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UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

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549TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARD

(ACRS)

+ + + + +

THURSDAY

FEBRUARY 7, 2008

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ROCKVILLE, MARYLAND

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

COMMITTEE MEMBERS PRESENT:

WILLIAM J. SHACK, Chairman

MARIO V. BONACA, Vice Chairman

GEORGE E. APOSTOLAKIS, Member

DENNIS C. BLEY, Member

DANA A. POWERS, Member

JOHN W. STETKAR, Member

MICHAEL CORRADINI, Member

JOHN D. SIEBER, Member

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COMMITTEE MEMBERS PRESENT (Continued):

OTTO L. MAYNARD, Member

SAID ABDEL-KHALIK, Member

J. SAM ARMIJO, Member

SANJOY BANERJEE, Member

ALSO PRESENT:

SAM DURAISWAMY

MAITRI BANERJEE

P.T. KUO

KENNETH CHANG

JONATHAN ROWLEY

JOHN DREYFUSS

TED SULLIVAN

LARRY LUKENS

GARY STEVENS

PAUL JOHNSON

MICHAEL MODES

SARAH HOFFMAN

JORAM HOPENFELD

JOHN FAIR

CHANG LI

MAKUTESWARA SRINIVASAN

STEVE JONES

JOHN JOLICOEUR

TREVOR COOK

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ALSO PRESENT (Continued):

SUD BASU

FAROUK ELTAWILA

STU RUBIN

MARK HENRY SALLEY

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P R O C E E D I N G S

(8:32 a.m.)

CHAIRMAN SHACK: The meeting will now come to order.

This is the first day of the 549th meeting of the Advisory Committee on Reactor Safeguards. During today's meeting, the Committee will consider the following: license renewal application for the Vermont Yankee Nuclear Power Station; draft final revision to Regulatory Guide 1.45, Guidance on Monitoring and Responding to Reactor Coolant System Leakage; proposed licensing strategy for the next generation nuclear plant; cable response to life fire testing and fire model improvement program; and the preparation of ACRS reports.

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

We have received no written comments from members of the public regarding today's session. We have received request for time to make oral statements from Mr. David Lochbaum, Union of Concerned

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Scientists; Ms. Sarah Hoffman, State of Vermont, Department of Public Service; and Mr. Joram Hopenfeld, consultant to the New England Coalition, regarding the Vermont Yankee license renewal application.

We also have several people on a bridge phone line listening to the discussions related to Vermont Yankee. To preclude interruption of the meeting, the phone line will be open one way during the presentations and Committee discussions.

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

I begin with an item of current interest, and that's Dr. Herbert Kouts, who served as a member of the ACRS between 1962 and 1966, and was ACRS Chairman in 1964, has died at the age of 88. He was the first Director of the Office of Nuclear Regulatory Research. He also served as a member of the Defense Nuclear Facility Safety Board and numerous other positions in the development of nuclear power.

Our first presentation today will be on the Vermont Yankee license renewal, and Dr. Bonaca will lead us through.

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VICE CHAIRMAN BONACA: Okay. Good morning. We are here to review the final SER license renewal of Vermont Yankee. Unfortunately, however, the SER is not final because it's incomplete. It's missing closure of the environmentally assisted fatigue issue, and Vermont Yankee has chosen to calculate the cumulative usage factor of 60 years for the limiting components, and the staff has not agreed with the approach chosen, has requested additional work.

The work has been done by the licensee, but has not been yet reviewed by the NRC. So the FSAR is incomplete in the sense of the particular portion.

We have decided not to write a letter at this meeting, but to have another session in March at which we will discuss this issue and then issue a report. This will give us the time to have a final SER in hand and the opportunity for us to review it ahead of time.

We will proceed, however, with the presentations today on the rest of the license renewal given on this issue. If you want to have some comments made, the focus should be the whole application and not only that particular issue that needs closure yet.

So with that, I will turn to Dr. P.T. Kuo,

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and he probably will read the statement regarding this specific calculation that still needs to be done.

DR. KUO: Yes. Thank you, Dr. Bonaca.

I'm P.T. Kuo, the Director of Division of License Renewal. To my right is Dr. Kenneth Chang, who is the Engineering Branch 1 responsible for the audit review at the plant site, and to my extreme right is Jonathan Rowley, who is the project manager for the Vermont Yankee license renewal application, and he will be leading the presentation, staff's presentation, today.

Before the presentation starts, I would like to make just a short summary of the status of our review. Typically we come before the Committee with a final SER with no open items, but this is one of those rare occasions that we one issue that we haven't been able to totally resolve it. The exception is that the issue is the metal fatigue and the environmental effect.

We have been working with the licensee for the past few months on this very issue, and we have had meetings with them and have had very extensive discussion on this issue. The issue here is that when they perform the fatigue evaluation, they use the software that uses a methodology which is different

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from the conventional methodology. I mean that, you know, what ASME code kind of requirements.

They use a methodology that simplifies the calculations. Generally we have 6,000 functions for a component, three moments for stresses and all of that, and then compute the transfer function, the Green's function, and then calculate stresses. But with this methodology, they use entirely the calculation by combining six components into one component.

In that we cannot really relate this one component into any physical meaning, this mathematical manipulation, but that is hard to tell what this one component represents, and they use the term "virtual stress."

Okay, and as far as we understand it, this methodology has never been published in any professional literature before, and that was not generically benchmarked anyway. So the staff took time to look into what his methodology really is, and based on our extensive discussions with the applicant and our staff's own evaluation, we have concluded, we have come to the conclusion that this methodology may be okay for certain conditions, but certainly it's not going to be generically applicable to all.

And the limitation there, based on our own

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evaluation, we believe that this methodology could be applicable, valid if there is a component of axisymmetric nature in geometry, and the axisymmetric in loading. Then, you know, in these conditions the component may not be subject to any shear stress.

Once the shear stress is introduced into it, because of the non-axisymmetric nature of the geometry and the loading, then this methodology will yield results which may or may not be conservative. Okay. So we have that problem, and then we told the applicant what we really want to see.

And in the last meeting that we had with the applicant, they committed to do certain analysis, okay, for the locations, the critical location that is described in the GSI-190 as a result of GSI-166. That is documented in Reg. Guide CR-6260.

So we asked the applicant to look at six critical locations, but because three of those components that are of axisymmetric nature and the loadings, so we don't have any concerns with that. But the other three that consist of nodules, for instance, and some pipe-to-pipe connections, then you know, we need them to look at it, do some independent calculation.

So the applicant committed to do the

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calculations for the most critical locations using the industry-wide recognized methodology and computer code, ANSYS. They performed that analysis, came up with the answers that the CUF is less than one.

They have submitted the latest information as yesterday. We received it yesterday over the last submittal. So as Dr. Bonaca pointed out, we didn't have time to evaluate yet. So we left this issue open in SER, and hopefully we will be able to explain to the committee in the next meeting scheduled for March, but we think that the applicant now is in the right path to resolve the issue. If we, after our review of this latest submittal, if everything that we agree with, I think this issue should be resolvable.

And that's my brief summary of where we are in terms of this issue. Today's presentation is going to be led by Jonathan. It's going to be everything except this issue. So if you members have any questions about this issue or anything else, I'll be glad to answer the question now or we can leave it to during Jonathan's presentation.

MEMBER BANERJEE: May I just ask?

DR. KUO: Yes, sir.

MEMBER BANERJEE: In your view, why the methodology which was not what you call an industry-

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wide standard was used in this case, to begin with?

DR. KUO: Well, why, I cannot answer why, but that is one methodology they have used in the software. Okay? I think probably the intention is to simplify the calculation.

MEMBER BANERJEE: So that was the intention, to try to simplify the calculation. That was the reason; that was one of the reasons that was used?

DR. KUO: Perhaps.

MEMBER BANERJEE: Were there any other potential reasons, the geometry, anything like that which might have --

DR. KUO: That I cannot answer. The authors will have to answer that. I could not answer that.

VICE CHAIRMAN BONACA: My understanding is that other applicants may have used this methodology, right?

DR. KUO: Many.

VICE CHAIRMAN BONACA: So I'm saying that may be one of the reasons why they used it, is that it had been used before.

DR. KUO: This methodology was used before, but the staff wasn't aware of until we do the

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license renewal application review. So there is a generic implication to this issue, and we are looking into it right now, how to handle this, and we will definitely --

CHAIRMAN SHACK: Can you state what the software is?

MEMBER BANERJEE: ANSYS he said.

CHAIRMAN SHACK: No, that's what they used to correct it. What is the software that was used or is that something you prefer not to discuss?

DR. KUO: The software has been used associated with a fatigue monitoring program.

CHAIRMAN SHACK: Right, and those fatigue monitoring programs are everywhere.

DR. KUO: Well, the fatigue monitoring program can be different. Okay. Certain fatigue monitoring programs, certainly monitoring the cycles, and certain fatigue monitoring programs try to counting the cycles also calculate the fatigue using SPECTER on real time basis, and this is one of the examples. They try to compute the CUF on a real time basis.

Any other questions?

If not, then I would turn over the presentation first to the applicant and then the staff

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presentation will follow.

VICE CHAIRMAN BONACA: Yeah, just one note before we start. Be aware of time. Make sure that, you know, we have a number of additional persons of the public that will make statements at the end.

So with that, let's proceed with the presentation.

MR. DREYFUSS: Very well. Thank you.

Good morning. My name is John Dreyfuss. I'm the Director of Nuclear Safety Assurance for Vermont Yankee. We appreciate and thank the Committee for having us here.

As Dr. Bonaca mentioned up front, there is a broad context of license renewal for Vermont Yankee.

Our intention is to provide that broad overview, but in addition, we will discuss the heat analysis and environmentally assisted fatigue in some detail, both the methodology that we used initially as well as the confirmatory analysis, and of course we'll entertain any questions.

Before I introduce the rest of the license renewal team I'd like to introduce the site Vice President, Ted Sullivan, for Vermont Yankee.

MR. SULLIVAN: Good morning. I'm Ted Sullivan, site Vice President, and I'd like to also

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thank the Committee for allowing us to present the status of our license renewal application.

I'd like the Vermont team to introduce themselves, and then I'm going to turn it very quickly over to John Dreyfuss. He's our lead presenter today.

MR. MANNAI: Dave Mannai, licensing manager.

MR. RADEMACHER: Norm Rademacher, Engineering Director.

MR. FITZPATRICK: Jim Fitzpatrick, Design Engineering.

MR. METELL: Mike Metell, license renewal project manager.

MR. COX: Allen Cox with the Entergy license renewal team.

MR. DREYFUSS: Very good. Next slide, please. And the next.

As far as the presentation goes, we do have a number of back-up slides and additional information, and we can go to any depth that you would like to go to. Of course, we are mindful of the time issue. If you've seen enough and would like us to move on on any particular issue, we'll also do that. So any questions that you have, of course, we'll entertain during the course of the presentation.

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As far as the agenda goes, we'll go through some key background issues and the project itself. We'll talk about the issues that prompted some schedule changes. We anticipated through the initial schedule that we would be in front of the full ACRS in September. Three issues drove some additional review on the part of the staff and some additional information that we needed to provide to the staff for them to come to their conclusions.

Key presentation topics that we went through at the subcommittee we'll give abbreviated versions of today, and they involve industry issues associated with drywell shell, the torus shell, as well as our station blackout source, the Vernon hydroelectric station.

Next slide.

A general site overview. We are a GE BWR-4 with a Mark 1 containment, 650 megawatt electric. We did do a power up rate, extended power up rate over the last several cycles. We implemented in 2006. We'll discuss that briefly.

The plant is a forced draft cooling on the Connecticut River. We do use cooling towers. We'll talk a little bit about that during the course of the presentation. Six hundred and fifty people, including

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the contractors at the site.

Relative to the history, these are some of the highlights. We did do our application in January of 2006. The operating license for the plant expires in March of 2012, and again, we did the power up rate in 2006.

Key major plant improvements. We have kept pace with the industry on the generic issues in the industry, and we've done the major modifications that you do see listed here. The noble chem. application in 2001, in the last refueling outage, we reapplied noble water chemistry as well, and over the last few cycles, as I said, we did the power up rate modifications.

CHAIRMAN SHACK: What's the difference between applying the noble metals in 2001 and going to hydrogen water chemistry in 2003?

MR. DREYFUSS: We actually did not inject hydrogen. We did the noble chem. initially and then subsequently did hydrogen injection.

As far as the power up rate enhancements, we did a lot of modifications for positioning ourselves for power up rate. We feel that places the plant in good position for extended operation.

New high pressure turbine, we rewound the

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statter. We reinsulated the rotor, new feedwater high pressure heaters. The LP heaters had been replaced in the 1990s. We did some condenser mods to accommodate to additional steam flow. Lots of new switch yard equipment based on analysis of the new output of the plant, new switch yard breakers, protective schemes.

Major control systems were upgraded for both reactor pressure control, feedwater level control, the feedwater heater level control system, and others, recirc control, our recirculation system control.

We also upgraded to three feedwater pump operation, which prompted us to put in new protective circuitry and plant response in the event of loss of a condensate pump and control schemes with runbacks and other selective pump tripping to preserve feedwater flow to the reactor vessel in power operating conditions.

Next slide.

From a plant performance standpoint, currently the plant is operating at full power, 650 megawatts electric. We have no equipment issues.

We did have a refueling outage last year in May of '07, and there are a couple of outage items of interest that we wanted to speak to. These are

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areas of interest for the Vermont Yankee docket, and they involve both the steam dryer and flow accelerated corrosion issues. We'll speak to them briefly.

Next slide.

For steam dryer performance, we did have a license condition associated with the extended power up rate. We are compliant with General Electric SIL 644, a lot of industry operating experience out there with power up rates and the particular design dryer that we have. We did a lot of work on this issue as part of the power up rate.

We do online monitoring. Key is looking for changes, unexplained changes in reactor water level, as well as reactor pressure. We have procedures in place that do that monitoring and look to potential changes and issues with steam dryer. We have seen no issues with reactor water level changes.

Additionally, one of the other parameters to be monitored for steam dryer integrity is moisture carryover, and we do that monitoring on a weekly basis, and we're seeing no issues and no changes in that as well.

We operated the plant at a full year prior to the refueling outage. During the refueling outage we, of course, did substantial inspections of the

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steam dryer, visual inspections of all accessible and susceptible surfaces, visual inspections, and we found no fatigue indications that had been seen elsewhere in the industry for plants that had also done power up rates. So we saw no fatigue cracking at Vermont Yankee in the steam dryer.

We did identify some intergranular stress corrosion cracks, and we are monitoring them, and we dispositioned all of those cracks acceptably, and those indications are dispositioned. We will do monitoring over the next two cycles as well in accordance with our license condition and ongoing inspections thereafter in accordance with the SIL.

MEMBER ARMIJO: Exactly what did you do when you dispositioned those cracks? I mean, is it an administrative dispositioning, saying they're small and we know the growth rate, or was there a physical repair or what?

MR. RADEMACHER: This is Norm Rademacher.

What we did was we entered them into our corrective action system. We had GE review them and had their technical experts agree that they were acceptable as it, and then our Engineering reviewed their work and determined that that was acceptable.

So there was no repair work that was

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required.

MR. DREYFUSS: And we'll inspect those areas again in our next refueling outage.

CHAIRMAN SHACK: And with a VT-1 inspection, how do you decide that they're IGSCC?

MR. RADEMACHER: Larry Lukens, would you please address that?

MR. LUKENS: Larry Lukens, Entergy.

This is on, right?

MR. RADEMACHER: Yes.

MR. LUKENS: The disposition of indications that we found in the dryer, as Norm said, were done by folks at the reactor supplier who have been reviewing dryer cracks since people have been looking at dryers, and so a VT-1 examination provides sufficient resolution so that the indication can be characterized either as an IGSCC stress relief sort of crack or a fatigue.

And if there's any indication that that indication is fatigue related, it goes down an entirely different path, but these were all IGSCC stress relief indications.

MEMBER SIEBER: VT-1 is a visual exam?

MR. LUKENS: Yes, it is.

MEMBER SIEBER: And it's just the surface?

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MR. LUKENS: It is a visual, yes.

MEMBER ARMIJO: There was no metallurgical sample to verify that it was truly intergranular as opposed to fatigue?

MR. LUKENS: That's correct. It was done by characterization of the indication itself.

CHAIRMAN SHACK: Well, we'll trust GE's experience, I guess.

MEMBER MAYNARD: Well, it was dispositioned by GE. Are they the ones who looked at it themselves or are they going by whatever the site inspectors had provided?

MR. LUKENS: The actual visual data stream was transmitted to the folks at GE, and they had the same display information. I keep wanting to use the word "indication." They had the same information that we had so that they could characterize the indication, and although this was a VT-1, this was a VT-1 that is significantly superior to the minimal requirements for a VT-1. It was nearly, but not quite; it was nearly an EVT-1 quality exam, a very high resolution exam.

MEMBER ARMIJO: But they didn't have direct evidence that it's IGSCC. Maybe by location, from prior experience, and other kinds of stuff they concluded that.

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MEMBER SIEBER: No volumetric exam.

MR. LUKENS: It was not a volumetric exam, and we didn't do anything like that example. That's correct.

MR. DREYFUSS: Additionally though, in the prior refueling outage, we had done a full baseline of the steam dryer and had identified these IGSCC indications in that refueling outage. In 2007, we went back and we saw no growth associated with these particular indications.

We found some additional because we had used a different visual technique. So we did find some additional indications, but those that we identified in the prior outage did not indicate any growth, which is similar to IGSCC.

MR. MANNAI: This is Dave Mannai.

Also, you mentioned at the subcommittee. This was of particular interest to the NRR Operating Reactors Branch staff. We had given them a proactive briefing on the indications that we did find during the outage in accordance with our license conditions, which was mentioned earlier. We had to submit a report. We did submit that report within the required time frame and there were no follow-up issues from the NRC staff at that time.

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Okay. Next slide.

Regarding flow accelerated corrosion, again, as part of the power up rate because we were increasing the steam flow through the plant as a proactive measure, we decided that we would increase the number of samples that we took in the FEC program.

We did do 63 inspections. All of them indicated that we were having satisfactory performance, nothing adverse associated with the power up rate and the increased flow that we had seen, and we will do additional increased scope inspections during our next two cycles.

MEMBER BANERJEE: Are you still continuing to monitor the steam line strain gauges?

MR. DREYFUSS: No. We are not doing steam line strain gauge monitoring.

MEMBER BANERJEE: You were.

MR. DREYFUSS: We did that as part of the power ascension program and to measure the acoustic flow induced vibration that we were seeing, the acoustic loads, and satisfied ourselves that we were not having adverse consequences, that we were within margin and the ASME limits for that.

Now we are on the online monitoring and the steam dryer inspection.

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MEMBER BANERJEE: So you're only monitoring the moisture carryover water level, no longer the steam line itself.

MR. DREYFUSS: That's correct.

MEMBER BANERJEE: When did you stop?

MR. DREYFUSS: After that --

MEMBER BANERJEE: In 2007?

MR. DREYFUSS: Correct.

To speak to the project itself, relative to application of the GALL, we were the first one to use the Revision 1 to the GALL. We are compliant with the GALL. There were a number of exceptions that we did have to the GALL. We discussed these at length at the subcommittee meeting. We characterized those exceptions that we did take as technical exceptions, plant design changes that did not allow us to comply with the GALL or cases where the GALL criteria did not apply to the plant itself.

We do have additional information if you have any questions on that.

As far as the license renewal commitment, we have made 51 commitments during the course of the license renewal review. These are all tracked in our commitment tracking program and formalized that way. And we are also committed to updating our safety

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analysis report with those commitments as well.

We do have 39 aging management programs. A number of them are in place fully. Some require enhancement. There are also new programs that we will be developing. We have a schedule for those. We have some that were developing this year. All of them, of course, will be in place prior to the period of extended operation.

As far as the initial SER summary, we did have no open items from the initial SER. There are six confirmatory items. We have provided all of the information that was necessary to resolve them. Based on plant walk-downs and drawing reviews, we provided all of that information and were satisfied that those are resolved.

CHAIRMAN SHACK: I'm sitting here thinking. Since I'm still generating ISCC on the steam dryer with hydrogen water chemistry and my noble metals, I assume there's no noble metal coating on the steam dryer, but does the noble metal cover the top guide also when you do the application?

MEMBER ARMIJO: Underwater it will.

MR. METELL: It covers all wetted surfaces.

This is Mike Metell.

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Dr. Shack, it covers all wetted surfaces.  
So we can credit for that.

CHAIRMAN SHACK: And how high up? Is it just above the top guide essentially that gets coated?

MR. METELL: I believe so.

MR. DREYFUSS: And we can confirm that.

MR. LUKENS: This is Larry Lukens.

The wetted surfaces would go all the way up to the dryer skirt. They would not cover the bulk of the dryer that we've been talking about.

MR. DREYFUSS: All right. There were three key issues that drove some need for additional review on the part of the staff and some additional information that we provided to the staff during the course of the review application, and one of them involved scoping. The other one involved an event that we had with the cooling towers at Vermont Yankee in August. We'll talk about that, and we'll also talk about the environmentally assisted fatigue.

Next slide.

The key reason or the key issue that we had on scoping was the level of detail that we had for the scoping in particular in the turbine building itself was lacking. What we did is we had to define what those boundaries were and then populate within

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those boundaries what were the specific components that were within the A(2) scope.

We did complete that review. We submitted that, and we have resolved that issue with NRR in the region.

MEMBER BANERJEE: What is the A(2) scope?

MR. DREYFUSS: This is the impact of non-safety related on safety related. So in the turbine building, in particular, we had to take a look at some systems that had the potential to impact safety related.

MEMBER BANERJEE: Like what?

MR. DREYFUSS: Some examples, Al.

MR. COX: In the turbine building, we take a pretty conservative approach in that we look at cables or piping. We use the database to do the initial work on A(2), and if we had a component in the database that had a location that was near safety related -- if we had a safety related component in the database, we took in all of the system, the non-safety systems around that, said these could have an impact.

The problem we ran into in the turbine building is that there's not a lot of components. We had areas where we had cables and piping that ran through large areas of the turbine building that

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didn't have components that showed up in the database.

So those were not included.

Normally those are components such as cables and piping without valves, just straight runs of piping.

MEMBER BANERJEE: So this would include taking into consideration of fires and things?

MR. COX: No, it's really more directed at leakage from piping, non-safety piping that contains liquid.

MEMBER BANERJEE: Not lubricating oil, making a --

MR. COX: Could be.

MEMBER BANERJEE: -- fire or something.

MR. COX: It's not directed at fire. It's directed at impingement, interaction because of leakage onto the safety related equipment, and again, most of the safety related equipment that we failed to include or failed to address in the turbine building was straight runs of cable and piping because those didn't show up with the specific location in the database.

MEMBER SIEBER: It often considers things like pipe width and breakage of pipe where it falls on a piece of equipment or other piping. I got the

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feeling from reading that that you don't have a lot of isometric drawings or room drawings where you show all of the pipes in a particular room or all the conduit.

Is that the case?

MR. COX: Well, we take a pretty conservative approach. We have the drawings, but you know, we look at anything that's in the turbine building. If you have safety related equipment in that building or in that room of the turbine building, then all of the non-safety related fluid filled systems in that area are included in the scope.

