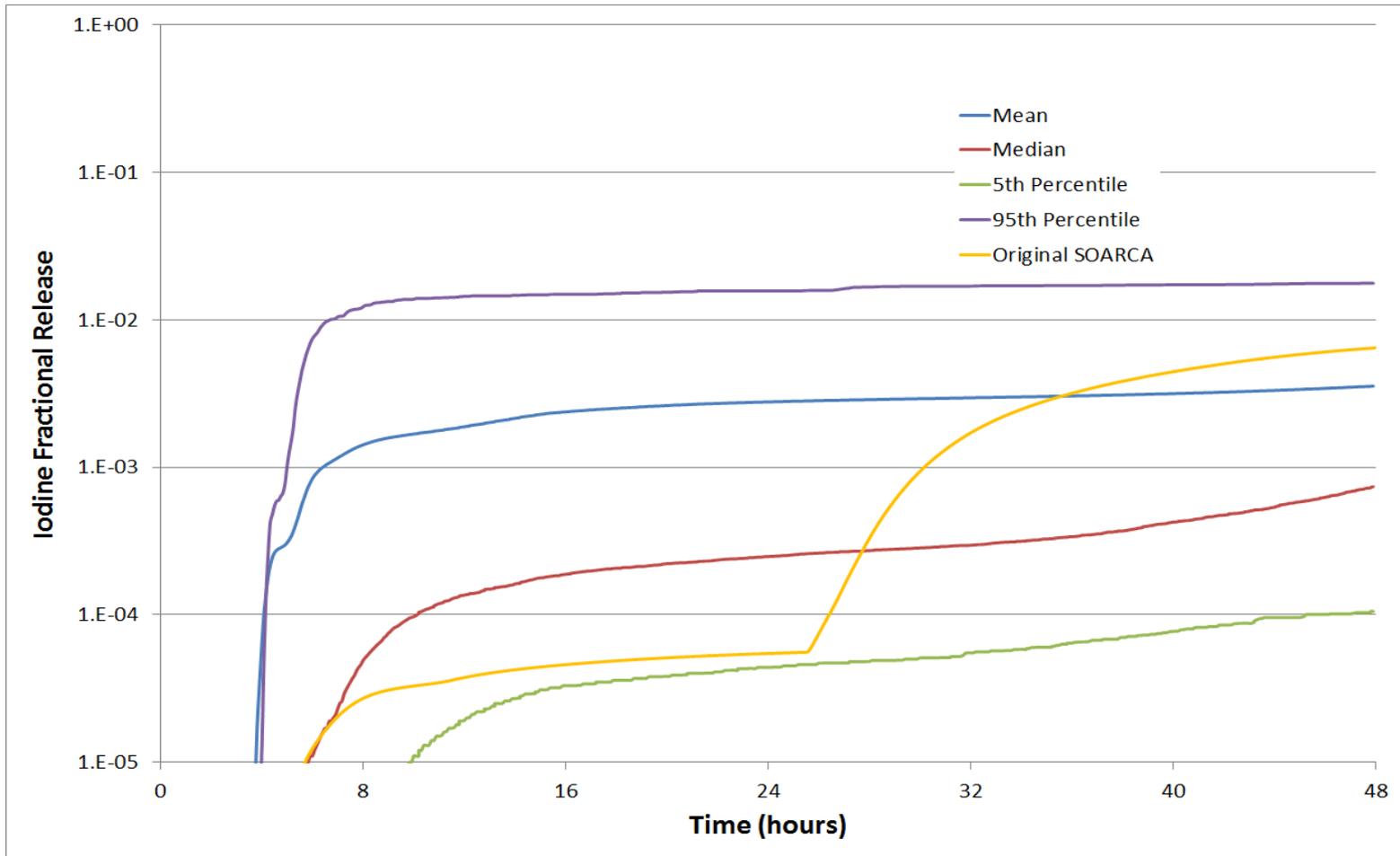


Figure 6-3 Comparison of iodine release fraction in the original Surry SOARCA STSBO to the calculated values of all successful realizations

Consequence Regression Analyses, LNT (10 mile with SGTR)

	Rank Regression		Quadratic		Recursive Partitioning		MARS		Main Contr.*	Conjoint Contr. *
Final R ²	0.66		1.00		0.71		0.51			
Input	R ² contr.	SRRC	S _i	T _i	S _i	T _i	S _i	T _i		
CFRISK.8	0.12	0.33	---	---	---	---	0.28	0.28	0.067	0.000
VDEPOS.1	0.12	0.25	---	---	0.01	0.07	0.26	0.26	0.065	0.013
TUBTHICK	---	---	0.02	0.22	0.15	0.43	0.12	0.12	0.065	0.130
GSHFAC.3	0.09	0.21	---	---	0.04	0.29	0.25	0.25	0.063	0.059
I.134_ICH.9	0.02	0.19	0.01	0.01	0.18	0.24	0.00	0.01	0.040	0.016
SV_STATUS	---	---	0.11	0.31	---	---	0.00	0.00	0.037	0.067
DLTEVA_5.7	0.06	0.14	---	---	0.08	0.22	---	---	0.029	0.033
DLEAK	0.01	0.09	0.08	0.59	---	---	0.00	0.00	0.023	0.171
CO.60_ICH.9	---	---	0.07	0.08	---	---	---	---	0.023	0.002
CFRISK.6	0.03	0.21	0.01	0.01	---	---	0.09	0.10	0.021	0.001
PROTIN.2	0.05	0.16	0.02	0.07	0.01	0.02	---	---	0.017	0.023
SVOAFRAC	---	---	---	---	0.07	0.12	0.00	0.00	0.016	0.013
CYCLE	0.03	0.14	0.02	0.03	---	---	---	---	0.012	0.006
SR.91_ICH.9	0.04	-0.17	---	---	---	---	---	---	0.011	0.000
GSHFAC.2	0.02	0.23	0.01	0.01	0.01	0.03	0.00	0.00	0.007	0.008
RH.105_ICH.9	0.03	0.22	---	---	---	---	0.00	0.01	0.007	0.001
DLTEVA_2.8	0.02	-0.08	---	---	---	---	---	---	0.004	0.000
TE.132_ICH.9	0.01	-0.15	---	---	---	---	0.00	0.00	0.004	0.000
DLTEVA_5.8	0.01	0.09	0.00	0.08	---	---	---	---	0.004	0.025
DLTEVA_3.5	---	---	0.01	0.16	---	---	---	---	0.003	0.049
DLTEVA.2	---	---	0.01	0.01	---	---	---	---	0.003	0.002
DLTEVA.7	---	---	---	---	0.01	0.07	0.00	0.00	0.001	0.014