MEMBER SIEBER: But the turbine building was not the only place where you had to take additional inspections, right?

MR. COX: That's true, but the initial application had included those other areas because you had to -- you know, you had valves and components that actually showed up in the component database in those areas.

MEMBER SIEBER: Thank you.

MEMBER BANERJEE: Was there any sort of increased leakage of things like lube oil and things as time goes on?

MR. RADEMACHER: Norm Rademacher.

The answer is that, you know, our

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operators do a daily tour through the turbine building and the reactor building in all operating spaces. So they keep an eye on those kinds of things, and if identified, it gets immediately put into the corrective action process and then moved into getting repaired.

MEMBER BANERJEE: Have you seen any increase with time?

MR. RADEMACHER: No.

MEMBER BANERJEE: So for 30 years it has stayed more or less the same?

MR. RADEMACHER: We have a pretty aggressive packing program where we go back after packing. We've been putting in, you know, improved packing and replacing equipment to make sure that it is operating properly. We don't allow that to -- you know, when things need repair we put it into our long-range plan or put it into the outage plan to get prepared for the next forced outage depending on what its priority is.

MEMBER BANERJEE: But what is the main effect of aging here? What happens?

MR. RADEMACHER: In the turbine building?

MEMBER BANERJEE: Yeah.

MR. RADEMACHER: For a lube oil system?

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MEMBER BANERJEE: Yes.

MR. COX: Norm, I guess in terms of the aging management review, the things that we call out are corrosion, loss of material due to corrosion. That's the main thing. The oil piping would be mainly carbon steel. The fact that you have oil on the inside means that you don't have a lot of corrosion there. It's pretty well protected by that, but we monitor the conditions of the oil to make sure we don't have water in it.

I think in general in the operating experience reviews that we've done for license renewal, we haven't seen a lot of -- we haven't seen any kind of trend as you mentioned of increasing leaks due to aging of the components. It's a fairly benign environment. Outside piping ins protected from the weather, and it's normally dry. You don't see a lot of aging on those type components.

MEMBER MAYNARD: I would think that most of these really wouldn't be any different for the extended period of operation than it is for -- you have an ongoing maintenance program that inspects and monitors these systems. So I doubt that you had to do much different for the extended period than what you do during the initial license period.

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MR. COX: That's correct. There's a few cases, such as you know we may look at a tank low point in the system where you have some water collection that could increase the rate of corrosion.

Of course, things like the FAC Program, under the current term you're looking for areas and you've taken corrective action to replace piping. You've addressed a lot of those issues that would be of a concern for license renewal.

MEMBER BANERJEE: It still was water because there's always a little bit of water and oil that drops out. You sort of get sealed to pitting corrosion. Would you see that in your FAC Program?

MR. COX: Well, again, we do the visual inspections.

MEMBER BANERJEE: I know because in the oil and gas industry this is a huge problem. So I'm just asking you how you see this.

MR. COX: We haven't seen a lot of problems, but again, the programs that we've identified for license renewal include some visual inspections that may not have been done routinely in the past that will look for those things at the low points.

MEMBER BANERJEE: So you would see CO<sub>2</sub>

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pitting corrosion when you do water dropout? How would you see that?

MR. COX: We have inspections where we'll drain some of these tanks and look at the bottom of them, where you have places where the water would normally accumulate.

MEMBER BANERJEE: Have you seen any?

MR. COX: I'm not aware that we've seen any significant corrosion. Again, some of these inspections are not things that we've done a lot of in the past. We'll be doing more of those as part of the license renewal.

MR. RADEMACHER: For example, one of the inspections that we're currently planning either this outage or next is for the fuel oil tank, lube oil tank and so forth. The bottoms of the tanks, they're lined with UT, the thickness and so forth, visual inspections of the tanks and so on.

MEMBER SIEBER: The fuel oil tank?

MR. RADEMACHER: Pardon me?

MEMBER SIEBER: Of your fuel oil tank?

MR. RADEMACHER: Yes.

MEMBER SIEBER: This is the plant with the John Deere diesel?

MR. RADEMACHER: That's correct.

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MEMBER SIEBER: And not your day tank, but you main fuel oil tank is fiberglass?

MR. RADEMACHER: Stainless.

MEMBER BANERJEE: Oh, it's stainless?

MR. RADEMACHER: Yes, for the main fuel oil, yes.

MEMBER BANERJEE: None of these are carbon? Any of these tanks carbon steel or are they steel?

MEMBER SIEBER: Yeah, I've got to figure out.

MR. ARMIJO: He corrected it. It was carbon steel.

MEMBER BANERJEE: Oh, it is. Okay, okay. So the problem is the carbon. With stainless you wouldn't have the problem.

MR. COX: I think in general we do a pretty good job. I'm not that familiar with the oil industry, but we do a pretty good job of monitoring. On the fuel oil we sample when we receive a load of fuel to make sure, you know. We check for water content, and we typically drain tanks, low points to try to check for water, to see if there's any water that accumulates in the bottom of the tank. I know we do at some of the other plants that I've worked at.

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MEMBER BANERJEE: All right. Okay. Let's move on. Proceed.

MR. DREYFUSS: The next issue has to do with the cooling towers. Vermont Yankee, again, is a forced draft cooling. We have two towers. Each tower has 11 cells to it. In Cooling Tower 2, the first cell is safety related. It provides a mode of alternate cooling in the event of loss of river or fire where we lose the intake or another issue like that.

Adjacent to the safety related cell is a seismic cell, and in August of this year we did have a partial collapse of cooling tower cell 2-4. This was a significant event for us and clearly did not meet our expectations. It did drive and prompt some questions from the staff regarding whether or not we had properly scoped the cooling towers.

We did go back and re-review that scoping.

We were satisfied with the initial scoping that we had done. There was no impact to the safety related cell from the non-safety related cell. There are break-aways on the safety related cell, for example, in the event that there is a seismic event or any other issue that would prevent the safety related cell from being impacted by effects on the non-safety

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related cell.

So we did, again, in summary, satisfy ourselves that that scoping was proper on the cooling towers.

MEMBER ARMIJO: Could you explain the cause of that collapse and why that same cause couldn't affect your safety related cell?

MR. DREYFUSS: Yes.

MR. RADEMACHER: This is Norm Rademacher.

The bottom line was that our preventive maintenance process was not detailed enough for inspection inside of the fill material, and as a result, we did a detailed root cause evaluation, and we were not seeing the potential failure coming up of those members.

And on the safety related cell there, we have additional monitoring and preventive maintenance, and it is a stronger design, and it's a combination of those elements are different between the two cells, the non-safety and the safety.

MEMBER ARMIJO: So the safety related cell had more preventive maintenance and inspection than the non-safety related cell.

MR. RADEMACHER: Yes, that's correct.

MR. DREYFUSS: And the design.

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MR. RADEMACHER: And the design had more strength. It's seismicly designed so that it has more capability than the non-safety.

MEMBER SIEBER: I hate to go back to old things, but I have now found the reference to the underground storage tanks in license renewal application section C(1), 2.3.3.12, and in the staff's SER, that's 12-1, where it states that the underground storage tank is fiberglass, and I'd like the staff to determine whether it's fiberglass or stainless steel or whatever it is and let me know. Because you say you've got to test the thickness of the bottom of that tank using UT, and if it's fiberglass I'm not exactly sure how you do that.

MR. RADEMACHER: There's two different tanks, one for the John Deere diesel, which is fiberglass, and one for the diesels and the house heating oil and that's carbon steel. So if we were unclear on that, that was --

MEMBER SIEBER: Well, the diesel is fiberglass.

MR. RADEMACHER: That's the security diesel for the John Deere diesel.

MEMBER SIEBER: Okay.

MR. RADEMACHER: That's not the main

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diesel tank.

MEMBER SIEBER: So you're relying on the hydro plant for part of your emergency backup. Is that true?

MR. RADEMACHER: The John Deere diesel?

MEMBER SIEBER: Station blackout.

VICE CHAIRMAN BONACA: Please speak up.

MR. RADEMACHER: Yes, this is Norm Rademacher.

That John Deere diesel is used to supply power for the plant process computer, and it's a non-safety related component. It is used for monitoring and so forth, but its main purpose is not, and it also has some security purposes.

MEMBER SIEBER: But you don't do the inspection of the condition of the tank, right? Other than moisture and things like that.

MR. RADEMACHER: Yes, and we are committed as part of license renewal to enhance that program, I believe, as part of the application.

MEMBER SIEBER: Yeah, that's what the comment says.

Thank you.

VICE CHAIRMAN BONACA: We need to move on.

MR. DREYFUSS: Okay. Moving on, I'd like

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to talk about the environmentally assisted fatigue. Along with the A-2 scoping and the cooling tower questions that we got from the staff, we had a number of challenges from the staff on the methodology that we used, and we'll go into this in some detail. Jim Fitzpatrick will assist, and we also have Gary Stevens from Structural Integrity to answer any questions as well.

Environmentally assisted fatigue, VY plant specific calculations were completed in September of 2007, and, Beth, let's go to that link, please, for that.

And, Jim, if you could step us through.

MR. FITZPATRICK: Okay. Jim Fitzpatrick.

For the environmental assisted fatigue, we analyzed the locations identified in NUREG CR-6260. We used the EF relationships to fatigue correction factors, NUREG CR-6583 for carbon and low alloy steels, and NUREG CR-5704 for stainless steels.

We used design transients, not actual operation transients. We used design step transients for the analysis.

MEMBER BANERJEE: We don't have this slide, right?

MR. RADEMACHER: Yes, you do not have that

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slide.

MR. DREYFUSS: Yes, I'm sorry. This is a linked slide. We will provide you with a copy of these.

MR. FITZPATRICK: The number of cycles, we used a 60-year set of design cycles, based on our 40-year design cycles, plus we considered what we had to date. We added some transients from typical BWR-4s, the later vintage than ours that have more detailed transient definitions than VY's; put a full spectrum in there.

And we used existing analysis for the RPV shell and lower head and the recirc inlet nozzles. We took the existing analysis and applied the bounding Fen factors to those.

MEMBER BANERJEE: This was existing for the EPU or --

MR. FITZPATRICK: For EPU and fire. You're allowed to use an existing analysis and apply the fatigue factors. Most of the times in the original design they were so conservative that you have to go back in and do a little bit more realistic calculation of fatigue because their mission was to get to below one. If you put a large Fen factor on it, the existing analysis will show it's more, and that was in

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the cable 4.3.3, the application, if you look at the numbers that are more than one. That's why we went back and did the EF calculations.

We did three new analysis for the feedwater. We started out with core spray nozzles using the VY analysis approach. That approach, we used a numerical method to calculate the thermal transients. That is many discussions with the staff. That uses a Green's function approach to calculate the thermal stresses.

We calculated the maximum stress intensity from that, added that with the maximum stress intensity from the pressure stress and the maximum stress intensity from the piping loads. Combine those with the maximum stress intensity and they did the range pairs per --

MEMBER BANERJEE: Obviously a Green's function deals with linear systems. So all of these stresses superpose linearly? Is this a reality?

MR. FITZPATRICK: Gary, do you want to?

MEMBER BANERJEE: It's just a very simple mathematical tool for handling linear systems.

MR. STEVENS: Gary Stevens, Structural Integrity Associates. We're a contractor to Entergy, and we did the calculations.

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MEMBER CORRADINI: Could you speak a bit up? I'm sorry.

MR. STEVENS: Okay. Gary Stevens, Structure Integrity Associates, a consultant to Entergy, and we performed the environmental calculations.

And I'm sorry. I didn't hear the entire question. Would you --

MEMBER BANERJEE: I say Green's function is a way of handling, superimposing linear, if you like, right-hand sides of equations in looking at its response. Okay? It's a straightforward linear procedure, and I assume that you feel that the system is sufficiently linear that you can use such a superposition metric.

MR. STEVENS: Yes.

MEMBER BANERJEE: I mean, all it is is an integral of the right-hand side with the Green's function.

MR. STEVENS: Right. The NB-3200 analysis is intended to be linear elastic and superimposed stresses. So --

MEMBER BANERJEE: Why is that an appropriate assumption?

MR. STEVENS: I think generally it's

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conservative in terms of calculating fatigue compared to, say, a nonlinear elastic plastic analysis. That's the intent of NB-3200. There are provisions in NB-3200 to do a plastic analysis that would be less conservative that's generally avoided because of the resources involved.

MEMBER CORRADINI: Just to make sure what I interpret is in a simple way, so in a stress-strain model you're basically assuming linear, and so if there's any bending or any sort of behavior here that's non-linear, that's considered non-conservative or that's not as bounding as what you've done. Is that --

MR. STEVENS: Correct.

MEMBER CORRADINI: -- how to interpret your answer?

MR. STEVENS: Correct.

MEMBER CORRADINI: Okay. Thank you.

MEMBER BANERJEE: This is Hook's Law.

MR. STEVENS: That's correct. The non-linear nature of the problem is taken into account by other means like K-sub B, simplified elastic plastic factor that's built into the NB-3200 methodology to account for those non-linear effects in a very conservative fashion.

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MEMBER BANERJEE: And this is all approved and blessed somewhere back in history?

MR. STEVENS: It has been used extensively over the life of the industry.

MR. FITZPATRICK: Re-analysis used with that approach, and those are the ones that have been in discussion for the past few months, and then for the Class 1 piping, the classical ASME 3 and NB-3600 analysis. That's what we've done up to September.

MR. DREYFUSS: So we had submitted the initial calculations and --

MEMBER ABDEL-KHALIK: Excuse me. The staff contends that this approach is appropriate for axisymmetric components and axisymmetric loading. Would you care to comment?

MR. FITZPATRICK: Jim Fitzpatrick.

The approach, is the thing axisymmetric? The thermal transient stresses are actually symmetric with the nozzle. Their contention was when you have the pressure stress in a cylindrical vessel, you get peak stresses at, say, 90 to 70 and less stresses biz-azimuth the horizontal azimuth zero and 90, and we applied a correction factor on the pressure stress to account for the top and bottom, the higher increased pressure stresses, and that was added into the thermal

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stresses.

But the thermal transients, they were modeled with the Green assumptions.

DR. CHANG: Excuse me. Ken Chang. The license renew.

We said for axisymmetric geometry or axisymmetric loading. Transient loading, in general, axisymmetric. Okay? For BWRs, this is virtually true. For PWRs, because they are stratification, the loading, the similar trend in loading may not be axisymmetric. So that's why we put in conditions, axisymmetric loading and axisymmetric model.

MEMBER ABDEL-KHALIK: Thank you.

MR. DREYFUSS: A number of challenges from the staff on this issue from this period of October through January. I had requested and worked with Dr. Kuo to have a public meeting on this issue where we could bring the right technical people together to discuss it. We did explain our methodology, and it was at that meeting that we had committed that we would perform a confirmatory analysis.

That work was underway at the time of the meeting itself. We did complete that confirmatory calculation using the classical approach and completed that January 30th. We did submit that to the staff.

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We also addressed reactor water chemistry effects as well, and I would like to go to the confirmatory calculation.

MEMBER ARMIJO: Before you leave that, what's the issue with reactor water chemistry in this context?

MR. DREYFUSS: We'll talk both about the reactor water chemistry as well as the confirmatory calculation. We'll talk about the confirmatory calculation and then go to chemistry effects.

CHAIRMAN SHACK: What we're really arguing about is whether you can calculate the thermal stresses. With the Green's function you have to go to a finite element analysis.

MR. FITZPATRICK: Yes. This is Jim Fitzpatrick.

They really concerned at the blend radius for the axisymmetric in the safe end of the nozzle. The principal stresses line up. So they're not concerned about that area that much.

VICE CHAIRMAN BONACA: Well, the dispute on the methodology may still be open. However, you have submitted now results using ANSYS, which is the accepted methodology, and you have results to show?

MR. DREYFUSS: That's correct. We do.

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MR. FITZPATRICK: This is a summary of the confirmatory calculation. We looked at one nozzle and did the full ANSYS analysis, which is the feedwater nozzle. It had the most severe design transience and had the highest fatigue uses out of the three nozzles.

We used the same models we did in the other approach, the simple plan approach that we used.

We used the same transients, the same number of cycles, and the same water chemistry. To calculate the total stress ranges, we used all six stress components. They were combined at the component stress level for NB-3216.2, and under transient pair for fatigue years, this was calculated per ANSI NB-322.4(e), and that was the same as the existing analysis we did.

MEMBER BANERJEE: The boundary conditions you can impose are only those of temperature and pressure, right? And maybe the sheer stress due to the flow. This has to be somehow translated into stresses. How do you do that?

MR. FITZPATRICK: They are input to the model.

MEMBER BANERJEE: How is this input?

MR. FITZPATRICK: For the pressure, straight pressure loading, ANSYS can handle that

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directly. For the thermal transience calculations --

MEMBER BANERJEE: You only have a wall boundary condition on the outside. You have a heat transfer coefficient.

MR. FITZPATRICK: Yes, there's heat transfer coefficient that's used on each section of the model, one representing the outside of the vessel, one representing the shell in the inside, and different ones with different sections in the nozzle representing the flows and what the geometry of each section is and the materials.

MEMBER BANERJEE: Are you going to get into this in some detail in the next meeting?

VICE CHAIRMAN BONACA: Well, yes. I would suggest --

MEMBER BANERJEE: So we can defer this, and we will want to know exactly what you did.

VICE CHAIRMAN BONACA: My expectation is that the SER will contain a full description of the approach. We will also discuss the results of being presented. You have a table now there showing "go to show," right?

MR. DREYFUSS: That's correct.

VICE CHAIRMAN BONACA: Okay, and also you will talk about, for example, the multiplier that you

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apply for environmental effects. There is a question that has going to be raised later on regarding that multiplier. There is no fundamental discussion about that, where it comes from and what the conservativisms of the number is and so on, but the details of all of this will come together in March. So you know, you can show the results, and we don't need to go into that until March.

MEMBER BANERJEE: But we will get a chance in March to go into it?

VICE CHAIRMAN BONACA: Absolutely, because we will receive a number of pages in the SER with a description of why it's acceptable and what has been done, and I hope we get through a discussion of why the current methodology is not acceptable, you know, the issues of axisymmetric --

MEMBER BANERJEE: In fact, I'm most suspicious of statements which say "answers the industry standard." I'd like to see why it's the same as the industry standard and what the issues are there. It's like saying fluent is an industry standard, you know.

VICE CHAIRMAN BONACA: Okay. Let's move on.

MR. DREYFUSS: All right. Again, we also

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in the analysis address reactor water chemistry.

MEMBER ABDEL-KHALIK: Was that as far as you were going to talk about these confirmatory calculations?

MR. FITZPATRICK: We have two more bullets, two more bullets to hit.

VICE CHAIRMAN BONACA: You hand a table here that you hand out.

MR. DREYFUSS: Why don't we do the table or the chemistry?

Next slide.

For all of the nozzles that we've done the calculations for the CUFs adjusted for the environment are less than 1.0 with margin. What you see below addresses the feedwater nozzle confirmatory results. The analysis we performed in accordance with ANSYS, and at the nozzle corner, that was the limiting geometry. The initial analysis showed the .64. The confirmatory analysis showed .35.

Let's go back one slide back.

MEMBER MAYNARD: I just want to make sure that I understand.

MR. DREYFUSS: Yes, sir.

MEMBER MAYNARD: Your EAF analysis, that's what you had originally done, correct, and the

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confirmatory analysis is the one that you've done using the ASME --

MR. RADEMACHER: Finite element.

MEMBER MAYNARD: Okay. I just wanted to make sure.

MEMBER ARMIJO: So this shows you have more margin than your initial.

VICE CHAIRMAN BONACA: Yes.

MEMBER ARMIJO: But did you do that for the other nozzles, core spray and others?

MR. RADEMACHER: No. This was the limiting nozzles. We used the feedwater nozzle as the confirmatory analysis.

MEMBER CORRADINI: Can I just make sure I understand? Because in the opening statement, Dr. Kuo made a point of saying that in axisymmetric loadings what you guys are doing seems acceptable, but in non-axisymmetric loadings it could be high, it could be low.

So did this surprise you it was lower or in what situations would the confirmatory analysis end up being higher?

That's what I heard you say, unless I misheard, but here it's low in both cases. So I'm curious. Was that an expectation? If so, why?

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MEMBER BANERJEE: I'm sure it's very sensitive to the boundary conditions you put in.

MEMBER CORRADINI: Well, so I guess I'm --

DR. CHANG: Ken Chang.

If I may provide some clarification for that.

MEMBER CORRADINI: Well, it's their calculation. They're on the hook first. I want to hear from them.

MR. FITZPATRICK: We expected it to be lower.

MEMBER CORRADINI: Why?

MR. FITZPATRICK: The whole simplified approach. We were using bounding elements for each step of the way, along with the stem transients, the way we calculate the thermal stresses, combining the maximum with the maximum pressure stresses to end up with a large range.

So when we combined stresses at each step, we expected it to be lower.

MEMBER CORRADINI: So it's the way in which you do the EAF that you're saying guarantees that you're always bounding it so that there is not a non-axisymmetric loading where you would expect it to reverse itself when you see the confirmatory analysis

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above your calculation?

MR. FITZPATRICK: The only non-axisymmetric loading was the pressure, and that's one direction.

MEMBER CORRADINI: Okay.

MR. FITZPATRICK: And that was always added the same way in the strain, stress pairs.

MEMBER CORRADINI: Sorry. I didn't mean to --

DR. CHANG: Well, what I meant to say is --

VICE CHAIRMAN BONACA: I would suggest that we move on because this issue is going to be at the center of the presentation in March. That's the only issue that is going to be discussed then.

MEMBER BANERJEE: So the thermal loading is always axisymmetric?

MR. FITZPATRICK: Our design, yes.

MEMBER BANERJEE: Very, very clever design then. WE'll find out.

CHAIRMAN SHACK: Well, you don't get the highly stratified flows that you can get in the steam generator, but just coming back to this Fen, you did the chemistry. You did it for essentially an infinite rise time. Is that how you bounded the Fen?

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MR. FITZPATRICK: We have a slide on that.

CHAIRMAN SHACK: A slide coming up.

MEMBER ARMIJO: Now, these slides aren't in our handout.

MR. RADEMACHER: That's correct. These are back-up slides, and we'll provide that to the Committee.

MR. FITZPATRICK: As I said before, NUREG 6583 and 5704 --

CHAIRMAN SHACK: And we believe those.

(Laughter.)

PARTICIPANT: We approved them.

MR. FITZPATRICK: There's four inputs to the Fen factors chemistry. The sulfur content applies to the carbon low alloy steels. We used the valuable print 015 (phonetic) that maximizes that contribution.

The strain rate we considered low, less than .01 percent, and that maximizes that contribution.

The temperature, we used 550 degrees for all locations, and that bounds all of the transient pairs so that Fen factor has maximized that contribution.

The one thing we did use, we used the dissolved oxygen in different parts of the circuit in

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the feedwater line, different parts of the vessel. We used data from the BWR VIA model, given hydro-line chemistry inputs and dissolved oxygen inputs in the feedwater.

The values we used represent measured data in the feedwater line, plus one standard deviation. We have a number of years of feedwater data that we cannot determine what number to put in.

MR. DREYFUSS: And again, we'll be discussing more on environmentally assisted fatigue in March.

MEMBER BANERJEE: Was there any effect of the EPU on any of these stresses?

MR. FITZPATRICK: The Fen factor was appropriate for the chemistry EPU, and it goes up for some and down for other components within the material. The oxygen level changes at different points.

MR. DREYFUSS: Okay. All right. We'll move on.

VICE CHAIRMAN BONACA: Yeah, you do have the two lengthy presentations though for the drywell and the torus.

MR. DREYFUSS: Yes.

VICE CHAIRMAN BONACA: And so try to

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condense them.

MR. DREYFUSS: Very good. We will step through these smartly.

So the drywell and torus, we'll talk about those as well as the Vernon hydroelectric, and the drywall shell we'll talk about first. Yes. We'll talk first about -- Beth, can you bring that in -- refueling bellows area.

Next.

This is the sand cushion region and the torus shell as well, and these are all industry issues that we have assessed for Vermont Yankee and have not seen some of the impacts that have been seen elsewhere, but we will talk about them.

Next slide.

This shows a depiction of the refueling bellows and the monitoring and detection system that we do have. During refueling outages when we're flooded up with the spent fuel pool and we are in communication between the dryer separator pit, the spent fuel pool, and the reactor vessel itself, we have a bellows here that provides that separation.

This is the leakage detection system. There's a trough that goes the circumference around the shell here, the concrete bioshield, and leakage

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collection pipe with an alarm and flow switch that does alarm in the control room.

Next slide.

This would show in the event of a failure of that bellows how we would identify that. There's a telltale drain in the reactor building spent fuel heat exchanger room that the operators go on a shiftly (phonetic) basis, as well as the alarm would come in at five gallons per minute leakage. The pipe itself is capable of a 200 gpm leak.

Next slide.

MEMBER SIEBER: So the pipe would never be full.

MEMBER ARMIJO: It would have to be a big leak.

MR. DREYFUSS: Should not be, should not be.

MEMBER MAYNARD: Do you have a program that periodically verifies the line is clear and open and would handle that kind of flow?

MR. DREYFUSS: We do check the alarm. We do put water in the system and confirm that we do get the alarm. We calibrate the alarm as well.

This depicts the sand cushion region here. The industry operating experience that's out there is

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that leakage can find its way down this air gap, collect in the sand cushion region, and cause corrosion of the drywell shell. This shows the drywell shell here and the drywell floor.

One feature I wanted to point out is the moisture barrier. We did do an upgrade to that. We'll speak about that very briefly.

Additionally, this area here, some plants have left this insulating foam in there. That insulating foam is detrimental in two ways. One, it's an area that it can just collect the moisture and retain that moisture environment against the shell itself. Additionally, it's a source of chlorides that do accelerate the corrosion as well.

We do not have that insulation in. It was a construction material that was put in to form that sand drain. We did remove all of that insulation. In fact, we do see convective currents. These sand line drains here open up to the torus area, the torus room, and we do when we have looked in the air gap region, we do see convective air currents go from that torus room up through this, maintaining that same cushion region dry, indicating to us that we don't have any ongoing moisture issues as well.

Next slide.

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CHAIRMAN SHACK: And historically you've had none?

MR. DREYFUSS: That's correct. No issues and no events of leakage.

MEMBER ABDEL-KHALIK: How do you detect those convected air currents?

MR. DREYFUSS: We have boroscopically looked in that region and did not -- you can actually see small particles of the sand moving around.

Larry Lukens.

MR. LUKENS: Larry Lukens.

During the most recent examination in 2007 we videotaped every one of those examinations and what we observed was that we could see dust flowing through those drain lines, and it was verified on the videotape by all the people who saw it so that we know there are natural air convection currents going through those lines.

VICE CHAIRMAN BONACA: Okay.

MR. DREYFUSS: So in summary, the protective features. Again, the potential for moisture intrusion, water intrusion is minimized through the design. We don't have foam insulation that's been problematic elsewhere. We do see this air flow when we look there, indicating to us that that

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sand cushion is being maintained dry, and we do have diverse methods of identification of water leakage.

If there is leakage into the sand drain, the actual sand drains, eight of them, go to the torus room. Operators on a shiftly basis during refueling outages look at them, and on a daily basis during normal operation operators do look at those drains to see if there are any moisture. We see none.

VICE CHAIRMAN BONACA: Okay.

MR. DREYFUSS: Again, in response to your question, Dr. Shack, from 1969 to 2008 we've had no issues and no events involving bellows for pool or liner leakage issues.

We did do the boroscopic examinations in the years that you see there, most recently 2007. We do find that the sand drain lines are clear of obstruction and would allow us to identify any leakage into that region.

In 1999, we did our initial IWE examinations in the drywell. We did identify some minor degradation of that seal issue, that moisture barrier at the interface of the shell and drywell floor. We did -- go to the next slide, please -- upgrade that moisture barrier in 2001.

I, along with the senior resident

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inspector, as well as a regional inspector, I examined that seal barrier, and it's in good shape. There's no degradation of that new barrier.

Additionally, when we did our UT measurements of the region, we found there was full wall thickness and nominal wall thickness, no issues there in terms of generalized corrosion.

MEMBER SIEBER: You have no thickness measurements for the sandbed region because you can't get access to it.

MR. DREYFUSS: Jim.

MR. FITZPATRICK: Yes, that's correct.

MEMBER SIEBER: Okay.

MR. FITZPATRICK: We did --

MEMBER SIEBER: You never took the sand out.

MR. FITZPATRICK: No.

MEMBER SIEBER: We didn't feel you had to.

MR. FITZPATRICK: No.

MR. DREYFUSS: And again, we've adjusted our program to do periodic inspection with the boroscopic exams. The bottom line is the drywell shell, the history is well known, and we are maintaining it properly.

From a torus shell integrity monitoring

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standpoint -- next slide, please -- these photographs are from our most recent refuel outage. Although this area is accessible at all times, this depicts the general condition of that room. It's typical of what the room looks like.

We do maintain it well, and it is clean with good housekeeping.

Next slide.

This shows a bit of before and after. In 1998, we did the ECCS strainer, suction-strainer modifications. We also took that opportunity to desludge the torus, and in addition, we recoated the torus.

This does show some of the before and after shots here where we did do some reapplication of those coatings and shows you some of the work in progress and the after shots.

Next slide.

Again, this shows the SRVL lead pipe here and showing the newly coated downcomers, and again, we are maintaining the torus and internals well.

Next slide.

The interior coating that we again re-performed in 1998. It's a zinc primer. It has got a phenolic top coat that's Level 1 qualified coating

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that we put on. We did the wetted surfaces in conjunction with those Mark 1 program improvements that the industry did.

In 1998 we did this full recoating of the wetted surface. We took it down to bare metal and reapplied this qualified coating, and again, the zinc primer with the phenolic top coat at the water line.

Next slide.

In 1998, when we did the initial IWE exams, what we identified is that the condition is satisfactory. There is no generalized corrosion. We did identify some limited areas of localized corrosion. We did extensive UT measurements as a result to satisfy ourselves of the torus shell integrity.

We did the inspections there that you see, and --

CHAIRMAN SHACK: You saw spalling of the coatings or something at those locations? Is it coating failure or is it pin hole failures of the coating?

MR. DREYFUSS: Jim, you got a good look at that.

MR. FITZPATRICK: Basically coating failures, blistering of the paint. We were mapping

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those out prior to that point. There was a period of inspections from underwater, and we had areas to map out to look at the UT when we ran the torus and use those 15 areas.

MEMBER POWERS: Do you know why the paint was blistering?

MR. FITZPATRICK: Probably the way it was applied. It was the top coat that was blistering. The primer was in pretty good shape, and we did UTs to insure that there was no base metal loss.

MEMBER ARMIJO: So it wasn't blistering as a result of oxidation underneath it or corrosion underneath it?

MR. FITZPATRICK: I wouldn't know. We ended up blasting it off and cleaning it off.

MEMBER ARMIJO: Well, you would have seen things like pitting or surface rough --

MR. FITZPATRICK: In UT data we didn't see any pitting.

MEMBER ARMIJO: Yeah.

MR. FITZPATRICK: So if they were they were inconsequential.

MR. DREYFUSS: And it's important to note, too, that we've installed a grid system, and we do periodic reassessment of the torus shell thickness and

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do these routine measurements and are committed to doing that.

Conclusion.

Next slide.

The torus does fully satisfy all design requirements. We have not seen any measurable general corrosion compared from the 2007 and 1998 results. We're seeing no corrosion. The coating is working. That's the bottom line.

We do examinations through our IWE program to maintain the help, and we do, again, perform the periodic UT measurements of the torus shell at these locations.

So the torus has been coated. It has been maintained, and we are taking care of the torus and also looking for degradation as we go further into the extended renewal period.

MEMBER SIEBER: So what you're doing is just following the code and you'll follow the GALL report.

MR. DREYFUSS: That's correct.

MEMBER SIEBER: Nothing extra because nothing showed up.

MR. DREYFUSS: That's right.

Vernon hydroelectric station, this is our

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station blackout source. It's a unique feature that we have at Vermont Yankee. It's about half a mile from the plant. You can see the plant in the background. That's the hydro station up in the front, in the foreground. You can see the cooling towers in operation there.

Vernon hydro is 99.5 percent reliability over its lifetime. It was built in 1907.

Go to the next slide, please.

It has undergone a number of renovations over the years. Most recently, over the last couple of years it has undergone a major overhaul. A number of the turbines have been replaced. There's an uprate that's been done at the hydro itself that raised the output from 20 to about 32 megawatts, and they are taking good care of it.

The way that it's set up is we do have wheeling contracts that are established and procedures through the independent system operator and the sub ISO. The REMVEC is what they're called.

MEMBER CORRADINI: They're a separate operating company?

MR. DREYFUSS: They are. We do not own the Vernon damn. That's correct.

MEMBER SIEBER: And you rely on a system

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operator bringing in the service to support you.

MR. DREYFUSS: That's correct. We have contractual provisions with Green Mountain Power as well as the wheeling contracts and the ISO rules that dictate reestablishment and restoration of power to Vermont Yankee under blackout conditions.

MEMBER SIEBER: Have you tested this?

MR. DREYFUSS: We have. There's an annual test.

MEMBER SIEBER: How long does it take you to reestablish power or get power?

MR. DREYFUSS: Paul Johnson.

MR. JOHNSON: Hi. I am Paul Johnson from Design Engineering.

The cable is live to our 4 KV bus at all times, and if we had an event at Vermont Yankee, as long as the hydro station is on line, it's a matter of seconds before we can reestablish power.

If the hydro station tripped and came off line as a result of a large regional blackout, it takes about 30 minutes. Now, we've submitted --

MEMBER SIEBER: The hydro station is unmanned, right?

MR. JOHNSON: Right.

MEMBER SIEBER: So somebody has to go

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there from someplace?

MR. JOHNSON: When it's unmanned, they would have to get to the station, and there's a very simple procedure to restart, yes.

MEMBER SIEBER: Who does it?

MR. JOHNSON: Hydro station staff.

MEMBER SIEBER: And what's the maximum amount of time you could wait before you got the power if 30 minutes is --

MR. JOHNSON: WE have an analysis. I believe it says two hours, John?

MR. DREYFUSS: We have a two hour coping analysis.

MEMBER STETKAR: It said the hydro station is currently rated 32 megawatts. What kind of provisions do you have if the hydro station is putting out 32 megawatts and the rest of the grid is separated from it and you're trying to put 32 megawatts into your bus 4?

MEMBER SIEBER: You can control that.

MR. JOHNSON: If the hydro station were --

MEMBER STETKAR: They run back pretty slowly though. I know of another plant who has had real problems with this. It's not in the U.S..

MR. JOHNSON: There are 12 units, and

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essentially all you need is one unit.

MEMBER STETKAR: All you need is one, but suppose all 12 units are on line and what you depict on this slide, the Vernon town load is separated, and now you're generating 12 units of capacity into Vermont Yankee.

MEMBER SIEBER: You can trip that.

MEMBER STETKAR: You have to trip?

MR. JOHNSON: They would only restart one unit. If the entire hydro station loses power and all units would shut down, in the restart procedure they would only restart one unit.

MEMBER STETKAR: Okay.

MEMBER MAYNARD: And you have priority for the power from that if needed?

MR. DREYFUSS: Yes. That is true.

VICE CHAIRMAN BONACA: All right. I think you can move on.

MR. DREYFUSS: That's effectively it for the Vernon hydro station. It has been around a long time. It has been upgraded and has some additional redundancy as a result of those modifications that were done that help us in terms of being assured that we have a reliable station blackout source.

The one thing I did want to come back to,

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Dr. Bonaca, Dr. Shack, I know we talked about it, but I just wanted to reiterate relative to the environmentally assisted fatigue, we are satisfied that both the initial analysis and the confirmatory analysis are satisfactory. We do show our CUFs are less than one in both cases, and that we have conservatively addressed the effects of chemistry as well.

VICE CHAIRMAN BONACA: And we will discuss this next month, provided that we get the final SER, and I have an expectation that we will do that.

MR. DREYFUSS: That concludes our presentation, pending any questions that you may have.

MEMBER ARMIJO: Just a clarification. This picture may help me. Which are the cells that -- the cooling tower cells? That picture shows two rows of cooling towers.

MR. DREYFUSS: This is Tower 2. This is Tower 1.

MEMBER ARMIJO: Okay.

MR. DREYFUSS: This is Cell 2-1, is the safety cell. Cell 2-2 is seismic. Cell 2-4 is the one actually on the east side where we had that partial collapse.

MEMBER ARMIJO: Okay. That's all I wanted

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to know.

VICE CHAIRMAN BONACA: Well, thank you for the presentation, and we will move now to the staff.

MR. DREYFUSS: Thank you.

DR. KUO: As I said, Jon Rowley is going to lead the staff presentation. We also have Region 1 staff here to brief the Committee on the inspection that they did have done and some performance indicators there that he is going to show, and we will have a number of the tech staffs here that will answer any questions you may have.

MR. ROWLEY: Good morning. As Dr. Kuo has mentioned, I'm Jonathan Rowley, the project manager for Vermont Yankee license renewal application, along with Kenneth Chang to my right and Mr. Michael Modes to my far right, will discuss the safety evaluation report for Vermont Yankee.

I'll begin by providing an overview of where we stood at the time of the ACRS subcommittee meeting in June of 2007 and an overview of the major modification to the review over the past eight months.

Mr. Modes will discuss the license renewal application and then myself and Mr. Chang will discuss the results so far of Sections 2 through 4.

At the time of the June 2007 Subcommittee

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meeting, there was 386 audit questions that were asked during our five audits that we had performed at that time. There were 85 REIs, the safety evaluation report with confirmatory items was issued in March 30th, 2007. As B.Y. had mentioned, there were zero open items, six confirmatory items, and at that time we also had three license conditions that we were going to apply.

Subsequent to the Subcommittee meeting, we had a resolution of those six confirmatory items. We had an additional audit which we asked six additional questions to bring the total up to 392. We asked three new REIs, which brought the total up to 87, and we have one unresolved item, and that is the adequacy of the environmental fatigue calculations, which we'll discuss a little bit here and continue on in our March meeting.

At this time I'd like to ask Mr. Modes to discuss Region 1 inspection.

MR. MODES: Yes. Michael Modes. I'm the Region 1 senior reactor inspector and inspection team lead for VY.

Next slide.

We did a two week on-site inspection initially, dedicating one inspector a week to the

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subject matter of 542(a), which is the non-safety effect safety. We reviewed 19 aging management programs using 12 inspector weeks. It was quite a large team, quite an extensive inspection, and we reserved one week of inspection for the beginning of the outage specifically since we hadn't been in containment in regard to aging management for some time. We wanted to take a confirmatory inspection of the internal base seal since it was renovated.

We had seen problems prior to this at other utilities when we got in there.

We also wanted a confirmatory inspection of the drywell condition, being somewhat skeptical about the glowing reports we were getting, and we did a follow-up on the torus ultrasonic testing as well.

So we did note some weaknesses, areas of improvement. They discussed the turbine building scoping analysis, which was missed for the non-safety effect, safety components. That was in regard to a walk-down the one inspector week.

We did note that the containment management had an inconsistent monitoring program at that time. They had pretty much resolved in their own mind that none of this applied and, therefore, they really needed to do less than we thought maybe they

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should. So it was really just an area that needed some improvement.

And we also noted that the firewater system lacked a corrosion monitoring biofouling management system. Those were the highlights of the inspection.

MEMBER ARMIJO: Do you mean completely missing?

MR. MODES: Completely what?

MEMBER ARMIJO: There was no corrosion management and biofouling management in their firewater?

MR. MODES: It appeared to be missing, yes.

So at the conclusion of all three weeks of inspection, we concluded the screening and scoping of non-safety related systems, structures and components was implemented as required by the rule after they rolled in the turbine stuff, and the aging management portions of the license rule were conducted as described in the application.

Any questions?

(No response.)

MR. ROWLEY: Thank you, Mike.

Section 2 of the application is titled

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"Structures and Components Subject to Aging Management Review." The only major concerns are raised in Section 2.3, which is scoping and screening results of the mechanical system. So for the sake of time I'll only discuss Section 2.3 here today.

As we mentioned there were six confirmatory items at the time of the ACRS Subcommittee meeting. We did discuss two of those confirmatory items at that meeting. So today I'll discuss the resolution of the remaining four.

The first one was revocation of component system subject to the AMR in the circ water system. The resolution was that any non-safety related portions of the circ water system in the building containing safety related components was put in the scope. Additional components were added to the LRA due to special impact in the turbine building, as discussed earlier.

Similar for the reactor water clean-up system that was put into scope as well, but there were no additional components added to the LRA. It was already there. They just showed us where it was located.

The third confirmatory item was also surface water system related. We on the drawing

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couldn't determine where a piping section was. So we had Mr. Modes and his team go out and look for us and determined that that portion of the piping was located in the reactor building, and it was in scope for a potential spatial interaction with safety related system.

The fourth confirmatory item related to the equivalent anchor seismic of the service water system, and again, all non-safety related portions of the service water systems that were attached to the safety rated systems were included up to the first or equivalent anchor. That was determined by our regional team as well, and the district components were added to the license new application due to impact of -- the special impact on the turbine building.

To recap the scope of related events that led up to the lay of the ACRS full Committee meeting until today was really scheduled for September. VY, as I already mentioned, there was three major issues. I'll cover those quickly as well.

The first one was scoping of the turbine building. Regional inspection found there were deficiencies. The resolution was that a lot of the components in the turbine building were added to the

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scope that they revised. The summary of aging management evaluation tables, they added or deleted from those existing tables. They also added or revised components subject to the AMR tables and deleted from those tables as well.

Cooling towers, they mentioned on August 21st, 2007. It was a partial collapse of cooling tower number two, cell number four, which is B, beta, C-2 -- CT 2-4.

On August 29th, we asked an RAI to verify that that component or that structure was adequately in scope, and our resolution was that, yes, the scoping was done adequately, and the LRA cooling towers 2-1, 2-2 and air cooling tower 2-D basin were in scope for 10 CFR 54(a).

That's still the case. There are other remaining cells that did not meet the criteria of 10 CFR 54.4(a).

Conclusion for Section 2 was that the scope of the screening methodology was consistent with the requirement for 10 CFR 54.4(a) and 54.21(a)(1), and the systems, structures and components within the scope of license renewal subject to AMR are consistent with the requirements of those same regulations.

Section 3. VY had mentioned there were 39

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AMP, ten of which are new, 29 that were existing, and of those programs 21 had exceptions and/or enhancements.

So based on review of the AMRs, AMPs, the staff concludes that applicant had demonstrated effects of aging will be adequately managed such that the systems and components will serve their intended function during the period of extended operation.

Okay. Sorry for going through that so fast, but because of time and the EAF issue. I wanted to get that just in case we needed more time to discuss that, as well as have our people make their comments.

Section 4, the major area of concern was metal fatigue, and that delayed the SER so to this point as well.

For TLAAs, the regulations require that applicant must comply with either 10 CFR 54.21(c)(1)(i), (ii), or (iii). Initially, Vermont Yankee had attempted to comply with this regulation by having a commitment. The commitment was revisited by or the issue was revised by OGC. The regulation wasn't. I'm sorry, and OGC, our Office of Inspector General or General Counsel determined that a commitment couldn't be used to satisfy this

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regulation.

So, therefore, VY revised the LRA to comply with 54.21(c)(1)(iii) in a letter dated September 27th. They decided to come in and use their fatigue monitoring program. Initially their fatigue monitoring program contained exceptions or enhancements. They removed those exceptions or enhancements to make it consistent with our GALL report XRM-1 (phonetic), which is the metal fatigue reactor coolant pressure boundary.

One of those elements of that program allows for reanalysis of components that demonstrate that their limits will not be exceeded during the period of center operation. So in that same letter VY transmitted their results to us of the reanalysis.

CHAIRMAN SHACK: This is a generic problem, too, right? I mean this OGC decision. You've accepted other commitments to do this similar to as VY had proposed before, right?

MR. ROWLEY: Yes, we had.

DR. KUO: Yes, Dr. Shack. This may have some generic implication, and we are looking to them going to take care of it.

MR. ROWLEY: Okay. With this submittal of those re-analysis, as we do with all analysis that are

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in the application, we perform an audit. So on October the 9th and 10th, we went to the site to review their calculations.

We asked six questions during that audit, and you can see the full response on November the 14th. One of those responses to audit question 387 did not fit our needs. So we sent and REI to them further address the issue on November 27th.

We received that response on December 11th, the response to the RAI on December 11th. We've had a few calls to discuss this issue. The major one was on December 18th. At that time VY sent some disconnect there and requested a face-to-face meeting to help facilitate the resolution of this highly technical issue.

So we had a meeting on January 8th. At that time the applicant agreed to submit some plans specific, confirmatory comments to the analysis, and that's where we stand today.

MEMBER ARMIJO: And that submittal has been made now?

MR. ROWLEY: That submittal was made. That was made on January 30th, which was just a few days ago. So we've had a preliminary review of what they submitted, and I'd like Dr. Chang to take over

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here to discuss that.

DR. CHANG: Thank you.

My name is Ken Chang. I'm the Branch Chief for Engineering Review Branch at the Division of License Renewal.

I've been involved in every audit, every conference call. Every year I have public meetings on this. So I hope I can address this issue today in a satisfactory manner, but in the March meeting will be in a complete manner.

The plant specific confirmatory EF analysis is by definition the confirmatory year analysis. It is not the EAF analysis. The EAF analysis was submitted, was contained in the december 11th submittal.

The confirmatory analysis, the purpose of that is to use the typical ASME methodology without any fancy tools or anything to do the analysis to show that the December 11 analysis is conservative. So, therefore, we are result driven. As long as the CUF is less than 1.0 by a classical ASME analysis, even you say state of art analysis, that should be okay.

And we have enough time to perform the review of their benchmarking calculation. Specifically for Vermont Yankee, we are not endorsing

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anything beyond Vermont Yankee from that review. That is such a big, broad subject. It cannot be achieved in such a short time.

Now, our point of review is to see using the same assumptions but the right methodology without any fancy tools, would the December 11 analysis sustain the conclusion?

As the previous axisymmetric finite element model, the same model was used, and this time strictly the ASME 3200 methodology was applied. We used the same transient definition. I don't mean "we." Sorry. The applicant used the same transient definition and cycles, and they overcome one of our major objections, say, 1(d) versus stress. This time they use all stress components, calculate the stress intensity, the principal stress, and stress intensity based on ASME definitions.