* highlighted if main contribution larger than 0.02 or conjoint contribution larger than 0.1

Table 6-27 Mean, individual, LCF risk (based on LNT) regression results within a 10-mile circular area for realizations with an SGTR.

Consequence Regression Analyses, LNT (50 mile with SGTR)

Final R ²	Rank Regression		Quadratic		Recursive Partitioning		MARS		Main Contr.*	Conjoint Contr.*
	0.69		1.00		0.79		0.63			
Input	R ² contr.	SRRC	S _I	T _I	S _I	T _I	S _I	T _I		
TUBTHICK	---	---	0.04	0.15	0.15	0.55	0.16	0.16	0.087	0.142
VDEPOS.1	0.11	0.31	---	---	0.02	0.06	0.25	0.25	0.071	0.010
GSHFAC.3	---	---	---	---	0.00	0.03	0.27	0.27	0.057	0.008
GSHFAC.2	0.16	0.29	0.02	0.10	0.06	0.20	0.00	0.01	0.056	0.064
CFRISK.8	0.05	0.29	0.02	0.05	0.01	0.01	0.14	0.15	0.041	0.011
SVOAFRAC	---	---	0.01	0.27	0.09	0.15	0.00	0.00	0.025	0.104
DLEAK	0.04	0.09	0.03	0.61	0.03	0.10	0.00	0.01	0.023	0.214
CYSIGA.1	---	---	0.00	0.01	0.01	0.00	0.09	0.08	0.019	0.004
DLTEVA_5.6	0.02	-0.16	---	---	---	---	0.09	0.09	0.019	0.000
RCPSL	0.07	0.23	---	---	---	---	---	---	0.018	0.000
DLTEVA_4.8	---	---	0.00	0.04	0.06	0.36	---	---	0.017	0.093
SR.91_ICH.9	0.01	-0.10	0.02	0.05	0.03	0.09	---	---	0.013	0.027
PROTIN.2	0.05	0.17	---	---	---	---	---	---	0.013	0.000
CFRISK.7	0.03	0.16	0.01	0.20	---	---	0.00	0.00	0.010	0.064
DLTEVA_5.8	0.04	0.09	---	---	---	---	---	---	0.009	0.000
TE.132_ICH.9	0.03	-0.10	---	---	---	---	---	---	0.008	0.000
DLTEVA_2.11	---	---	0.02	0.16	0.00	0.02	---	---	0.007	0.052
DLTEVA.2	---	---	0.02	0.02	---	---	---	---	0.007	0.000
TIMHOT.	0.02	-0.18	0.01	0.11	---	---	---	---	0.007	0.034
DLTEVA_2.4	0.02	0.17	---	---	---	---	0.00	0.00	0.006	0.001
DLTEVA_2.8	0.02	-0.14	---	---	---	---	0.00	0.00	0.005	0.001
I.134_ICH.9	0.02	0.14	---	---	0.01	0.07	0.00	0.00	0.005	0.017

* highlighted if main contribution larger than 0.02 or conjoint contribution larger than 0.1

Table 6-29 Mean, individual, LCF risk (based on LNT) regression results within a 50-mile circular area for realizations with an SGTR.

Updated MELCOR Base Case

Timing of Key Events: MELCOR Updated Base Case compared to Surry SOARCA

Event Timing (hh:mm)	Updated Base Case	Original SOARCA Value
STSBO – loss of all AC and DC electrical power, AFW unavailable	00:00	00:00
Reactor trips Main steam isolation valves (MISVs) close RCP seal leakage initiates at 21 gpm/pump	00:00	00:00
RCP seal failure (enhanced leakage)	-*	02:22
SG SV fails to close	01:11	-*
SG dryout	01:22	01:16
PRT rupture disk breaks	02:09	01:46
Pressurizer SV fails to close	03:00	01:27
First fission product gap release	03:22	02:27
Loop A hot leg nozzle rupture	04:28	-*
Loop C hot leg nozzle rupture	-*	03:45
Accumulators begin discharging	04:28	03:45
Accumulators empty	04:29	03:45
RPV lower head breach	07:41	07:16
Reactor cavity dry	07:46	07:27
Containment pressure reaches design (45 psig)	25:01	11:00
Containment liner yields	41:05	-*
Containment rebar yields	-*	25:32
End of calculation	48:00	48:00

*Indicates event did not occur