In doing this analysis, we say only based on the industrial acceptable computer code that everybody else is using. So we are on the same level. ANSYS code, computer code, was used.

And the methodology is SME elastic-plastic analysis. Basically it's elastic analysis, and as the applicant stated earlier, the effect of plasticity is included in the ASME methodology by a turn called  $K_e$ ,

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plastic correction factors. The  $K_e$  for the standard steel could go up to 3.333, to be precise.

The same water chemistry input was used. What do I mean by that? There is no change of water chemistry input, but it doesn't mean the  $F_{en}$  will be the same. The  $F_{en}$ , the correction factor, environmental correction factor for the CUF is based on transient path. Each transient path, maximum and minimum, become a range. Each range is associated  $F_{en}$  factor. Naturally, you can create, you can generate a huge  $F_{en}$  factor to bound the whole  $F_{ens}$ , but that's not really appropriate. That would just be super conservative.

So in this confirmatory analysis, they use the  $F_{en}$  in the transient path sense. Combination one,  $F_{en}$  equals one match (phonetic), say X. Compare number two, Y, Z, those kind of things. So it's really appropriate.

The stress intensities corrected for modulus elasticity, E values. The ASME curve is based on certain assumed E values. If your E value for your component, for your analysis different from that, you need to make a correction by the E value, by the ratio of the E values before you go into the fatigue curve to get your allowable cycles.

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Next. That's it?

Okay. The plan specific confirmatory analysis, why is the feedwater nozzle bounding? Because the feedwater nozzle is more transient. Feedwater nozzle has more cycles for transients, and feedwater nozzle experiences more severe transients.

In the previous analysis performed by applicants out of the three nozzles which do not have axisymmetric, the feedwater nozzle, the CUF is only on the order of five to ten times compared to the other nozzles. And also if you notice that these three nozzles, although the geometry is different, they are similar.

Why is different? Because it's one nozzle. The inside surface of the nozzle is skewed. It's not straight. So from review, we did raise the question how do you say this feedwater nozzle is bounding. The applicant provided a response yesterday morning. We have the pleasure of looking at it.

In a nutshell, why the geometry is bounding? Why the skewed is covered by the straight nozzle? One is there is a BWR VIP-108 that's endorsed by the NRC. In that BWR VIP the 3D model, actual 3D model was used to calculate the nozzle corner pressure stress. So that is covered, and the results are not

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much different.

Secondly, for the similar transient, I think we have mentioned several times the similar transient is the axisymmetric model in loading for the BWRs. So, therefore, although it's skewed, the 2D axisymmetric model can generate exact geometry. So there shouldn't be any concern of using the feedwater nozzle to bound the three cases.

And the Fen calculation we have mentioned already. They use bounding value for each trending path, and the detailed calculation, we didn't have time to review it, but the philosophy is right. So on that basis and also on the basis that the fatigue monitoring program will verify that the transient actually occurred is less than -- the transient cycle that actually occurred is less than the transient cycles that has been analyzed. That gives us assurance that if analysis is correct, the fatigue monitoring program is functioning. And that's commitment number five.

And commitment number 27 applied to the trending fatigue monitoring program removed all the exceptions. So now the plan people, as well as we at NRC, we know that the fatigue monitoring program well monitored in addition to the traditional fatigue will

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also monitor the environmental assess of fatigue.

And that's where we are.

MR. ROWLEY: Our Section 4 review is ongoing. As Ken said, they just yesterday provided some additional information about the nozzle configuration differences, and then some additional information regarding the chemistry impact of the Fen value. Staff's review of Section 4 is thus incomplete, and we will have this completed over the coming weeks in order to discuss this in our March meeting.

Here are the three license conditions that we applied thus far.

Questions?

VICE CHAIRMAN BONACA: Questions for the staff?

Nothing. Thank you for the presentation, and I think we have three members of the public who want to speak. Do you have a list of those?

CHAIRMAN SHACK: Yes.

MEMBER ARMIJO: Just before, I have one quick question for Mr. Modes. He mentioned about glowing reports about the drywell and torus shells.

MR. MODES: Yes.

MEMBER ARMIJO: Did you find that those

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were exaggerations or were those components in good shape?

MR. MODES: Yeah. No, it's in good shape. Yes, it is.

MEMBER ARMIJO: Thank you

MR. MODES: It is, but it's my job to be skeptical.

MEMBER ARMIJO: Yes, and I appreciate that.

PARTICIPANT: We gathered that.

VICE CHAIRMAN BONACA: Okay. First of all, Ms. Hoffman.

MS. HOFFMAN: Thank you very much, Dr. Shack, Dr. Bonaca, and all of the Advisory Committee.

I'm Sarah Hoffman. I'm the Director for Public Advocacy from the Department of Public Service in Vermont. My job has been made much easier today. I actually was coming down here to ask you to not finish your review today because we are aware that many of the answers were coming in right before this meeting, and I knew the RAIs last had come in January 30th and that some information had come in yesterday.

So thank you so very much for delaying your complete review.

This is important to the State of Vermont.

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We actually feel that when we came down here a couple of years ago to talk about containment overpressure that we were really heard by this Committee. The depth and breadth of your probing questions was absolutely exactly what we were looking for and really appreciated. We think you're a very smart group of men, and I notice two years later you're still a very smart group of men.

(Laughter.)

PARTICIPANT: Only older.

MEMBER POWERS: Flattery will get you anywhere you want to go.

MS. HOFFMAN: And we would like obviously to have you have the benefit of the final SER, and it sounds like you're in total agreement with that. So I really have to say my job is very easy today. I understand how much information you really have to go through probably to prepare for these meetings, and we want to make sure both the NRC staff, who we appreciate their work as well, and you don't feel pressured.

The Atomic Safety and Licensing Board hearings aren't set until July in this case. So at this point we are just asking that there's no rush to judgment, and it sounds like you're already in

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agreement with that. So we thank you for taking a real clear look at the issues that are presented by the Vermont Yankee relicensing, and just the State of Vermont appreciates it and will continue to watch what's happening at this level.

So thank you very much.

VICE CHAIRMAN BONACA: And next one is Mr. Hopenfeld.

MR. HOPENFELD: Good morning. Thank you very much for giving me the opportunity say a few words.

I am acting -- can you hear me okay? -- I'm acting as a consultant to the New England Coalition, and I would like very --

PARTICIPANT: Excuse me. Could you identify yourself?

MR. HOPENFELD: Yes. My name is Jerald Hopenfeld. I'm acting as a consultant to the New England Coalition in connection with their litigation of the life extension at Vermont Yankee.

I'd like to make a few comments and leave you with this.

Entergy made numerous assumptions in connection with their fatigue and corrosion analysis, as well as stream dryer monitoring. These assumptions

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have significant impact on plant safety because they affect how aging will be managed.

I strongly urge you as a minimum to examine the validity of the following assumptions before you write your final report.

With regard to the fatigue analysis, first, the heat transfer coefficients, which were used for the various transients are not applicable for the nozzle geometries and the specified flow rates. The CUF results are very sensitive to the heat transfer coefficients.

Two, the environmental correction factors are based on ten years or and relatively few data points. A more comprehensive, recent database has been ignored. The new data indicates a much shorter fatigue life of selected components.

Three, no justification has been provided by Entergy for assumptions that the number of transients would increase linearly with time. The number of oxygen incursions in the plant during the extended period of plant operation was assumed to be zero, and I would remind you that the correction factor, the environmental correction factor depends exponentially on the oxygen content as well as the temperature.

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Five, the oxygen at the surface of the component was assumed to be the same as the measured oxygen at some other location and at some other time.

The use of Green function show that the CUFs are very sensitive to the geometry. Nevertheless, Entergy assumed that the design geometry was the same as the installed geometry or S-mount geometry. Now, when you design a component, it's not necessarily what you find after the component was installed. There's plenty experience to indicate that effect.

Because of complexity in geometry and loadings, sheer stresses have been neglected and the assumption of axisymmetry for the feedwater nozzle has been invoked.

Number eight, the effect of feedwater nozzle fatigue due to different in thermal expansion and diffusivity between the clad and the base metal can be neglected when using the Green function methodology. This is purely an assumption.

With regard to the flow accelerate corrosion, Entergy assumed that only several years would be required following the power uprate to benchmark the computer code CheckWorks and, therefore, determined the magnitude of frequency and tight wall

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(phonetic) inspections.

Corrosion is a slow process, and the rate is not necessarily constant. The fact that the last two inspections indicate that no appreciable increase to the extent that the number of components have been examined is not really sufficient to indicate that the code has been benchmarked.

With regard to seam dryer inspection, in spite of continuous crack formation on surface of the dryer, Entergy assumed that all acoustic instrumentation can be removed, and it will be sufficient to rely only on visual in service inspection of the dryer and level changes in the water.

Entergy -- and this is the most important aspect of that problem -- operates the dryer without knowing what the actual loads on the dryers are.

My general comments really come following the presentation this morning where I saw that Entergy provided some values on a CUF indicating they believe that the accuracy of that value is within four decimal points. It's almost funny. If you look at the ANL data on this subject and if you considered the number of parameters that have been neglected in generating the data on the Fens, like velocity effect, surface

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roughness, and I can just keep on going on and on; the uncertainty of that Fen is within three orders of magnitude, but you are being asked to believe that the CUF is within the accuracy of .6195 or whatever it is.

Take a look at the ANL data, at the recent data. You might as well look at the previous data that was generated ten years ago. That's the one that Entergy is using. They completely ignored the new data.

With this I'll just again urge you please consider these comments. Look at these assumptions very critically before you decide that everything is okay.

Thank you.

VICE CHAIRMAN BONACA: May I ask a question?

MR. HOPENFELD: Yes, sir.

VICE CHAIRMAN BONACA: Have you provided those comments to the staff?

MR. HOPENFELD: No. I have provided some comments following the last meeting. I haven't received any response on that. That one was in connection with the heat transfer coefficients, which are not really applicable at all, and the other relates to the uncertainty. I don't know what the

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uncertainty is, but there's no certification as to what geometry they are looking at.

I mean, if you'll look, I don't know whether they have or have no replaced the thermal light, but some have replaced the thermal light, but I don't know whether they did or did not. But I would like to see when they indicate that there's extreme sensitivity to the geometry as to what geometry they are talking about.

What we are interested in is that the geometry is going to be there on Friday, 2012, not when the geometry was in somebody's office and was designed.

I go back on my experience, and I can tell you time and time again what you design is not what you find there, specially if there are modifications during the plan. I don't know if there were or there were not. Entergy has refused to provide us that information.

So I might as well -- I don't know if I'm answering your question, sir.

VICE CHAIRMAN BONACA: Okay. Thank you.

And we also have a request by Mr. Lockbaum.

He is not here now. I think we're pretty

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much done. The question I have: is there any question for the staff here? Any questions for Mr. Hopenfeld from members?

MEMBER ARMIJO: I'd like to ask with respect to the last presenter's comments about new data. Is the staff familiar with -- no, I'm asking the staff if they're aware of the new data that you referred to

MR. FAIR: Hi. I'm John Fair with Division of Engineering who did a lot of the reviews on environmental fatigue.

Yes, we are. The new data is the latest Argonne data that was being applied in new design certifications. Basically the criteria they're using ins license renewal was criteria that was developed quite a while back, and we made a decision at that time that we would, as criteria, we would maintain that criteria because there were a lot of applications in process. So we didn't want to keep changing the rules as these people were putting in new applications. And a lot of the criteria had changed and was massaged over the years.

Actually if you go back and look at the latest criteria we're applying to new reactors, it's not as conservative as the old criteria because we

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changed the basis for deriving the curves. So if you go and look at the Fen factors themselves using the new criteria, they'll generally be lower.

MEMBER ARMIJO: Okay. Thank you.

VICE CHAIRMAN BONACA: Any other questions?

If not, Mr. Chairman, I'll turn the meeting back to you.

CHAIRMAN SHACK: Okay. Well, it's five minutes late. I'd like to take a break now. I thank the presenters, staff and the industry, for a good presentation, I think, very informative and Mr. Hopenfeld for his comments.

We're slated for 15 minutes. So we'll be back at ten of.

(Whereupon, the foregoing matter went off the record at 10:35 a.m. and went back on the record at 10:55 a.m.)

CHAIRMAN SHACK: The next topic is a draft final Revision 1 to Regulatory Guide 1.45, "Guidance on Monitoring and Responding to Reactor Coolant System Leakage, and, Sam, I think you're going to take us through that.

MEMBER ARMIJO: Right. Thank you, Mr. Chairman.

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Reg. Guide 1.45, the current reg. guide, was issued in 1973. So it's --

CHAIRMAN SHACK: An oldie but goodie.

MEMBER ARMIJO: It's been around a long time. The revision, which is going to be presented by the staff today, is a complete rewrite for all practical purposes, and with a much broader scope.

One of the things that we'll talk about, that at least I would like to hear in the presentation, is the logic of applying the new, improved reg. guide only to new plants, where the real issue is to operating plants.

But with that opening, I'd like to turn it over to the presenters, Dr. Srinivasan and back-up with Chang Li of the staff.

MEMBER BANERJEE: Is there a reason why it's stapled?

MEMBER ARMIJO: I don't -- that's another --

(Laughter.)

MEMBER ARMIJO: That's another mystery.

MEMBER CORRADINI: It is just easier for left-handed people.

MEMBER ARMIJO: Well, I'm going to unstaple it, but please go ahead.

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MR. SRINIVASAN: Good morning, gentlemen.

I'm Srisni Srinivasan. I'm a senior materials engineer in the Office of Nuclear Regulatory Research.

This morning, together with Chang Li on my right-hand side of New Reactors Office, I will present technical information on the staff efforts to update the Regulatory Guide 1.45 on reactor coolant pressure boundary leakage systems.

Ken Karwoski, who is the co-author of this presentation and a member of the working group which worked on this revision, is in Boston at the ASME code meetings.

Since the wording of the publication in 1973, the current revision is the first. One of the major changes is to include guidance on managing reactor coolant leakage and plant response based on an assessment of the safety significance of the leakage.

To reflect this change, the revision also includes a title change. The title for the revised guide is "Guidance on Monitoring and Responding to Reactor Coolant System Leakage."

In this representation, first I will provide background information on technical issues that led to the revision of Reg. Guide 1.45. Responding to the vessel head corrosion at Davis Besse

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Nuclear Power Plant in February 2002 and other operating experience related to coolant leakage and boric acid corrosion, the staff conducted research to better understand the implications and addresses the need for updating guidance on leakage monitoring.

I will briefly summarize the safety significance of managing coolant leakage and provide information on some of the technical factors that were considered for revisions to Reg. Guide 1.45. I will then summarize the staff regulatory positions in the device guide.

The draft guidance DG-1173 was sent for public comment during June of last year. A total of ten industry comments were received. I will conclude this presentation by providing a summary of how we address these comments in the final revision.

The primary impetus to revisit leakage monitoring requirements are those from the discovery of a cavity in the Davis Besse Nuclear Power Station vessel head. Approximately 75 pounds of metal was lost due to corrosion in the vessel head. In responding to Davis Besse lessons learned task force recommendations, we evaluated two specific recommendations related to reactor coolant leakage monitoring.

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One recommendation addressed the ability to discriminate the unidentified leakage from identified leakage and then show that the plant operates at power with no pressure boundary leakage.

The other recommendation was related to insuring the structural integrity and reliability of critical prime components by monitoring leakage from these sources at levels significantly below one gpm, gallon per minute.

To understand the current status of leakage monitoring, we conducted research at Argonne National Laboratory. The original project manager for this research was Tanny Santos from whom I inherited the subsequent responsibilities.

(Laughter.)

MR. SRINIVASAN: Dr. Dave Copperman (phonetic) was the lead investigator, along with Dr. Bill Shack and others --

CHAIRMAN SHACK: Oh, no.

MEMBER ARMIJO: This was going good until then.

(Laughter.)

MR. SRINIVASAN: That report was in the form of a new SER that was issued in November 2004.

MEMBER APOSTOLAKIS: Whose idea was it to

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staple the thing this way?

(Laughter.)

MR. SRINIVASAN: The relevant conclusions from this report are that, one, the leakage monitoring can be improved. Lower levels of leakage at localized areas could be detected by modern techniques. Such monitoring may provide the opportunity for corrective actions to be taken early, thus avoiding boric acid corrosion.

Leakage limits will not insure structural integrity of all components in the reactor cooling system. Leakage rates less than the technical specification limit can result in high corrosion rates depending on the actual conditions associated with the leak. For example, the temperature of the metal, leakage rate resultant of boric acid solution and the availability of oxygen.

Lowering the technical specification leakage limits may increase the number of plants down inspections (phonetic) and personal exposure.

Reductions in the coolant activity over the years has limited the usefulness of the gaseous reactivity monitoring systems.

A working group consisting of NRR and research staff evaluated the task force

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recommendations assessing the conclusions from ANL research and the regulatory activities then underway to address the vessel head corrosion at Davis Besse.

The staff review recommended that, firstly, the massive corrosion on the vessel head was a unique occurrence which was not found in other plants.

MEMBER POWERS: I am perplexed by the statement here on the viewgraph. It says, "With the exception of the Davis Besse corrosion vessel head at other plants, if any, has not been significant."

That perplexes me a bit. Did we not have cracking induced by stress corrosion cracking at Oconee?

MR. SRINIVASAN: Right. We did.

MEMBER POWERS: Okay.

CHAIRMAN SHACK: But I think he's inferring the corrosion --

MR. SRINIVASAN: The corrosion.

MEMBER POWERS: It's not what it says, and --

CHAIRMAN SHACK: Well, that's the vessel head.

MEMBER POWERS: Let me go on.

CHAIRMAN SHACK: Cracking in the CRDM is

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not --

MEMBER POWERS: It seems to me to be part of the head.

MEMBER ARMIJO: I think the intention was sever secondary damage to the vessel head itself as a result of the fracture.

MEMBER POWERS: Then it doesn't seem to me that the statement is very useful because that's a consequence of the initial corrosion phenomenon.

I'm just not sure what you're driving at here. Are you saying this is a "no, never mind. Only Davis Besse is important in this regard," given at Davis Besse and we don't have to worry about corrosion?

I just don't know where you're going here.

MR. SRINIVASAN: No. Okay. Like significant amounts of metal and things, the corrosion, significant corrosion occurred at Davis Besse. The other issues that have been periodic or not periodic, as the events occurred and things, we have responses in the form of actions and so on continuing since 1988 at other places also.

The Oconee incidence was also a technical basis for driving this revision to this reg. guide. Corrosion per se was a -- corrosion by itself, I mean,

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massive corrosion at Davis Besse, in addition to the cracking of CRDM, is an issue. What we are saying is that similar kind of massive corrosion was not found in other places. That's what the bullet was intended to say.

MEMBER ARMIJO: Okay. Let's just move on.

MEMBER POWERS: So what you're saying is that wastage corrosion wasn't observed at other plants as a matter of luck.

MR. SRINIVASAN: As a matter of what, sir?

MEMBER POWERS: Good fortune.

MEMBER ARMIJO: We're fortunate that it didn't happen to that extent.

CHAIRMAN SHACK: You could interpret it to mean that Oconee got nervous when they saw an aspirin size table of boric acid on their head, whereas at Davis Besse the presence of --

MEMBER ARMIJO: Truckloads.

CHAIRMAN SHACK: -- a ton of the stuff didn't seem to spur any action.

MEMBER SIEBER: They need glasses.

MEMBER POWERS: Presumably, a factual statement. I'm still not sure what the point is here. I'm just totally perplexed by the statement, and it seems to be the most cavalier thing to say, "Oh, well,

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Davis Besse was the only one. So let's not worry about things."

MEMBER BANERJEE: Well, actually that's not it. You know, this whole reg. guide revision, one of the major drivers is the Davis Besse. So they are worried about it. The statement doesn't really introduce --

MR. SRINIVASAN: That statement is probably not necessary.

PARTICIPANT: Take it out.

MEMBER MAYNARD: First of all, I believe this reg. guide overall is good. We can discuss some things and everything. I think that some of the reasons that are being given aren't really beneficial.

First of all, I don't think Davis Besse should have been the real -- I think there's other items out there that cause need for this. Davis Besse, I'm not sure what you might have had in place in the way of rules and requirements. I mean, if people -- I think they had enough indication and stuff and rules. I don't think Davis Besse is really a good reason for this.

I think the fact that we've had some cracks and we've had some issues with reactor coolant and pressure boundary, I think, in itself is the

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reason that we need to be taking a look at some of this.

MEMBER ARMIJO: Yeah. I think there's also an NRR user need document that came out. I don't know if it was a result of Davis Besse or was before Davis Besse, but --

MR. SRINIVASAN: A combination of things really. Actually I think what happened was that the Davis Besse basically gave us move on (phonetic). Revision has been in the plan, in the works, but actually impact was --

MEMBER POWERS: I mean in some sense it seems to justify the third point here, which is also manifestly incorrect. It says the effectiveness of existing inspection and monitoring programs provide adequate protection. Obviously it did not in the case of Davis Besse.

VICE CHAIRMAN BONACA: Well, I think that they neglected a number of signs.

MEMBER POWERS: Then the program is obviously not effective if you can neglect a number of signs.

MEMBER SIEBER: There's so much margin in the requirements that the requirement says they existed, were not effective in halting that, but if

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you look at all of their plant data, I mean, including radiation atmosphere inside containment, their daily leak rate calculations, there's certainly evidence there that something was wrong.

MEMBER POWERS: And the monitoring program failed to respond to that either on the part of the licensee or on the part of the regulator.

MEMBER SIEBER: Because they had too much margin until --

MEMBER POWERS: We should have gone ahead and had a small break LOCA. Then it would have caught our attention at that point, I suppose.

MEMBER ARMIJO: Well, can we go ahead with the assumptions? There's plenty of justification for improving the reg. guide.

MEMBER POWERS: Well, you know, one can't help but wonder about the basis for improvement if you think that the existing program is adequate, which manifestly is not.

MR. SRINIVASAN: Well, I will go on to the next slide that will also be reinforcing and amplifying what we just discussed.

The operating experience has shown that leakage that occurs at very low rates compared to the plant technical specifications can still be a

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potential safety concern if such leakage occurs for a prolonged time.

Such type of leakage will contribute to corrosion also. This, in turn, could lower the structural integrity of the affected component which could have used a higher leakage rate in the calculations.

If the leaking coolant were to drip onto nearby components, this could result in the corrosion of those components and the fact there's structural integrity as well. Leakage can affect the sensitivity of other instruments or, if very high leaks occur, then they could mask the smaller leaks whose detrimental effects could not be observed earlier to prevent component damage.

Also, the radiation monitor subsystem drains of the RCS leakage detection systems will become unreliable because of fouling with boric acid and iron oxide particles. Prolonged leakage at very low leakage rates could result in the accumulation of boric acid in the containment and challenge the ability to maintain the pH of ECCS sump following a loss of coolant accident.

In addressing leakage monitoring, we decided to focus on these safety issues and concerns.

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Leakage monitoring is necessary for the application of the leak before break criteria and evaluation as per standard review plan 3.6.3.

The risk informed ECCS rulemaking also considers the effect of leakage monitoring.

MEMBER POWERS: Let me ask you. I am just getting totally lost. How in the world does the accumulation of boric acid anywhere affect the ability to maintain the ECCS sump pH?

MR. SRINIVASAN: Do you want to comment on that?

MR. LI: We tried to learn the boron accumulation in the sump when it goes into the recirculation phase. The boron, that concentration in the loop would -- could, when accumulation is large enough, it could affect such that goes beyond this recirculation boron limit within the tech spec. So normally the tech spec specifies a boron concentration limit when it takes from other VCU, but in the recirculation phase if a tremendous amount of boron accumulate in the sump, taking the water in recirculation, and that could affect the original boron limitations specified in the tech spec.

MEMBER POWERS: I'm going to be fascinated to see the pH calculation that says the amount here is

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affecting the pH.

MR. LI: And the pH aspects, I'm not familiar with it. I think --

MEMBER POWERS:

Well, somebody wrote the line down on the slide.

MEMBER STETKAR: Given the fact that you're injecting 2,000 parts per million boric acid in your injection or higher, I suspect you'd have to have quite a large accumulation of boric acid throughout the containment to have any measurable effect on the pH.

MEMBER SIEBER: This roomful.

MEMBER STETKAR: Yeah.

MEMBER POWERS: I mean, I'm sitting here doing the pH calculation in my head, and I can't get an effect. I can certainly get borate to precipitate out in the calculation in my head, but I can't get the pH to be affected.

Okay. Another mystery to add to the previous mysteries.

MR. SRINIVASAN: Information on this slide is crowded. I'll take you through this in the next couple of subsequent slides, but basically this illustrates the overall philosophy of managing RCS leakage and the approach taken by the staff in

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providing guidance for leakage monitoring and management of leakage to insure that component degradation will not result in potential safety degradation.

The overall approach has been based on concentrational data from analytical models of material degradation contributing to cracking and leakage, operational experience, assessment of safety significance of leaks, desired attributes of effective leakage detection and monitoring programs and performance based and progressive and proportional plant responses to managed leakage.

I will address the various elements in this slide in the next two slides.

Guidance for leakage monitoring and plant response to observe leakage can be obtained from a combination of information from material degradation on analytical models that predict pipe failure, correlating crack sizes to leakage rates, operational experience, and the capability of online leakage monitoring systems.

Reactor design and construction should include every effort to use materials and environments that limit the potential for degradation. During the operational life of a reactor plant, the reactor

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components could degrade through normal operational bath (phonetic), mechanical deterioration, corrosion and/or fatigue. This degradation can lead to the coolant leakage.

The limited amount of leakage inside containment may occur from reactor coolant system that plants cannot practically render 100 percent leak tight. The safety significance of leakage from RCS can vary widely depending on the source of leakage, as well as the leakage rate and duration. Operating experience and research have indicated that very low levels of leakage could cost or indicate material degradation arising, for example, as a result of boric acid corrosion, primary water stress corrosion cracking and intergranular stress corrosion cracking.

Such forms of degradation could potentially compromise the integrity of the system leading to a loss of coolant accident.

The effective methods of monitoring including detecting of any leakage and locating its source are important because leakage may indicate that a component no longer has adequate structural integrity. Cost degradation or corrosion of a component other than the leaking component as a result of the interaction between the leaking coolant and the

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other component indicate that there is accumulation of chemical compounds that could invalidate radiant design assumptions, contaminate roof surfaces, and affect the capability of other instruments, including leakage monitoring instruments or components.

Prompt corrective action requires continuous online monitoring for leakage. Various instruments and methods are available for monitoring RCS leakage. The capabilities of these instruments and methods differ in terms of their response time, sensitivity and accuracy.

In addition, some instruments and methods continuously monitor for leakage while others are for periodic use only. An effective leakage monitoring strategy will include a combination of leakage monitoring instruments and methods.

The revised guide provides guidance provides guidance on requirements for leakage detection systems as well as plant response to observe leakage in a flexible performance based approach. To minimize the probability of rapidly propagating failure and rupture of the reactor coolant pressure boundary attributable to material degradation, plants should keep the leak pH level that is as low as practical and take prompt action in responding to

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leakage to limit the safety consequences.

Leakage monitoring systems must be able to detect the degradation of the pressure boundary to limit the potential for gross failure of the pressure boundary. Some flaws might develop and penetrate the pressure boundary wall, exhibit very slow crack growth, and afford sufficient time for a safe and orderly ratchet down (phonetic) after detection of a leak.

Nonetheless, quickly growing flaws leading to larger leakage rates may require more rapid detection, more frequent monitoring and more urgent corrective action based on safety significance.

In addition to monitoring for leakage, it is important to quantify the reactor coolant leakage and locate its source to assess its safety significance. Detecting and effectively responding to leakage as early as possible provides defense in depth for the integrity of the pressure boundary.

Plants should analyze the general trend in the unidentified and identified leakage rate well below the technical specification limits. To insure timely response to leakage, plants should establish a step-wise approach with actual levels for responding to leakage. Procedures should establish time limits

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for continued plant operations with an unidentified leakage source because it may be impossible to determine the safety significant of the leakage without knowing its source.

During the revision of this reg. guide --

MEMBER APOSTOLAKIS: So let me understand this.

MR. SRINIVASAN: Yes.

MEMBER APOSTOLAKIS: Why is this performance based?

MR. SRINIVASAN: Basically below the technical specification limit the plants will be trending leakage, the unidentified leakage as they observed with respect to the baseline, and on observing an adverse trend, for example, then depending on the amount of the unidentified leakage increase, if you will, from the baseline, you take progressive actions really, and that's what it is. It's performance.

There is no unidentified leakage observance and things in the plan is behaving as it should, as expected and things, and then there is no need for a prompt corrective action. So basically it's just not deterministic. You know, your value that is there, you don'[t worry until the technical

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specification limit, but before it's over you start giving performance based.

MEMBER ARMIJO: But for the same leak in a BWR and a PWR, the same leak rate from roughly the same component, you would take two different actions, and each plant has to come up with that action plan and get that reviewed by the staff.

MR. SRINIVASAN: That's correct.

MEMBER BLEY: Just back on one of your first slides you listed reasons why you had to do this and things to worry about, and one of the reasons was when activities have gone down to rad monitors don't work as well. I don't know how extensively true that is, but you also had a note that lowering the tech spec limits may increase the number of plants shut down and exposure.

What kind of analysis did you do of the effective shutting down a plant, putting a thermal cycle on it as far as going down to fix a very small leak? Every thermal cycle tends to generate new problems. At least that's what we used to see. I don't know if we still see that. Did you do a tradeoff analysis? When is it worthwhile to do this? When do you lose more than you gain?

It seems we're worried about boric acid

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doing things that I'm not sure if we have a real experience base showing very serious problems with it.

MEMBER ARMIJO: There is one data point.

MEMBER BLEY: But other people have said other things are going on. As long as we're relying on an administrative control system, you have the chance of not carrying it out.

MEMBER SIEBER: In my experience, there is not, you know, a tremendous amount of precision in leak rate monitoring and deciding when you're going to take action. Obviously the tech specs are probably a factor of five away from what you can actually do, but you know, a real tight plant may come up with a negative leak rate. We had negative leak rates where I worked.

And so you know, you have to sort of decide not to justify why that's happening and look for changes, and you're acting on the trend. That's what performance based means in that context. And, frankly, when you get a leak, you do see rad monitor changes. In your inventory balance, you may see changes in that, but each time you do the leak rate, the plant operating condition is slightly different, and so there's going to be a band of uncertainty there that's due to variation in plant operation.

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MEMBER MAYNARD: Isn't the main thing this thing is doing is not so much lowering what the ultimate tech spec limit is but in requiring detection methods that are better than what we have today and imposing action levels and things that need to be done before reaching the tech spec levels?

MEMBER SIEBER: That's right. If you wait until you get to the tech --

MR. LI: We did our assessment -- the tech spec limit get more stringent material, and I have to study. Now that statement is after we study. It is not a real rigorous analysis. It's a matter of we have feedbacks and discussions from the experience engineers, you know, from the utilities. We understand when we lower down the tech spec limit that we may create additional problems --

MEMBER SIEBER: That's right.

MR. LI: Unnecessary trips. Co we made a conscious decision that we're not lowering down the tech spec limit. However, we try to have the procedures and the requirements to let utilities, the operator doing something before you reach the tech spec limit, and that's --

MEMBER MAYNARD: This would make it a requirement rather than voluntary. Right now a number

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of utilities do this, but not all, and it's not required by any, and this one --

MEMBER SIEBER: And a reg. guide is not a regulation, too.

MEMBER MAYNARD: Right.

MEMBER ABDEL-KHALIK: Is it possible to have significant wastage without significant indication of leakage if you have --

MR. SRINIVASAN: Yes.

MEMBER ABDEL-KHALIK: -- a flaw in the liner?

MR. SRINIVASAN: Yes, it is.

MEMBER ABDEL-KHALIK: So how do you address that?

MR. SRINIVASAN: Okay. What you are questioning with your question is exactly, if I can go to the next slide, that really is the crux of the whole thing. Basically the question that you asked was the one that posed us in this. Let me read this and then reliance on this.

Basically during the divisional -- of reg. guide we were aware that the industry has been developing standard guidelines after all for responding to low levels detected leakage in a quantitative step-wise fashion. We also recognize

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that there are leakage detection systems that are being currently installed and are operational at several PWRs which have the capability to detect leakage below a tenth of a GPM.

We needed to address the key issue in the division, which is what guidance can be provided for the duration of the leakage since the current technical specifications allow an indefinite period of unidentified leakage below one gpm. Basically from our operational experience we do know that even at below 0.1 gpm unidentified leakage, if it goes on for a long time, corrosion can occur, and it will be safety significance issue, and that's the crus of the thing.

How do we address that was to have the plants monitor leakage substantially below the technical specification limits and take action when an adverse trend is noticed.

MEMBER ABDEL-KHALIK: Can you have a flaw in the liner at a location that doesn't produce leakage and yet would result in wastage? I don't understand.

CHAIRMAN SHACK: No, because you don't have any oxygen. You really need it to get out into the atmosphere, but I mean, .1 gpm will produce about

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1,000 pounds of boric acid. You know, it makes a big pile of boric acid at the end of a year.

MR. SRINIVASAN: Just to give you a rough idea --

MEMBER SIEBER: But it's not going to plug the sun.

MR. SRINIVASAN: To give you an idea, at Davis Besse the leakage rate was between .1 to .3 gpm for the period of 1998. They take an average data point, two, but basically, yes, you know. I mean, it again depends on the --I showed you earlier, in an earlier slide what are the variables and so forth.

MEMBER ABDEL-KHALIK: Do the current EPRI guidelines on oxygen concentrations preclude that possibility?

MEMBER SIEBER: Huh-un.

CHAIRMAN SHACK: Oh, inside, yeah. In the interior, yeah.

PARTICIPANT: Once it's outside, yeah.

CHAIRMAN SHACK: You can't concentrate the bore -- you know, it's 2,000 ppm, as John says, until you start evaporating off the water and piling it up. So until you can evaporate it off you're left with a fairly benign solution.

MEMBER SIEBER: Just to address your

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question about boric acid corrosion on the inside when the system is solvent, there are reactor vessels out there with chips in the cladding down to the base metal the size of a quarter or 50 cents, and they were approved for operation based on the lack of oxygen.

MEMBER MAYNARD: The leak rate detection will never address all of it. There's still going to be a need for inspection, and I think what you think for new plants is better accessibility for inspections and stuff because you can never get a leak rate detection system that's going to address all of it. There's got to be some inspection done, too.

MEMBER BLEY: But it can kill your inspection.

MR. SRINIVASAN: To answer the question, basically what we are saying is that the revision of Reg. Guide 1.45 provides such guidance based on observing the leakage rate. The required vigilance in monitoring the RCS leakage, making engineering decisions based on evaluating the safety significance of the leakage after locating the source of the leakage and taking plant actions commensurate with the severity of the leak will then show the plant has operated safely.

For this revision, the title of the

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regulatory guide was changed to "Guidance on Monitoring and Responding to Reactor Coolant System Leakage" in order to more fully reflect the content of the regulatory guide. There are four categories of regulatory positions as shown in this slide. There are five positions that are of general nature and set the background for detection requirements.

There are six positions related to leakage monitoring, four to operations, and one to technical specifications.

The general positions related to leakage monitoring are given in this slide. The first one states that the source and location of a reactor coolant leakage shall be identifiable to the extent practical and the plant should measure the leakage rate.

The second one states plants should collect or otherwise isolate leakage to the primary reactor containment from identified sources so that the following criteria are fulfilled. Flow rates from identified sources are monitored separately from the flow rates from unidentified sources. Plants can establish and monitor flow rate.

The positions one and two are essentially the same as they were in the original Reg. Guide 1.45.

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Position number three --

MEMBER ARMIJO: You say flow rates. Do you mean leak rates?

MR. SRINIVASAN: Yes, that is correct.

MEMBER ARMIJO: Okay.

MEMBER ABDEL-KHALIK: Is it possible to have simultaneously a leak from an identified source, which is considerably larger than a leak from an unidentified source --

MR. SRINIVASAN: Yeah.

MEMBER ABDEL-KHALIK: -- whereby the leak from the unidentified source is within the uncertainty of the measurement so that, you know, it is possible that this process could be going on even though you think you know what the source of the leak might be?

How do you handle that situation?

MR. LI: I think for identify the leakage is channeled through some collection tank or collectors so that they'll be able to -- that's how they identify leakage, used as identify leakage. They identify leakage that doesn't know where it comes from. You don't have specific places to --

MEMBER ABDEL-KHALIK: I don't think you understand my question. I'm asking you the situation where you have simultaneously and identified and an

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unidentified leak, and the identified leak is you know what it's coming from, and it just happens to be significantly larger than the unidentified leak source.

So you think you know where the leak is coming from and how much it is, and yet there is another unidentified leak that's going on at a lower rate that could cause --

MEMBER POWERS: Well, it goes on all the time.

MEMBER BLEY: There is always unidentified leaks.

MEMBER POWERS: -- unidentified leaks going on that's small compared to your identified leakage.

MEMBER ABDEL-KHALIK: How does this revision address that scenario?

MR. LI: The identified leakage portion got its own tech spec limit, which collected as you're aware with ident. number, with its own tank. The unidentified leakage which goes to the sump or to the radiation monitor, those tech spec specified instruments, and it could happen simultaneously that there are different tech spec limits and identify leakage goes into one gpm in the sump. Actually we're

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trying to say that's even below one gpm should start trending and monitoring and, you know, keep a close look and do something, manage the leak.

MEMBER ARMIJO: Let's go on.

MEMBER BLEY: Can I interject a question? Because I'm coming to this a little late. I'm curious about if somebody, our panel or you guys can explain how people are detecting .1 gpm leaks when you're letting down water, especially in a PWR, at a fairly cold temperature. You're injecting water at kind of a warm temperature. You've got a system whose volume is changing. Are they getting that precise readings of let-down flow rate and charging rate --

MEMBER SIEBER: Yes.

MEMBER BLEY: -- to get a .1 gpm?

MEMBER SIEBER: When you decide to take the leak rate and you do it every day --

MEMBER BLEY: Yes.

MEMBER SIEBER: -- and you hold the plant as steady as you possibly can so that this set of conditions looks like yesterday's set, looks like last month's set, and the intersystem leakage which is really the identified leakage almost always intersystem, you can tell --

MEMBER BLEY: So it's a daily interfacing.

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MEMBER SIEBER: -- from the water balance.

The unidentified leakage is either pressure bound leakage or leakage from joints which is packing glands, pump shafts, and so forth.

That one you can't tell, but when it changes, you can see that change. Many plants will plot these every day. Some of them will take it three times a day, and out of that you can see a change and you can see relatively small leakage on these charts.

It's the operating crew that maintains that.

MEMBER MAYNARD: You do not get an instantaneous reading. It is something that is done --

MEMBER SIEBER: It ramps up.

MEMBER BLEY: So it's your integral leak rate test that you're doing this way.

MEMBER SIEBER: Yes.

MEMBER BLEY: Okay. Fair enough.

MEMBER SIEBER: It's over an hour is the minimum time to do your leak rate.

MR. SRINIVASAN: The position number three is a direct result of the implementation of one of the Davis Besse lessons learned task force recommendations to monitor critical components for degradation. So that is a new one.

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Position four was the same as it was before.

Position five is new. This is a new position which improves a requirement that the capabilities of the monitoring system -- effective management of the leakage by the plant. So basically these are the general positions.

Now, coming to the leakage monitoring, monitoring leakage positions, position six is new. This requires the plant to have procedures to detect, monitor the method flow rates substantially below technical specifications. Any early awareness of potential boric acid corrosion of components exposed to leaking coolant for prolonged times.

Position seven has now changed from the previous version, except specifically to include the limitation imposed by the detected signal transport delay time.

Position eight is rather long, but gives the listing of different types of monitoring instruments that the plants can use and provides greater flexibility in leakage monitoring. Both direct and indirect methods have included, but the list is open to new additions that may result from other emerging innovative techniques.

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MEMBER ARMIJO: Let me make sure I understand this.

MR. SRINIVASAN: yes.

MEMBER ARMIJO: With respect to the tech specs, are you obligated to use the A, B or C or if somebody said, "No, I don't want to use any of those things. I'm going to use it all acoustic emission for tech specs," is that possible or is there something that's required? You've got to use the sump level or particulate radioactivity and tech specs.

MR. SRINIVASAN: These are the quantitative recommendation matters.

MEMBER ARMIJO: So those are requirements?

MEMBER MAYNARD: If you commit fully to the reg. guide. You can always ask for an exception or a totally different method that the staff could approve, provided --

MEMBER ARMIJO: But if you take -- so if the reg. guide is issued this way and you came in with a sump level flow and a particulate radioactivity monitor for your tech spec, there would be no argument. It's built in. If you came in with some other technology --

(Laughter.)

MEMBER ARMIJO: I'm just trying to

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understand. How much flexibility do you have or do you want?

MEMBER MAYNARD: It all comes down to a case-by-case discussion. None of these things are all done.

MEMBER ARMIJO: Okay.

MEMBER SIEBER: Most PWRs do it the same way, which is water balance every day with the plant held steady. Very few do acoustic monitoring even though that does work. It's not clear to me that it's any better than the water balance.

MEMBER ARMIJO: But for local --

CHAIRMAN SHACK: You might do that if you had some particular location --

MEMBER SIEBER: Oh, yeah.

CHAIRMAN SHACK: -- you were to monitor. That's sort of an arrangement.

MEMBER SIEBER: Our leakage used to come out negative, which --

CHAIRMAN SHACK: You were creating water.

MEMBER SIEBER: -- if you think about that --

(Laughter.)

MEMBER ARMIJO: Okay. Let's go on.

MR. SRINIVASAN: The guide also recommends

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the use of techniques and methods that may not necessarily have the protection capability and response time of one hour of leakage, one hour for a leakage rate of one gpm because they may be able to provide early warning of a leak.

Acoustic emission monitoring and conducting radio surveillance are new additions to the previous Reg. Guide 1.45

MEMBER ARMIJO: How do you know how much is enough? You know, if I was a plant guy coming in and I did tech specs, I used two or three acceptable methods in the tech spec and said, "I'm not going to do any of the other stuff. I don't think I need it," maybe you would insist, well, you've got to have at least one other. I mean how do you know when you're finished?

MEMBER SIEBER: It's called judgment.

MR. LI: Yeah, over here we don't have a quantitative, specified. In addition to the tech spec, how many? It's a judgment. It depends on how you design and where you consider those more critical elements, where you place additional supplementary leakage for certain situations that you have to consider.

MEMBER SIEBER: And part of that judgment,

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some plants operate with greater leak rate than others do, but if every time your leak rate went up just a little bit you don't know that it's an artifact from the calculation. So you don't go and shut the plant down necessarily, but you can find some pretty small leaks from the data, and you go into the, you know, bring the power down and send people in to look for it and you can find them, you know, with packing glands and things like that, pump seals.

MEMBER ARMIJO: Okay. Go on.

MR. SRINIVASAN: Position nine provides greater flexibility in the type of leakage monitoring system that should be functional after a seismic event plant shutdown. The previous version was prescriptive and stated that the airborne particulate radioactivity monitoring system should be functional.

Position number ten is essentially the same as it was in the previous Reg. Guide 1.45 and requires the ability to calibrate and test the leakage monitoring equipment during plant operation.

Position 11 is new. This new staff position is directly the result of operational experience of the LWRs, which has indicated that prolonged leakage at less than the technical specification limits could be an issue.

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We now require the plant to trend the leakage rates, perform an analysis, and take precautionary measures on observing an increased trend in the observed leakage rate over time. This proven measure, which is done at substantially lower levels of leakage than the technical specification limits includes an assessment of the safety significance of the leak, insures that the leakage is managed before it could become a potential safety issue.

MEMBER ABDEL-KHALIK: You know, I still can't get this clear in my own mind. You're essentially asking people to go down to .05 gallons per minute. Have you approached the problem from the other end? What is the lowest leakage rate that can actually cause problems if left unchecked for a long period of time? Could it be .01 gallons per minute? Could it be .001 gallons per minute?

MEMBER POWERS: Yes. It depends how long.

MEMBER MAYNARD: That's why the inspection is important. The leak rate is not going to answer all of these things.

MEMBER SIEBER: That's why you shut down every 18 months or so.

MEMBER ARMIJO: But if you knew where it was and you knew there was -- that's local detection

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-- you would then go do an inspection and look there and see what's going on.

MEMBER ABDEL-KHALIK: But within the normal frequency of inspection, let's say the length of a cycle --

MEMBER ARMIJO: A couple of years.

MEMBER ABDEL-KHALIK: -- what is the lowest leakage rate if undetected would cause concern in terms of wastage?

MEMBER MAYNARD: I understand Davis Besse, and I believe that's really a bad example and reason for this reg. guide. Your typical problem is not the wastage. For those lower leak rates, it's really a cracked weld or something like that and the pressure boundary that you're really worried about, and it's that growing and causing your problem.

The wastage isn't the issue. You're really allowed zero reactor coolant pressure boundary leakage.

MEMBER SIEBER: That's right.

MEMBER MAYNARD: From a crack. Flange connections and stuff you're allowed some leakage, but if you identify any evidence of a leak around a welded connection or anything like that, you have to shut down and fix it there. That's why the

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inspection, I think, is --

CHAIRMAN SHACK: But you can have remarkably large cracks with small leaks.

PARTICIPANTS: Right.

CHAIRMAN SHACK: The Ocone crack was a big one, 60 percent circumferential.

MEMBER SIEBER: Tiny leak.

CHAIRMAN SHACK: The leak rate was something less than a gallon per year.

MEMBER POWERS: But it seems to me that the problem here is enormously simple. The tech spec was written and said, "Look. We'll allow you an unidentified leakage below a gallon per minute."

And they said, "Oops, that was wrong. Now, we don't want to go through a backfitting analysis. So we're going to change this reg. guide."

Never have I seen a reg. guide more deserving of asking NEI to write a point guidance that they can endorse rather than going through this convolution. This seems to be getting into the operational details that the NRC is probably not well suited to do. They should be asking NEI to prepare a plant guidance that they can simply endorse here rather than writing their own reg. guide.

MEMBER SIEBER: But this is pretty close

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to what the plants are doing anyway.

MEMBER POWERS: That's the problem I have with it, is that it's very close to what plants are doing, but you're codifying a particular set of behaviors that a plant may deviate slightly from them, and now he has to come in and plead with the staff his case, whereas if it were a set of guidances, that NEI endorsed, they could encompass things like that. That's the difficulty I have with this.

MEMBER ARMIJO: Or IMPO or somebody. Well, that's the issue. If this is really good guidance, why is it limited only to new plants? Well, I guess it's because existing plants are doing something like this already, but on a voluntary basis.

MEMBER MAYNARD: Well, you're in a whole different world if you're going to impose it on existing plants. You have to go through the regulatory process for that and everything. This gets a reg. guide out with guidance for the new plant coming in which will help with the design features and the design approval features so that this can be there.

MEMBER SIEBER: Yeah, in the old plants they're people that read these things anyway and say, "That's not a bad idea. I think I'll do it."

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MEMBER ARMIJO: That's really it.

MEMBER MAYNARD: And typically on these, sometimes you want to do anything new or different, you end up basically committing to a more recent version of the reg. guide or doing --

MEMBER ARMIJO: It's there when you want to do a trade.

MEMBER MAYNARD: It happens.

MR. SRINIVASAN: By default.

MEMBER ARMIJO: Okay. Where are we? On what page?

MR. SRINIVASAN: I'm on position 12. I don't know why it gave up on me here.

MEMBER SIEBER: That's Slide 15?

MR. SRINIVASAN: Sorry. Okay. Position 12 is new.

MEMBER POWERS: So wherever a pound of boric acid would be. It would probably break something if it fell in the right place.

MEMBER ARMIJO: Well, let's just go over the handouts.

MR. SRINIVASAN: I'm on page 15.

MEMBER ARMIJO: Okay.

MR. SRINIVASAN: Okay. Handout. Position 12 is new and requires plants to establish procedures

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for responding to leakage.

A major revision to Reg. Guide 1.45 is the guidance on expectations for plant response to leakage in a progressive manner by establishing the severity and the safety significance of the leakage. Preferably are substantially lower than the allowed technical specification limits.

The plant should have procedures for managing the leakage depending upon the observed trend. The procedures should include actions for confirming the existence of a leak, identifying its source, increasing the frequency of monitoring and verifying the leakage rate through your water balance, responding to trends in the leakage rate, performing a walk-down outside the containment, planning a containment entry, or adjusting along set point, limiting the amount of time that operation is permitted when the source of the leakage are unknown and determining the safety significance of the leakage.

For leakage monitoring to be effective, the plant procedures should also specify the maximum amount of time the detection and monitoring instruments other than those required by technical specifications may be out of service during active

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plant operation, namely, hard shutdown, hard standby, start-up, transience and power operation.

The next page, position 13 is similar to the previous version.

MEMBER MAYNARD: I'm sorry. I don't understand back on B, monitoring all phases, the amount of time it can be out of service during all phases of plant. I understand most of it is separate transients. I mean, how -- if you're in the middle of a transient --

MEMBER ARMIJO: You would have no way of knowing it happened. If you happen to be out of service when the transient occurred.

MR. SRINIVASAN: You can't do that.

MEMBER ARMIJO: Against my procedures. Anyway, go ahead.

MEMBER STETKAR: But this does not apply during cold check. That's the point.

MR. SRINIVASAN: That's the point.

MEMBER POWERS: That was a clarifying comment from the industry.

MR. SRINIVASAN: Position 13 is similar to the previous version and requires monitoring, output alarms be available in the main control room to provide early warning signal for implementing

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corrective actions as discussed in position 12.

Position 14 is new. Plant actions to identify the source of leakage during scheduled maintenance and refueling outages will provide an opportunity to fix the leakage and to eliminate the possibility that the observed leakage could become worse in subsequent plant operations.

The next position, position 15, is essentially the same as it was in the original Reg. Guide 1.45. The reg. guide specifies performance expectations and the required capability of the protection equipment but does not provide any limits on leakage rate. The staff position, however, requires that the plant technical specifications address this issue.

Adequate coverage and availability of the instruments is also required during active phases of plant operation, as I said before.

Now to address the public comments, basically if we go to slide number 19, a total of ten industry comments were received on this draft guide. Of these, two were from NEI, three from Areva, and five from Stars.

I will now discuss how the staff disposition these comments in the final reg. guide.

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NEI first asked if indirect methods can be used to monitor leakage from critical components. The staff agreed that indirect methods of leakage protection to monitor particular components may be used as long as the significance of the leak can be assessed.

NEI asked if we considered the inspection manual Chapter 25.15, Attachment 1, for the revision.

The attachment that NEI cites provides guidance to NRC inspector for trending plant data based on statistical analysis of the monthly leakage rate data.

The working group which devised the reg. guide did consider the availability of this inspector guidance document during our deliberations. In fact, in reviewing an earlier draft, NRC's region staff had similar suggestion.

However, we decided not to incorporate this reference into the regulatory guide because, one, the guidance in IMC-2515 may not always be conservative;

Two, the guidance in IMC-2515 may be too restrictive in some instances;

And, three, the inspection manual chapter may change more frequently than the regulatory guide.

The next slide show Areva's three comments. Arena NP offered three comments. The first

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one was relative to the regulatory position eight, and basically we agreed with that comment. It was related to some editorial and technical areas. So we agreed with that and we made the revisions.

Areva also made comment on regulatory position nine, which contained two statements. They said that it would be appropriate to separate it into two statements. The staff agreed with this comment, and the regulatory guide has been revised to retain the first sentence as a regulatory position.

The second sentence has been deleted from that position, and I'll come to that because that had to do with the leak before break analysis and reference to that as a regulatory position.

With respect to the leak before break, the position, Areva basically commented that the capability guidance for the LBB detection system be revised to be clear that it does not necessarily have to be able to detect the leakage determined from the LBB analysis within an hour.

Rather, Areva believed that the detection capability should be addressed in plant procedures and would be based on the type of detection system, its use and its location.

The staff had withdrawn the proposed staff

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position nine in the second sentence of the draft reg. 173. When an LBB analysis is submitted for the plant, the staff evaluates the LBB analysis procedures of the licensee or the applicant as per the guidance provided in the standard review plan, 3.6.3, that such analysis incorporates the provisions of the leakage monitoring as per this regulatory guidance.

Thus, there is no need for a staff position on leakage monitoring specific to LBB. So we deleted that.

Star had the most number of problems. We had stated in our draft guide that the steam decay to containment atmosphere in the PWR can be predominantly secondary steam leakage. In current designs they said leakage collected in the containment sump cannot be directly correlated to primary unidentified leakage without sampling.

We agreed with the comment and added the following sentence to the regulatory guide. "It is important to note that there may be leakage into the containment from secondary other than the RCS, for example, secondary site steam leakage in a pressurized water reactor. This non-RCS leakage may increase the unidentified leakage rate. Chemical analysis of samples of the unidentified leakage may provide an

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indication of whether the unidentified leakage is from RCS or from other sources."

Stars commented also on regulatory position six. They said that the RCS inventory balance is the current method used to calculate RCS leak rate. However, the current equipment installed in some plants may not be sensitive enough to accurately measure an RCS leak to the rate of 0.5 gpm, 0.05 gpm.

While RCS leakage is collected in the containment sumps, the sumps would not be sensitive to an in-flow of .05 gpm, especially in the early stages of a small RCS leak when most of the hot coolant steam would be present in the containment atmosphere.

The staff's position is as follows. Although the implementation of this guide may provide a safety benefit for the current operating plants, it was not intended to be applicable to the currently operating plants. However, the plants licensed after issuance of this revision to this guide, it is the staff's position that the leakage monitoring system would be capable of detecting a 0.05 gpm leak given the potential safety significance of low levels of leakage.

Such monitoring capability should be

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achievable using current instrumentation and monitoring methods.

MEMBER ARMIJO: Is that .05 gpm leak rate even for a new plant, is that practical? Is that doable?

MEMBER MAYNARD: Again, I don't see from an instantaneous standpoint, and I'm not sure in response to this. Again, initially it depends on the timing of when you have to be capable of measuring that .05. If you're required to be able to identify that as soon as it happens, that's not possible.

If you're required to be able to identify that over a three-day period --

MEMBER SIEBER: Three gallons an hour.

MEMBER MAYNARD: -- or something like that, then it can be done because like the commenter said here --

MEMBER SIEBER: Three gallons an hour.

MEMBER MAYNARD: -- initially most of it is going to be going into the atmosphere. You're going to get it, but you're not going to get it instantaneously. So it's a timing.

MEMBER BLEY: Under their position six it's collected.

MEMBER ARMIJO: So is there a time related

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of how much time you've got at .05, within 24 hours?  
Is that in the reg. guide?

MEMBER STETKAR: When it says .1 gpm over  
an hour, right?

MEMBER BLEY: But their position six has  
this .05, but it doesn't say over what time period.

PARTICIPANT: Slide 12.

MEMBER ARMIJO: See, I'm confused. The  
thing that confuses me is when is the .05 controlling  
and when is the one gpm over an hour and what is .05  
over some undefined period of time controlling.

Maybe I should ask the staff that.

MR. LI: The one gpm within an hour is a  
requirement.

MEMBER SIEBER: That's tech spec one.

MR. LI: As far as the capability, .05,  
it's not something like within an hour of one gpm.  
It's something that the instrument will be able to  
have that capability so that we'll be able to credit  
the full tech spec, so that we'll be able to say  
that's good enough an instrument that we use to carry  
this procedures, that we'll be able to alarm the  
operator to start thinking about manage the leak.

MEMBER SIEBER: The only way you can get  
that accurately, you can't do that with a water

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balance.

MEMBER ARMIJO: That's mind boggling.

MEMBER SIEBER: Probably the best you can do is a tenth of a gpm by water balance. The only way you can do it is by changing levels, but if you go into containment, you've got service water and all kinds of things, cold service in a reasonably humid atmosphere that's dripping occasionally, and it's not clear to me that the answer you get is very conclusive as to RCS pressure boundary leakage.

MEMBER MAYNARD: And I don't think it's important that you be able to identify .05 on a real short term basis. I think it's important to have that ability over a time frame so you can have some action where you have a trend going or not because --

MEMBER ARMIJO: So this is an instrument capability.

MR. LI: That's right.

MEMBER MAYNARD: I think it's to give you the capability to be able to have meaningful trends.

PARTICIPANT: If you want to spend enough money, you can do anything.

MEMBER MAYNARD: And not have a larger level of uncertainty in your measurements and stuff.

MR. JONES: This is Steve Jones in the

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Balance of Plant Branch in NRR.

Just a quick comment to clarify this. A lot of plants have, for instance, for their containment sump instrumentation, they have a pumped system that pumps a fixed volume of collected leakage to the rad waste system at periodic intervals, and it's a time difference that's used to establish the leak rate.

However, if all of that leakage is rather collected in a separate tank and then quantified over a long period of time, you can get lower levels of detected leakage like .05, but if it's immediately pumped to rad waste, that information is essentially lost. You can't get an integrated leak detection.

MEMBER BLEY: Jack's point, I think, is still strong here. You can do that, but it's hard to imagine you wouldn't have some of these other sources of leakage in there so when you sampled it, it's not going to be straight --

MEMBER SIEBER: He addressed that by saying to sample, which you can do.

MEMBER BLEY: And the other would be mixed.

MEMBER SIEBER: Once you do that, you introduce a level of uncertainty, you know.

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MR. JONES: I think the intent is not to notice a .05 RCS leak. It's to be able to notice a change in overall leakage of .05 gpm over an extended period of time.

MEMBER SIEBER: Right.

MEMBER ARMIJO: But you haven't defined that. You're saying over a long period of time, but we don't know what that is.

PARTICIPANT: It could be days or weeks.

MR. JONES: That's true. I guess it could be refined somewhat, but by collecting the overall leakage, at some point there should be an integrated quantity that would be able to be quantified to that accuracy.

MEMBER MAYNARD: I think they're saying this reg. guide will require a program, and that program will get reviewed by the NRC, and that's where I think any time frames would probably be worked out.

MEMBER ARMIJO: Okay. Just wrap up.

MR. SRINIVASAN: The next comment with respect to leaking into containment, Star stated that the draft guide stated that methods that monitor temperature and pressure may also be used to input leakage of a coolant to the containment. Star has commented that such methods that are applicable to

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large leaks, one leak.

The staff agreed with the comment and revised the text to clarify that these methods can only detect large leaks.

Star commented next that the positions 14 and 15 lead the reader to believe that the NRC expects licensees to monitor RCS leakage during refueling outages. RCS operational leakage requirements in both five and six are currently not required because the reactor coolant pressure is far lower, resulting in lower stresses and the reduced potential for leakage.

Regulatory positions 14 and 15 either need further clarification and justification or they should be deleted. An explanation of acceptable leakage monitoring methods during refueling outages needs to be included if justification can be made for refueling outage monitoring.

The staff agreed that the RCS operational leakage requirements in MODE 5 and 6 are not required, and therefore, positions 14 and 15 were appropriately clarified.

The last comment from Stars was that the concluding paragraph of the regulatory analysis section of the draft guide implied that the current licensees will automatically adopt the later revision

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of this regulatory guide.

In order to adopt this guide without exception, licensees would need to upgrade the equipment. Therefore, for many licensees adopting the revised regulatory guide would not be practical.

The staff's disposition that the reg. guide 1.45, Revision 1, will be referenced in the standard review plan and will be applicable only to new reactors, but the requirements of 10 CFR 50.34(h).

No backfitting is intended or approved in connection with the issuance of Reg. Guide 1.45, Provision 1.

This concludes my presentation.

MEMBER ARMIJO: Okay. Comments or questions?

(No response.)

MEMBER ARMIJO: I think we've asked them.  
Mr. Chairman.

CHAIRMAN SHACK: Thank you very much, gentlemen.

It's time for a break for lunch now.

MEMBER ARMIJO: On schedule.

CHAIRMAN SHACK: If we can come back at five after one, we'll be pretty close to on schedule.

(Whereupon, at 12:04 p.m., the meeting was recessed for lunch, to reconvene at 1:05 p.m., the

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same day.)

CHAIRMAN SHACK: We will come back into session. Our next topic is the proposed licensing strategy for the next generation nuclear plant. And Mike Corradini will be leading us through that. Mike?

MEMBER CORRADINI: Thank you.

4) PROPOSED LICENSING STRATEGY FOR THE  
NEXT GENERATION NUCLEAR PLANT (NGNP)

4.1) REMARKS BY THE SUBCOMMITTEE CHAIRMAN

OPENING REMARKS

MEMBER CORRADINI: So to give all of the members kind of an update, some of you were at the subcommittee meeting yesterday which we had regarding this topic. The DOE or, I should say, the Energy Policy Act of 2005 essentially authorized the next generation nuclear power plant and had some details on how it has to be rolled out relative to development, licensing, and associated R&D. And I'm sure the staff will explain that.

In relation to where we sat yesterday for the subcommittee, one of the requirements of the act was that there must be a report back to Congress by this summer, three years after the act has passed, for a licensing strategy since in the act, as the plant is to be designed, constructed, and operated, it must be

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licensed via NRC regulations.

So yesterday we heard from the staff and the DOE staff a summary of where they are relative to the licensing approach at this point. It's still ongoing. We also heard a report out in terms of needed R&D via their PIRT process, which was concluded now I think about a little bit less than a year ago and is now in the process of being published. So the staff will take us through this.

I will remind everybody that this process is still to be reported to Congress. Therefore, it's pre-decisional. Therefore, what we are being talked about in the open meeting we must focus on what staff is telling us today, rather than some of the stuff we heard in the closed session, which is pre-decisional; therefore, cannot be discussed in open session.

And I think, with that, I will turn it to Dr. Basu. Oh, I am sorry. I am sorry. John Jolicoeur. I apologize.

#### 4.2) BRIEFING BY AND DISCUSSIONS WITH

#### REPRESENTATIVES OF THE NRC STAFF

#### STAFF INTRODUCTION

MR. JOLICOEUR: Hi. I am John Jolicoeur.

I am Chief of the New and Advanced Reactors Branch in the Office of Nuclear Regulatory Research.

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I would like to thank you for the opportunity to come in and give you a briefing on our status on our work on the NGNP licensing strategy.

With me today I have three individuals to brief you. First, Mr. Trevor Cook from the Department of Energy is going to talk about the actual NGNP design and technology. And then I have Dr. Sud Basu from the Office of Research and Tom Kenyon from the Office of New Reactors, who will talk about our strategy and the need for analytical tools. And this point, I will turn it over to Trevor.

MR. COOK: Good afternoon, everyone. I am Trevor Cook with the Department of Energy. I'm the Program Manager for the Next Generation Nuclear Plant Program.

We are somewhat limited in what we can say, but usually I can say a lot without stepping across the boundaries. I am here to really talk about the technology and the program developments to date and in broad terms what our near-term plans are and our long-term plans.

Primarily the main thing to know about this project is that it was established as a project by the Energy Policy Act of 2005, which perhaps overly defined our activities and gave us specific schedules

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and milestones for accomplishments, one of which was to develop this NGNP licensing strategy.

It also outlined a very sort of basic acquisition strategy that the department would use. It said that the department will partner with industry in developing the NGNP. It said that the NGNP will be built at Idaho. It said that there will be a competitive process for final design selection. So these are sort of the key mandates in the Energy Policy Act for how the department is conducting the project.

Our focus is on gas reactor technology to meet the purpose of the reactor, the purpose being to bring nuclear fission capability into the process heat end user community.

This plant is fully capable of making electricity and at a competitive cost. Its best purpose is to serve niche markets for electricity, whether you need a very small amount on the grid or whether you need a plant and you need capability in arid areas, where you have limited water usage. It's very good for that in terms of electricity. In terms of process heat, it's ideal for a number of process heat uses that you will see.

The gas reactor has a long history that

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dates back to the early '60s, right along with light water reactor development. And we are building on that history. We are building on the really billions of dollars that have been invested over the years by the U.S. government and by foreign governments and by private enterprise to move the project forward.

Here is an example. I don't know if this is readable -- I hope it is -- of some of the end user industries, process heat users, and what the temperature requirements are for their industrial processes.

The little arrows at the bottom show you that, in fact, light water reactors are applicable for some of these and that, beyond that, you need higher-temperature reactors.

I put in HTGR. There are other higher-temperature reactors that could fill in the gap in between here and there. But ultimately high-temperature gas reactors thus far are the technology that is best developed to meet the high-end needs, the very high-temperature needs, above 800 degrees C.

This is a cartoon layout of a plant that could -- say it again?

MEMBER APOSTOLAKIS: That's not a picture?

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It hasn't been built yet?

MR. COOK: We haven't quite built it yet. We're getting started soon, though. This cartoon shows an artist's depiction of a plant that could be used for both hydrogen production and electricity production. In fact, our focus while on hydrogen electricity for the EPA Act, the plant does have this more general purpose and could be used by a variety of industries, the chemical industry, the petroleum industry, cold liquids, all kinds of things.

We did in 2007 a series of pre-conceptual design studies. We hired the three leading vendors for the gas reactor technology. Westinghouse PBMR is one. General Atomics, and Areva filled out the other two. And each one submitted their take on what the NGNP should look like.

From that, we produced a pre-conceptual design report, which is publicly available. And this sort of highlights some of the findings when we look across the three designs, this figure here.

The additional slides just give more detail. You can key questions from that. But they show particular differences. And they are small, really, across the plants.

Now, some of the things that got left off

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these next two slides were asking questions yesterday.

I don't know if I can bring that up.

Somebody asked what the vessel heights are. Just so you know, the vessel height for the Areva plant is 25 meters. The vessel height for the Westinghouse PBMR is 30 meters. And it's 31 meters for the GA plant.

The vessel diameters are seven meters for the PBMR, go to about seven and a half for the Areva, and eight meters for the GA plant. Vessel thickness is about five inches, 110 millimeters. Pressure, system pressure, was left off these slides. They're all typically about 1,000 psi.

Our focus in technology development is fuel. That's our principal focus. So there's a lot to be done. And our R&D program is quite broad. It focuses on fuel in terms of fuel performance in the reactor during normal and accident conditions. So that's where the second bullet comes in, source term, among other things.

A critical component of gas reactors is graphite, which is used as both a structural material and reflector and also in the floor. And so we have a graphite qualification program underway.

Another critical area for this machine

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since it operates at high temperature is the heat exchanger to get the heat out of the reactor and into the process heat end user. And so we have a pretty comprehensive high-temperature materials development program.

And last, but not least, we're looking at updating old design and safety methods validation tools and creating new ones as well.

MEMBER APOSTOLAKIS: These programs that you have, they have deadlines? I mean, you have had --

MR. COOK: They have schedules.

MEMBER APOSTOLAKIS: Expectation when useful products will be available?

MR. COOK: Yes. Each one has a schedule.

MEMBER APOSTOLAKIS: And these are consistent with what it is Congress wants?

MR. COOK: Twenty twenty-one is the end date specified in the EPact.

MEMBER APOSTOLAKIS: So all of these programs will have produced something before that?

MR. COOK: We actually are aiming for an earlier date in our R&D program for two reasons. One, if we can actually build the plant out faster than 2021, that's great. We don't want R&D to be the

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limiting factor.

For another, even making 2021 is pretty tight. And we don't want R&D to make us miss that date either. So we're focused on an earlier date for R&D. Twenty eighteen actually is the date.

MEMBER APOSTOLAKIS: And that's feasible?

I think we could --

MR. COOK: It's feasible. We have detailed plans. It involves a lot of money and a lot of work. But it is feasible.

The fuel program looks like this. It's a kind of a complicated slide. Just view it as a list of our experiments. AGR-1 is the first experiment, which essentially looks at whether or not we could make fuel to the old German standard or not. It uses UCO fuel, which is a new kernel.

The Germans primarily use  $UO_2$ . And that experiment has been in the AGR and running for about 220 days, reactor days. And it will go another 120 or so. I can't remember the exact number off the top of my head.

So far we have run without any fuel failures. And we have passed the point at which new production reactor fuel, which was the last time we made TRISO-coated particle fuel in this fuel, started

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to have problems in the reactor. So we started to see fuel failures about a week ago in terms of irradiation space with the new production reactor fuel.

That fuel program was dissected left, right, and sideways. We think we know why that fuel failed. We built in the solutions to that, into this batch of fuel, and so far so good.

The next test will be a test of commercially available fuel, of fuel that would be made on prototypical commercial lines. This AGR-1 is made with laboratory-scale equipment. So AGR-2 will have both UCO and UO<sub>2</sub> fuel. And it will have UO<sub>2</sub> fuel we hope from all of the interested fuel vendors.

The next set of tests, AGR-3 and 4, are designed to fail fuel. And that is so that we can get at the source team.

MEMBER ABDEL-KHALIK: Just for reference, what was the burnup at which the NPR fuel failed?

MR. COOK: I don't remember. I don't. Let me see if I jotted it in my notes. No, I didn't. I'm sorry. But I can get back to you with that.

MEMBER ABDEL-KHALIK: All right. Thank you.

MR. COOK: Okay. AGR-3 and 4 is designed to fail fuel tests. Those tests will help us get a

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feel for fission product propagation through the fuel and into the surrounding graphite matrix. That's an important, very important, series of tests. Five and six is pretty much do or die time for the program? That's the fuel that we propose to put in the reactor.

And so that's the final fuel qualification proof testing. The last set of tests is for validation of our codes and methods for predicting fuel and fission product transport.

And then we have out-of-pile tests. So AGR-1 through 8 are in-pile. Out-of-pile testing is in these big furnaces that were set up to simulate, again, fission product transport from irradiated fuel.

And all of that taken together we hope -- and it has been informally and preliminarily reviewed at various conferences and meetings by NRC but not formally yet, but we hope that all of this taken together, provided the results are good, will form a qualification database that will allow us to move forward on the schedule that the EPAct calls for for loading fuel in the reactor.

MEMBER BLEY: Trevor, do you have any alternative plans if, say, at AGR-2, you start finding problems with the fuel?

MR. COOK: There are plans, but I wouldn't

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care to discuss them publicly at this time.

MEMBER BLEY: Okay.

MR. COOK: And I am not trying to give you the runaround. I'll be happy to do it ex parte.

MEMBER BLEY: Fine.

MR. COOK: I know I am running over, but Sud ceded me some of his time. I'll speed up.

MR. BASU: If you go over, yes.

MEMBER CORRADINI: You are doing fine.

MR. COOK: I will speed up a little bit.

This is the fuel test that we have right now. So this will answer some of the -- maybe it's on this slide. No. It doesn't say. I think we're at about six percent FIMA now.

MEMBER CORRADINI: Yes. That was what was mentioned before, yes.

MR. COOK: And so, given that we just passed the threshold for where the NPR failed, my guess is they failed at right about six percent FIMA, but I would have to get back to you on that.

This slide just essentially we're patting ourselves on the back. Under the able leadership at the department of Madeleine Feltus, we created a very nice capability for fuel testing at the ATR for this TRISO-coated fuel, including the ability to run at

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prototypical temperatures and measure those temperatures, the thermocouples that can take the cycling of this system and the temperatures that we're at, where that's no small feat just getting the thermocouples designed and installed and operating.

So a lot of good science, a lot of good engineering have gone into these tests. And I'd like to give credit to Madeleine Feltus and the team at Oak Ridge in making fuel and at Idaho for designing, building, and operating this experiment. They have done a really great job.

We do have quite a bit of time to go in irradiation space, but we're pretty confident with the fuel behavior to date that we're going to have a successful test.

These are the furnaces that we're installing and taking receipt of right now. They will be installed over the next year or so and will be able to have the capacity and put in the procedures and training and everything so that we can do the out-of-pile tests at the time that those are required.

The graphite program is really an ambitious program, too. It's, frankly, similar in scale and cost to the fuel program. It's a little earlier in its development than the AGR fuel program

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was.

The issue with nuclear graphite is that depending on the coking source and the means of producing the graphite, they're all unique. You know, each graphite is unique. And so each one right now has to be proven individually through irradiation testing and materials property testing.

MEMBER CORRADINI: When you say, "each one," you mean each fabrication process?

MR. COOK: Yes. I don't mean from batch to batch. I mean for a given coke source, for a given manufacturing facility for a given plant, that will produce --

MEMBER CORRADINI: Okay.

MR. COOK: -- versus another guy. And so what happens is the one that we used before on Fort St. Vrain was 451. And we're just out of it. The coke source is dried up. The well is capped. The factory is closed, can't make it anymore.

So we have to find an alternative graphite for this reactor. And we're looking at three that are, in fact, commercially available today. And we're testing those against the three that have been tested and have good databases that are no longer available but that we still have significant sample quantities

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of. And so that program is going on.

The first sort of lead big experiment in that is a graphite creep test. It's a loaded test. The load will be applied in the reactor, in the ATR. It's testing, like I just said, six candidate graphite types -- well, three reference types and three actual candidate graphite types. And that should go in the reactor in about -- well, it says March 2009. So there we go.

High-temperature materials are focused on the metals that will be used in the intermediate heat exchanger. Now, these metals have been determined -- have been picked, I should say, in no small part by Bill Corwin, sitting back there. They're picked because originally the program was focused on an even more challenging temperature, about 1,000 degrees. And we started setting up our R&D plans to 1,000-degree outlet temperatures.

As we have done pre-conceptual design work and gotten input from the vendors and the user community through those pre-conceptual designs, we found that 1,000 degrees really isn't required. And I showed you in that first or second figure that you really don't need 1,000 degrees for most of the industrial processes that we're looking at.

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So we're able to come down in temperature, which reduces stresses somewhat but, nevertheless, the materials we're looking at are materials that would have had probably the best chance of surviving even in 1,000-degree margin. And certainly they will have a good chance of surviving here.

As you come down in temperature, other materials become possibilities. And there are rather extensive databases on temperatures that survive at lower temperatures. So we are focused on these right now.

For design and safety methods, we're looking at bringing computational fluid dynamics into the tools quiver for analyzing gas reactors. We're also looking at updating a number of existing code suites. We have established some international benchmarking tests with the Generation for International Form Partners.

The last bullet is a pretty important one. We're planning for an integrated scale test of the reactor cavity cooling system.

There are a lot of facilities worldwide that are available to us that we have been talking to people in South Africa, for instance, about using. And we are planning right now to build some new

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facilities in Idaho to assist us with setting up large-scale test rigs.

This has been a crazy year for us. We operated under continuing resolution, as did the rest of the government up until end of December. We got an appropriation that was quite a bit larger than what the administration had requested. So we have a nice new influx of money. So we have been doing some sort of emergency program planning to spin ourselves up to spend the additional money.

We're spending our money as far as R&D goes in the same areas that I just talked about, doing the activities that I just discussed. In addition to that, we are funding a substantial conceptual design effort. We are funding the activities of the Nuclear Regulatory Commission in developing this licensing strategy.

And that's about it.

MEMBER CORRADINI: Any questions from the members?

(No response.)

MR. BASU: Thank you, Trevor.

MR. COOK: Thank you, Sud.

MR. BASU: Good afternoon. My name is Sud Basu. My co-presenter is Tom Kenyon from the Office

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of New Reactors. We agreed that I will give the presentation and he will field all of the questions.

MEMBER CORRADINI: I have a question.

(Laughter.)

MR. BASU: With that, let me start with the first couple of slides, give you some background.

Trevor has already given you some background, but at the risk of repeating myself, I will go to a couple of slides just to make some points here which will put us in perspective for the rest of my presentation.

The Energy Policy Act of 2005 -- and that's public law 109-58, subtitle C that was section 644(a) -- directed the Secretary of Energy to establish a project Trevor mentioned that's the next generation nuclear power plant project, or NGNP for short. Section 644(a) provided NRC the licensing and regulatory authority for any reactor to be authorized and built under this subtitle.

And, finally, section 644(c) said, "No later than September 30, 2021, the Secretary"; that is, Secretary of Energy, "shall complete construction and begin operations of the nuclear reactor NGNP."

The two messages that I want us to take away from this slide is that the schedule for NGNP construction and operation is 2021 and that's the

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prototype NGNP; and, second, that the licensing strategy that the Congress directed to agencies to work on would be a licensing strategy focusing on the purpose.

One more part of the Energy Policy Act language, section 644(b), that's a little more than three years from the enactment of the act, "The Secretary and the Chairman shall jointly submit to the Congress a licensing strategy for again the prototype, nuclear reactor prototype," NGNP. That's important for us to keep in mind. So that three years put us in the August 7, 2008 time frame.

Now, what is this licensing strategy? The Congress has provided some language in the Energy Policy Act that said ways in which current licensing requirements for LWRs need to be adopted for a prototype NGNP. This is very important for us to remember as we go along.

The language also said that the strategy should include a description of analytical tools that the NRC will need; other R&D activities that the NRC will need in order to conduct a licensing review; so, in other words, activities towards developing a licensing review infrastructure; and, finally, the resource requirements.

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Okay. So what's the product? The product is a strategy. It's a report to the Congress that will be delivered August 7, 2008. That strategy of the report will contain the licensing approach on account of NRC needs the analytical tools and supporting technical basis; other NRC needs, as I mentioned, in the context of developing an analytical structure for licensing review; and, finally, the resource needs.

MEMBER APOSTOLAKIS: How binding is this report? In other words, three years down the line, you may find that some things have to change. You don't need to go back to Congress, do you?

MR. BASU: I am not aware that we don't need to go back to Congress. I think we do owe Congress an answer. If you are alluding to whether or not we can complete our job by the August 7th, 2008 time frame --

MEMBER APOSTOLAKIS: No, no. That's not what I mean. Strategy. I mean, it's a concept that's not well-defined. So it can be at a fairly high level.

MR. COOK: I would like to take a --

MEMBER APOSTOLAKIS: Sure. Go ahead.

MR. COOK: The strategy is non-binding,

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period.

MEMBER APOSTOLAKIS: They just want to see that something is happening?

MR. COOK: It's an agreement. It's between the chairman and between the Secretary of Energy on an approach. And that's what it is. Ultimately the project once we have cost-sharing partners on board, they may want to deviate from it. But what we have all agreed to as staff is that if we meet the conditions from the design end, the NRC will meet their conditions from a research end. But it's not binding because there are other players still to play.

MEMBER CORRADINI: But it is in some sense. Just to make sure that I am on the same page, once stated and you have got an agreement between the Secretary of Energy and the NRC Commission, that at least is the plan. There may be --

MR. COOK: It is absolutely the plan.

MEMBER CORRADINI: There may be off-ramps or modifications to the plan, but that's essentially the stated plan that could be modified. I don't think they have to go back.

MR. COOK: Well, we probably would just because they want to be informed. And it calls for

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periodic external review with reports to Congress. So I think if we were to deviate in a significant way from the licensing strategy, we would probably owe it to Congress to at least brief them if not file a new report.

MR. BASU: That would be post-August 7, 2008, I presume. So why August 7, 2008? We will present to Congress something.

MEMBER CORRADINI: Right.

MR. BASU: And then it will be delivered around by Congress.

So what is this NGNP? What's the machine? It's an advanced reactor concept to nuclear electricity production and hydrogen cogeneration. And that, by the way, is also spelled out in some sense in the Energy Policy Act language that this next generation nuclear plant will be able to produce electricity or hydrogen or both. So that's where it comes from.

Now, initially in that next generation nuclear plant basket, there was a variety of designs that were contemplated as an evolution of the GEN IV designs, but ultimately very high-temperature gas reactors report the design of choice, at least from the DOE's vantage point. And for the purpose of

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today's discussion, we are defining a very high-temperature gas-cooled reactor as the reactor outlet temperature on the order of 900 degrees C and above.

The reactor uses TRISO-coated particle fuel with either the UO<sub>2</sub> kernel or UCO kernel. Trevor talked about a little bit of that. And I will have a cartoon later on.

It uses helium as coolant and graphite-moderated reactor. And I already said it's a couple of hydrogen plant. And for the purpose of defining the technology envelope, it was determined that the hydrogen plant power would be about ten percent of the reactor power.

Now, in principle, that's not a limitation. You can actually have more than ten percent in terms of the process heat utilization, but this is for the --

MEMBER CORRADINI: That is the minimum required by the design. Is that the way I understand it?

MR. BASU: Yes. For the purpose of, yes, the strategy development, that is what it is. And as far as the process is concerned for hydrogen, there are a number of processes that are being looked at,

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which includes the thermo-chemical process, the hydrate chemical and high-temperature basis.

So this is the cartoon of the machine. Basically it's a hydrogen pressure gas reactor. And then the process heat from the hydrogen pressure can go into gas turbine through the generator and produce electricity. It has the electrical aspect of the NGNP, electricity production aspect of NGNP, all the processes that can be taken through a series of heat exchangers through a steam process unit to produce hydrogen from steam dissociation. And that plant can be also powered by the electricity generated by the hydrogen gas reactor.

MEMBER APOSTOLAKIS: Did you say "or"? You said helium will take heat of the reactor --

MR. BASU: Well, the outlet helium, which is at about 900-plus, can be used as a process for --

MEMBER APOSTOLAKIS: Can be?

MR. BASU: Well, would be. It will be in the --

MEMBER APOSTOLAKIS: Will be.

MR. BASU: -- in the NGNP design.

MEMBER CORRADINI: It must be designed to do at least ten percent.

MEMBER APOSTOLAKIS: Right.

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MR. BASU: It will be.

MEMBER APOSTOLAKIS: That's, however, our design.

MR. BASU: For the NGNP design, yes. It will be, at least ten percent.

Okay. Here is the other cartoon that I was referring to. There are two types within the envelope of the HTGR, one that we put as pebble bed that uses the  $UO_2$  fuel kernel in the TRISO coating. And that may be a TRISO-coated particle. And hundreds of thousands of these particles go into this racquetball or the golf ball thing, which is graphite also.

The other type is these fuel particles that are actually put in compacts, on a compact, and then goes into, again, a graphite core structure, embedded in graphite core structure. And that's the prismatic.

Okay. Going back to the memo before elements of the licensing strategies and going back to the licensing approach, here the -- let me go back about a year. About a year or so ago; to be exact, in November 2006, DOE and NRC formed a working group to work on the licensing strategy and, in particular, the element, this element, which is the licensing

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approach.

So this group looked at various licensing options, starting from the statutory requirements to process options and looked at the process options again. Let us remind ourselves that the act language says ways in which you can adapt the current LWR regulations. So we looked at Part 50 and Part 52 options, process options.

We also looked at the technical requirement options. And those options ranged from deterministic approach to partially risk-informed approach to fully risk-informed.

MEMBER APOSTOLAKIS: What is the difference?

MR. BASU: Between the two?

MEMBER APOSTOLAKIS: Yes.

MR. BASU: All right.

MEMBER CORRADINI: We needed you here yesterday.

MEMBER APOSTOLAKIS: Excuse me. I mean, does it mean in the partially risk-informed approach that you have some risk information that you don't want to use because it's partial?

VICE CHAIRMAN BONACA: It's insights, the insights.

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MR. BASU: Let me see if I can explain the difference.

MEMBER APOSTOLAKIS: Come on. You have rehearsed this. Don't tell me you are improvising now.

(Laughter.)

MR. BASU: George, for you, I can never be ready.

MEMBER APOSTOLAKIS: You're killing me.

CHAIRMAN SHACK: Sud, you were born ready.

MR. BASU: We start with the deterministic approach. And that goes to licensing basis event selections to SSC classification to defense-in-depth and all of those. So that's --

MEMBER APOSTOLAKIS: You mean the design basis event, not licensing basis. Design basis is the traditional terminology, right?

MR. BASU: For the light water reactor. Now, we have to change our lexicon.

MEMBER APOSTOLAKIS: Oh, okay. But it is the event.

MR. BASU: Yes.

MEMBER APOSTOLAKIS: Okay. Okay.

MR. BASU: So we start with that deterministic. And then we form a sort of, if you

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will, universe of events that we need to consider for that. And we say, well, you know, some of these events are probably very, very low likelihood. So we bring the PRA insights into that. And then we say, well, maybe some of the events can be dropped from our consideration.

So that's one aspect of the partially risk-informed. The other aspect is there are regulations requirements that meet the requirements in Part 50 that can be also partially risk-informed. I mean, some of them can be risk-informed. As opposed to fully risk-informed, what we do is we start with the PRA.

And then we have this, again, universal event, if you will, but a much smaller universal event. And we say, well, we're not really confident that we have covered ourselves with all the events that need to be considered for safety case. So we bring the deterministic judgment, the overly deterministic judgment.

MEMBER APOSTOLAKIS: This is more or less the technology-neutral framework, is it not?

MEMBER CORRADINI: Don't go there. That's the fourth bullet.

MEMBER APOSTOLAKIS: No, but that's what

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we do in that --

MR. BASU: In terms of the activities, right?

MEMBER APOSTOLAKIS: The selection of the licensing basis events.

MR. BASU: That's one aspect.

MEMBER APOSTOLAKIS: Yes.

MR. BASU: But no. If you want to do this third option, fully risk-informed, starting on a clean slate, a clean piece of paper, no Part 50, Part 52, we start everything from PRA. And we write new regulations. That will be the fourth line, "New body of risk-informed performance."

MEMBER APOSTOLAKIS: Yes. I don't see much difference between that and the third bullet.

MR. BASU: Between that and the third?

MEMBER APOSTOLAKIS: Yes, but --

MR. BASU: In terms of the actual elements that go?

MEMBER APOSTOLAKIS: Right. The importance is how you implement these words is really the important thing. Okay?

MEMBER STETKAR: Right. I think, though --

MEMBER APOSTOLAKIS: It may be the

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terminology. I will show you risk-informed. I mean

--

MEMBER STETKAR: One example, George, in here that might help explain --

MEMBER CORRADINI: We are talking about what is being presented.

MEMBER STETKAR: -- is that a partially risk-informed approach might still require the single failure criterion for every safety system. And a fully risk-informed approach might say that one train is sufficient to mitigate a low-frequency accident.

MR. BASU: You may be able to --

MEMBER STETKAR: That is one subtle difference that is okay for this one.

MEMBER APOSTOLAKIS: That would be, actually -- I mean, you really wanted to play with the words, that would be a risk-based approach. If it's risk-informed you can still accommodate this. As I say, the words probably don't mean much until we see what you actually mean by them. But I just wanted to have some --

MR. BASU: I think --

MEMBER APOSTOLAKIS: No. The report is more discussion. I mean, I read that part. But I really don't like partially risk-informed. Okay? It

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sends the wrong message. Right?

MR. BASU: I think --

MEMBER APOSTOLAKIS: You have risk information, and you only use part of it?

MEMBER CORRADINI: I think the way I look at --

MEMBER APOSTOLAKIS: Is that what it means?

MEMBER CORRADINI: Can I repeat what Sud said? Because the way I heard it is from the second bullet, say bullet number two or option number two, they start with a deterministic framework. And they use the PRA and the risk insights to modify what their choices might be.

MEMBER SIEBER: The design.

MEMBER CORRADINI: Right. And in bullet three or option three, you might reverse that paradigm. You start with the --

MEMBER APOSTOLAKIS: Exactly. It's a matter of emphasis.

MEMBER CORRADINI: It's a matter of emphasis where you start. That's what I thought I heard.

MEMBER SIEBER: Or you may do the design as a risk basis but then afterwards include

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defense-in-depth measures and so forth.

MEMBER APOSTOLAKIS: Yes, absolutely.

MEMBER SIEBER: And so that would be partially --

MEMBER APOSTOLAKIS: A risk-informed approach would do that.

MEMBER SIEBER: Yes.

MEMBER APOSTOLAKIS: It would do. It would ask the question --

MEMBER SIEBER: It would do it, but it would be partial. I mean, once you take that extra step to partial.

MEMBER APOSTOLAKIS: Maybe it would be better to say a risk-informed deterministic approach. That's really what you said. It will be deterministic, but it will be risk-informed.

MR. BASU: And you will be satisfied with that, George?

MEMBER APOSTOLAKIS: For the second, yes.

MR. BASU: Risk-informed deterministic?

MEMBER APOSTOLAKIS: You are asking me to provide you a binding agreement?

(Laughter.)

CHAIRMAN SHACK: Until he finds out what you mean by it.

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MEMBER CORRADINI: You have 70 minutes of agreement. Go ahead.

MEMBER APOSTOLAKIS: That's what it is. It's a risk-informed deterministic approach.

MEMBER SIEBER: Let me ask a question just to clarify in my own mind since I wasn't at the subcommittee meeting. Are you going to license the reactor or are you going to license the reactor plus his chemical plant and all of this other stuff?

MEMBER ARMIJO: Just the reactor.

MEMBER SIEBER: Then you are going to have to build infrastructure between the reactor and everything else --

MR. BASU: Very good question.

MEMBER SIEBER: -- in order to be able to protect the reactor and let the rest of the plant do whatever it decides to do.

MEMBER BANERJEE: Yes. The only problem is hydrogen tends to detonate.

MEMBER SIEBER: Well, that's one problem.

MEMBER BANERJEE: It doesn't deflagrate. It detonates.

MR. BASU: In a confined environment.

MEMBER BANERJEE: Are you kidding? This is --

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MEMBER APOSTOLAKIS: I think they are licensing the reactor. Is that correct?

MR. BASU: That is correct.

MEMBER BANERJEE: And you are not considering hydrogen detonation?

MEMBER CORRADINI: No. We're considering all hazards.

MEMBER SIEBER: Well, that's an external hazard.

MEMBER APOSTOLAKIS: Everything that can affect the reactor is considered.

MEMBER CORRADINI: Absolutely.

CHAIRMAN SHACK: We can't have multiple discussions.

MEMBER APOSTOLAKIS: Sorry.

CHAIRMAN SHACK: One at a time.

MEMBER APOSTOLAKIS: Yes. I think we should talk at least three at a time.

MEMBER CORRADINI: Jack had a question for you.

MEMBER SIEBER: I think the question has been answered. If you license the reactor and all of this other stuff, the chemical plant becomes an external hazard.

MEMBER APOSTOLAKIS: Exactly, exactly.

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MR. BASU: You are absolutely right.

MEMBER APOSTOLAKIS: Otherwise you have considered all of the safety aspects.

MEMBER SIEBER: Well, they are linked very tightly, you know. When you actually build it, all of the pipes are going to connect. Conceptually from a nuclear standpoint --

MEMBER BANERJEE: Are they really going to do this? Can I --

MEMBER SIEBER: It is a hydrogen plant with a generator on the other side.

MEMBER APOSTOLAKIS: So in this case, then, as Professor Banerjee says, hydrogen can detonate. Your job --

MEMBER SIEBER: It wouldn't do that.

MEMBER APOSTOLAKIS: Your job will be to see if such a detonation occurs, what happens to the reactor.

MEMBER CORRADINI: Yes.

MEMBER APOSTOLAKIS: If you were licensing the plant also, then you would also put regulations in place to prevent the detonation. It's none of their business to do that. That's the difference because they are not licensing the hydrogen plant.

MEMBER BANERJEE: These plants are very

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intimately linked. I don't see how you can --

MEMBER APOSTOLAKIS: But, still, it's only the consequences that they would worry about. If there is a blast coming from the hydrogen plant, what do we do? How to prevent it is --

MEMBER BLEY: Or some feedback mechanism through the connector.

MEMBER CORRADINI: It would be the equivalent of the electrical grid, right, if you have a feedback from the electrical grid?

MEMBER BANERJEE: That is a little less dangerous.

MEMBER CORRADINI: Maybe.

MEMBER APOSTOLAKIS: They never said that it would be easy to license.

MEMBER SIEBER: It is conceivable that the chemical plant could be one of the safety features; in other words, absorbing heat out of the reactor plant. In that case, you have --

MR. COOK: Then we would have to regulate the chemical plant. It is not our intent to get into regulating these process heat end user activities.

MEMBER CORRADINI: Nor is it the PIRT.

MR. COOK: We are not allowed to.

MEMBER BANERJEE: Are you going to

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consider the chemical? I mean --

MR. COOK: You've got to.

MEMBER SIEBER: You've got to.

MEMBER BANERJEE: There's going to be this electrolysis unit and oxygen and hydrogen and all of this stuff.

MR. COOK: We will have to look at all of the releases that are possible and all of the consequences from all of those things.

MEMBER STETKAR: Sanjoy, the equivalent is when we worked at PLG. We did a risk assessment on the Midland nuclear generating plant, a portion of which heat was used for Dow Chemical across the river.

MEMBER BLEY: Steam was going across the river.

MEMBER STETKAR: Steam was going across the river for process heat. And as a necessary hazard, we had to evaluate effects from the chemical plant: feedback effects, releases, you know, you name it.

MEMBER BANERJEE: But there was quite a separation there, right?

MEMBER BLEY: A lot more physical separation.

MEMBER STETKAR: Less than a mile for a

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huge plant.

MEMBER BLEY: It's a large plant, a huge plant.

MEMBER SIEBER: Which they never built.

MEMBER STETKAR: Which they never built, but that's a different story.

MEMBER BLEY: It's huge. The chemical plant was there.

MEMBER STETKAR: A huge chemical plant.

CHAIRMAN SHACK: It still is.

MEMBER STETKAR: The Midland plant is still there. It just doesn't reflect the reactor.

MR. BASU: And there will be separation, by the way, also in this plant. And the separation, minimum separation, distance will be based on all these potential hazards you're talking about: detonation load and other hydrogen burning and corrosion and explosion of other ground-hugging gases, et cetera.

MEMBER BANERJEE: And there is no way that hydrogen could get into this nuclear plant?

MR. COOK: If it does, we have to analyze for what those effects are, make sure the plant can handle them.

MEMBER SIEBER: Yes. Well, right here --

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MR. COOK: Basically I wouldn't presuppose anything except that it will all be analyzed, it will all be open to the public, and it will be --

MEMBER CORRADINI: Stay tuned.

MR. COOK: Okay. Exactly.

MR. BASU: Can I move on?

MEMBER CORRADINI: Please do.

MEMBER BANERJEE: Scary stuff.

MR. BASU: So what the working group also found based on our analysis of various technical requirement options, licensing options, and the various options is that there are some key technical areas where we will need to have knowledge base developed, you know, appropriate technical basis for licensing review, and also technical basis for later infrastructure development. And I restate some of these here.

Fuel performance is one area at the top of the list and fission product transport source term issue, the high-temperature materials, graphite. And all of these Trevor also talked about.

MEMBER APOSTOLAKIS: What do you mean by "evaluation model"?

MR. BASU: These are the analysis tools for the accident analysis.

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MEMBER APOSTOLAKIS: So that would include the concerns that Sanjoy is --

MR. BASU: Absolutely, yes. Yes.

MEMBER APOSTOLAKIS: Okay.

MEMBER BANERJEE: In which part of it?

MEMBER APOSTOLAKIS: The last one, "evaluation model."

MR. BASU: "Evaluation model development and assessment."

Now, the working group also identified potential policy issues, such as defense-in-depth, use of PRA in the licensing process, source term, functional performance.

I will not bet these are not new issues. These issues did come up in the context of previously HTGR review. These issues were tabled before the Commission. And the Commission actually deliberated on these issues. The Commission approved some. The Commission disapproved.

MEMBER APOSTOLAKIS: Not in the context of --

MR. BASU: Not in the context of NGNP, but in the context of ACG. Then, again, you know, if you see the generic nature of the reactor plan that's going -- we have to go back and we have to revisit

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this in the context of NGNP, but what I am trying to say is that it is nothing new.

Okay. I am moving to the second element of the licensing strategy. That is the NRC need for analytical tools. And I mentioned that when we put together this working group over about a year ago, that at the same time also NRC in collaboration with DOE initiated an expert elicitation process, which we call PART process; that is, phenomena identification and ranking table process.

We actually applied that process previously in the context of many other issues. It turned out to be a very useful process for us to identify areas where R&D will be needed and also how we can prioritize our R&D.

MEMBER BLEY: Excuse me. Sud, but have you folks ever thought of applying the same general technique to operational issues and human interface issues early in the process so that those things can be potential problems identified and solved before you get the physical design far along?

MR. BASU: Good question. I'm not sure if I can answer you that question whether we thought about it. You know, I guess my breadth of knowledge only extends to more technical issues, but you were

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talking about human factor issues. I'm not sure.

I'm looking at a gentleman over there.

MEMBER BLEY: Wouldn't it be a good idea to do something like that early on?

MR. BASU: I think so. I do not know how I'm going to -- this is strictly due to my ignorance.

I don't know how I'm going to scope out that, but I'm sure there are, you know, resident experts here who can speak to that.

MEMBER CORRADINI: Does somebody on the staff want to comment or try to answer?

MR. BASU: Anyone?

MEMBER CORRADINI: Okay. Farouk?

MR. ELTAWILA: Your question is related to human factor issues.

MEMBER BLEY: Not just human factors.

MR. ELTAWILA: Yes.

MEMBER BLEY: My question was, you know, as designers, we typically focus on the physical phenomena --

MR. ELTAWILA: Yes.

MEMBER BLEY: -- and put all of our effort there. And we build a machine. And we start tacking on the operational issues and the human performance issues. Have you thought about doing something akin

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to the PIRT on operational and human performance issues early in the design process --

MR. ELTAWILA: I believe --

MEMBER BLEY: -- to identify the key issues to resolve early on?

MR. ELTAWILA: I remember from my old organization yes, we had a PIRT panel to address the human issue, but it is completely not related to the NGNP but related to advanced reactor design. And they identified a different phenomena and the effect of each of these phenomena and what is the information that we need to develop. I will look back and see if the report has been issued or if it is in the process of being issued here.

So we have convened a separate group on the human and operational issue of the plants, yes.

MEMBER BLEY: Okay. My follow-on was, why not do it specifically for this plant as well?

MR. ELTAWILA: I think, in retrospect, if I can say I must probably focus on the modular type of reactor, which will be similar to the NGNP. So I don't think there would be a measure.

MEMBER CORRADINI: It is a generic study. I will just ask the staff to take note of what it is. And we will get a copy of it when published.

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MR. ELTAWILA: We will definitely make it

--

MEMBER BLEY: Great. Thank you.

MR. BASU: Thank you, Farouk. So, actually, we are doing better than I thought.

(Laughter.)

MR. BASU: All right. So --

MEMBER BANERJEE: It is a pretty goofy concept, I must say.

MR. BASU: Yes, it is. Yes, absolutely.

MEMBER APOSTOLAKIS: What concept?

MEMBER BANERJEE: I mean, tying this thing to a hydrogen plant is a really goofy concept. You have hot gas next to a hydrogen heat exchanger.

MEMBER SIEBER: This is really a rocket ship.

MEMBER BANERJEE: Look at the diagram.

MEMBER APOSTOLAKIS: This is way above our pay. Somebody much more powerful has decided these things. We just want to make sure it is operating safely.

MEMBER SIEBER: Well, they've built HTGRs before, and they've built technical plants before. There isn't any reason why you can't pull them together.

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MEMBER BANERJEE: Yes, especially with a common heat exchanger.

MEMBER SIEBER: Well, you put isolation valves. Then you need to cool it.

MR. BASU: If we all agree to whatever we're agreeing to, let me go over this slide.

MR. COOK: I should just say one thing. I don't want to derail anything. They don't have a common heat exchanger.

MEMBER BANERJEE: Isn't that yellow thing?

MR. COOK: Forget the cartoon in that drawing.

MEMBER CORRADINI: That is a bad cartoon.

MR. COOK: It's the cartoon.

MEMBER BANERJEE: You are being misled by the cartoon, then.

MR. COOK: Yes. If you go back to the presentation that I gave --

MEMBER CORRADINI: This is DOE again.

MR. COOK: That is not DOE's cartoon.

(Laughter.)

MEMBER CORRADINI: No offense.

MR. COOK: I actually stripped all the cartoons from this presentation compared to yesterday's because that was mainly to speed things

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up. They could have stayed in.

The tables, though, there's a table here, slide 5, I think. It says, "Power conversion cycle: indirect." What that means is there will be this intermediate heat exchanger, which is going to isolate the reactor from this process heat user.

So there is a loop for the reactor heat. Then there will be another loop that will go over to a process heat exchanger that will then connect to the end user.

So there is an intermediate heat exchanger. Then there is a process heat exchanger. Then there is the end user.

MEMBER CORRADINI: I thought you were going to ask questions about the economics of it after all of these indirect cycles.

MR. COOK: Yes. We take a three --

MR. BASU: Sanjoy, the design is evolving. We stole this cartoon from an earlier generation --

MEMBER BANERJEE: Hopefully we will forget hydrogen in the next administration and do something else.

MR. COOK: Make battery acid.

MEMBER BANERJEE: Make batteries. Now, that makes sense.

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CHAIRMAN SHACK: There is the molten salt heat exchanger.

MR. BASU: Are we still on?

MEMBER CORRADINI: Still on.

MR. BASU: Okay. Getting back to the PIRT, we put together five expert panels addressing five major technical areas of NGNP: thermal fluids and accident analysis, hydrogen burning materials.

Hydrographite was a separate panel, even though it shows here including graphite. There were two panels. And there was a panel on the process heat and hydrogen cogeneration, some of the issues that, Sanjoy, you brought out. Those have been actually discussed in that panel and efficient transport and consequence. That was a panel there on that issue, on that subject.

The point is, though, we also conducted a tricyclic fuels PIRT in the context of HTGR. We have a published report. It's NUREG/CR-6844, which you probably have seen if you are --

MEMBER BANERJEE: Is the pebble bed reactor a serious contender or it's out of it?

MEMBER APOSTOLAKIS: What was the question?

MR. COOK: Yes. I didn't quite catch it.

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MEMBER SIEBER: It's a contender.

MEMBER BANERJEE: Is the pebble bed reactor a serious contender to this or it's out of it?

MR. COOK: There are three pre-conceptual designs that have been put out there that were solicited and that have been developed. One is the pebble bed. One is GA prismatic. And one is an Areva prismatic. They have small differences between them. The pebble bed is slightly bigger. Areva and PBMR went for indirect steam cycles.

MEMBER SIEBER: Right.

MR. COOK: But the program has decide don the indirect --

MEMBER BANERJEE: Is there a helium turbine yet? I've never heard of one that operates.

MEMBER SIEBER: Yes. Fort St. Vrain had one.

MEMBER BANERJEE: Was it a direct cycle helium?

PARTICIPANT: There was one in Germany.

MEMBER SIEBER: Like a jet engine.

MEMBER BLEY: Oberhausen had one.

MEMBER BANERJEE: How big was it?

MEMBER BLEY: It was pretty good size, but I think they had a lot of problems. It was 20 years

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ago or more.

MEMBER SIEBER: It's about the same size as a reactor vessel.

MEMBER BANERJEE: It's pretty hard to build a helium turbine.

MR. COOK: Yes. There has been a fair amount of developmental work on it. It would need to be built and tested or if we wanted to go in that direction, if any gas reactor program wanted to go in that direction, we would end up building probably a full-scale test, test rating.

MEMBER SIEBER: Right.

MEMBER BANERJEE: Have fun.

MR. COOK: That will be fun.

MR. BASU: So what did we do with the PIRT panels, we tasked them to identify safety-significant phenomena in their respective areas of expertise. And these are experts that were pulled together from academic, national labs, and international organizations.

We asked them to also assess the knowledge base for the important phenomena they identified. It's a six-volume report, NUREG/CR-6944 that's coming out. It's in publication. It will be available, I'm hoping, before the end of this month.

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We took the results of the process PIRT panel. And we identified the data gaps and the knowledge gaps. And we also identified the state of the analytical tools, existing analytical tools, to give us an idea of what developmental needs are, therefore, analytical tools.

I am just listing some of the very top-level high-level PIRT findings in thermal flow aids, very few phenomena that are design-specific. And here by "design-specific," I mean the difference between a pebble design and the prismatic design.

MEMBER BANERJEE: I don't think that's correct. I think that --

MR. BASU: I said there are a few. Obviously there are phenomena that are design-specific of --

MEMBER BANERJEE: It seems to me the most important phenomena for pebble bed is design-specific, which is the fact that you can get channeling and hot sporting and a whole bunch of stuff.

MEMBER SIEBER: Right, core random.

MEMBER BANERJEE: That has nothing to do with --

MR. BASU: Core flow can be design-specific, is design-specific for pebble bed in

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terms of how you model the core flow, but even in prismatic core, you need to account for core flow, heat transfer characteristics.

So if you look at the heat transfer aspects of it, how heat is transferred in terms of conduction, convection, radiation, that combination thereof, you still need to account for these things in both --

MEMBER BANERJEE: Yes. But, I mean, the phenomenon when you talk about a pebble bed because the distribution of pebbles is not uniform. And if you look at what is happening, you get regions where there are high-concentration regions, low concentrations. So these are changing dynamically in time and space. And you need to be able to handle the heat transfer in these areas of pebbles, which is an enormously difficult task compared to a prismatic.

So I think qualitatively even you are dealing with the different set of thermal hydraulic problems in the pebble bed than you are with the prismatic beds. I would say they were exactly wrong, that statement. It is exactly the opposite.

MR. BASU: I think the level of detail that you are referring to at this point, there are differences. And the differences have been actually

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discussed and identified. I was trying to give you a one-level-up type of perspective that there are -- I mean, one still has to deal with the core flow issue, the heat transfer issues in both reactor types. There will be differences, granted, and some of the differences that you pointed out will be taken into account in terms of --

MEMBER BANERJEE: Well, what I mean is you will need to develop a different set of analytical tools. You will need to develop a different set of experiments. I see almost nothing in common between the two concepts. There is nothing generic about it.

MR. JOLICOEUR: I think what Sud has been trying to say is that --

MEMBER BANERJEE: Yes, we all have to deal with heat transfer. For every reactor, you have to deal with heat transfer.

MR. JOLICOEUR: I think what he is saying is the importance measurement of these different phenomena may have a few differences among the designs. But we know that the specifics are going to have to be analyze differently when we generate our tools for doing the analysis.

MEMBER BANERJEE: We are going to need different tools.

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MR. JOLICOEUR: Yes.

MR. BASU: Sanjoy, your point is well-taken. I think you are one slide ahead of me.

MEMBER BANERJEE: Oh, okay.

MEMBER CORRADINI: Go to the next slide.

MS. BANERJEE: This is Maitri Banerjee. Can I just suggest a fix, if we put "a fuel phenomenon"?

MR. BASU: Okay. Just very quickly, in the high-temperature materials and graphite areas, many phenomena are manufactured in fabrication and design-related. And we acknowledge, the panels acknowledge, that the vendor's R&D program is in place or planned. So we can actually benefit from the outcome of these programs.

In the process area, the panel found that very few phenomena are generic. And that in large part is because the design of process applications is an ever-evolving subject. So naturally depending on which particular thermo-chemical process you use for hydrogen generation or if you use the high-temperature electrolysis and what other components come into play in the processing design, there will be phenomena that will assume more importance than some other phenomena. So that's what they found. There are very few

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generic phenomena.

And in the last bullet, we said that a longer-term R&D report and fuels and fission products are among them.

MEMBER CORRADINI: Just to help Sanjoy, John looked it up. Look at volume 1, table 7. Everything you have been asking about has been identified within the PIRT. That's at the level of detail I think that you're curious.

MEMBER BANERJEE: Yes. I am just dealing with the word "generic." I think there are very few generic phenomena. That's all. I'm saying most of them are design-specific issues.

MEMBER BLEY: Sud, I'm sorry. On that last slide, can you back up to it?

MR. BASU: Sure.

MEMBER BLEY: With your second to last bullet that you just talked about, there are mostly specific phenomena dealing with the process heat area. Is there anything in that that reflects back on the reactor that makes us less confident in the ability to just be licensing the reactor and looking at the process heat area as an external black box?

MR. BASU: And we already talked about in the last few minutes hydrogen detonation issues.

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Explosion issue is one of them, explosion of actually other gases, oxygen. If you are using electrolysis product, your byproduct is oxygen.

MEMBER BLEY: Now you have oxygen coming back toward you.

MR. BASU: And oxygen, which is heavier gas, ground-hugging. It may be coming towards a reactor plant. And that may cause some concern.

If you use the sulfur iodine, sulfur iodine cycle for hydrogen generation, it will be closer to byproducts.

MEMBER BLEY: And you are looking at things possibly coming back in --

MR. BASU: Coming back.

MEMBER BLEY: In the return streams?

MR. BASU: In the return, yes, which is --

MR. COOK: It is more along the lines of if you have tanks with hundreds of gallons of sulfuric acid and they rupture, for whatever reason --

MR. BASU: Those things are --

MR. COOK: -- and I run the tractor into it, you have to look at the fumes, the plumes, and the flows on the ground and all of that stuff.

MEMBER BLEY: I guess the thing I still keep hanging on -- and it has to do with what Said

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said yesterday -- is with this connective system, you know, the idea that maybe something is coming back to you that --

MR. COOK: You've got low pressure on the end user side and high pressure on our side.

MEMBER BLEY: Normally, normally.

MR. COOK: If there's going to be anything going, it will be going that way.

MEMBER BLEY: Normally.

MR. COOK: Yes. I think --

MEMBER BLEY: That's the thing. If you start believing in that too much --

MR. BASU: But we did, the panel did consider that, any uncertainty on the chemical plant side, what impact it might have, how that upset is going to propagate through the intermediate system on the reactor side and what impact it will have on the reactor. That was considered.

MEMBER BANERJEE: My only hope is that this will remain an academic exercise.

MEMBER CORRADINI: Let's move on. On that note, let's move on.

MR. BASU: So out of that exercise, what we identified are analytical tools in a number of areas, analysis tools in thermal fluids, accident

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analysis. This slide is quite generic. And I probably have -- well, I'll speak from this slide, confirmatory analysis tools in terms of fluids, fuel behavior in fission product areas. In thermal fluids, for example, we need to be able to model the core flow and heat transfer characteristics, some of the issues, Sanjoy, you pointed out. We need to be able to model the RCCS, thermal fluid behavior and performance. Also, there is the issue of the reactor kinetics feedback, how that ties in with the thermal fluid analysis.

In the fission products transport area, there are these whole fission product transport issues in the generic sense that are not any different from the LWR except that when you try to analyze this in the context of NGNP, then, you know, all of those other details show up, the fission product retention, the kernel, and then the transport through the metrics, graphite to primary system to the containment/confinement environment and pick out what pleasant important goal there is the generation of dust. And that's unique to HTGR to the NGNP design.

MEMBER BANERJEE: I was actually going to ask you about dust transport. I mean, this seems a very important problem and --

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MR. BASU: It is. It is important.

MEMBER BANERJEE: How are you going to be handling that?

MR. BASU: Well, if you look at the dust particle size in terms of the mean, average mean mass diameter, kind of, they are in the range of aerosol particles. We do have models for aerosol transport.

MEMBER BANERJEE: Are you in touch with the South Africans on this because they have done quite a bit of work on this?

MEMBER CORRADINI: Westinghouse is. That's part of the team.

MEMBER SIEBER: They are a contractor to this.

MEMBER BANERJEE: Okay. Because this is one of the significant issues. We have been talking to Mike and Min. We have been trying to not get involved with it at all, but --

MR. BASU: No. We do recognize that.

I want to focus on the last two bullets on this slide. We do recognize the needs for safety analysis tools, confirmatory tools, but here is the strategy that we are adapting in order to meet the act, Energy Policy Act, schedule. Our strategy is to modify and adapt existing tools that we have for NNGP

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applications. These are safety analysis tools, system-level code, MELCOR to be precise.

But, to supplement that with special purpose tools, like the CFD tools, for the type of calculations you were referring to, we do need that. And some of those activities are already in progress.

We also have a strategy to utilize tools and data from domestic and international program to the maximum extent feasible. We will maintain independence in our analysis. And by that, I am really alluding to that there are data available from the applicants' programs, from the vendors' programs.

We will try to get the maximum benefit out by using that.

MEMBER BANERJEE: One of the issues that has arisen with things like this is how transparent and how -- so when we use a code for confirmatory analysis, like RELAP-5 or TRACE, we have the source codes. We know everything.

Now, if you are going to do any confirmatory analysis, the concern -- and this is I think a very general concern, which is entering more and more, -- and you will see in Dana's R&D report, it will be there -- is the lack of transparency of using commercial tools to do analysis where we don't know

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precisely what is there. So we are using these as black boxes.

Now, it's okay if a vendor does and we approve it, but our own confirmatory tools need to be transparent, at least to us, and that we should at least have the source code and things.

And so when somebody says, "Okay. I'm going to do this calculation at CFX and I'll do it with fluid," it means nothing to me because, first of all, they're owned by the same people. Secondly, we don't know what the hell is in them. So I think there has to be a strong push to develop transparent tools that you own and you know yourself or you have the source code.

MR. BASU: Your point is well-taken.

MEMBER BANERJEE: Yes.

MR. BASU: I think that's an issue with --

MEMBER BANERJEE: Actually, it's becoming worse and worse all the time.

MR. BASU: Typically with the CFD types of tools, of course, the tools that we will develop using the CFD as the building block, let's say, we will have the source code. But what is in that building block may still not be that transparent. And we have to work towards that to make sure.

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MEMBER BANERJEE: At least the NRC will know what's in it if nobody else knows. You know, this is part of the problem now using these other commercial codes like black boxes.

MEMBER CORRADINI: Just one digression.

MR. BASU: Yes?

MEMBER CORRADINI: Aren't there open source CFD tools now being developed?

MEMBER BANERJEE: Well, that's got to be like NIST's fire models, for example, because it's open source. We know what the hell is there, you know, and so on.

MEMBER CORRADINI: I think that's the take-away. Sanjoy's point is I think very important.

MEMBER BANERJEE: Yes, it is very important.

MR. BASU: In fact, in one of the current programs, CFD development, we are using the open source program. So we will have that.

In the next slide, I have indicated needs in other technical areas. These are technical areas that were not covered by the PIRT panels. And some of these needs are not necessarily analytical in nature. There may be some data that we need to have not necessarily generated ourselves but data that we need

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to have from other programs that are in place or planned.

I mentioned some of these areas: the structural modeling of concrete or high temperatures; the high-temperature instrumentation and sensor technology; the human factor issues; and, finally, the PRA tools.

On the PRA tools -- and then George is looking at me, I see -- there are a couple of initiatives in place. It's a regulatory guidance initiative at NRC. And then there is also an ASME initiative to develop the PRA standards.

MEMBER APOSTOLAKIS: For what? For the high-temperature --

MR. BASU: Application and yes, yes. So I think --

MEMBER APOSTOLAKIS: South Africa I believe has already done the PRA, haven't they?

MR. BASU: Who?

MEMBER APOSTOLAKIS: South Africans for the pebble bed.

MR. BASU: Not that I'm aware of. Stu can probably --

MEMBER APOSTOLAKIS: Wait, wait, wait. They have not done it or you have not seen it?

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MR. BASU: Stu Rubin in the audience can probably --

MR. RUBIN: Stu Rubin, Office of Research.

Can you repeat the question so I understand it?

MEMBER APOSTOLAKIS: Has the South African utility done a PRA on the pebble bed yet?

MR. RUBIN: Well, the licensing approach in South Africa, as we have understood it through our discussions with NNR, did not use the PRA as extensively as we, you know, are applying it in this country for applications. But a PRA, as I understand it, has been performed by the applicant.

MEMBER APOSTOLAKIS: Has been done?

MR. RUBIN: Yes.

MEMBER BANERJEE: So are they taking, just for information, more of sort of like a DBA approach to licensing or what are they doing there?

MR. RUBIN: Well, they provided us with regulatory documents that are specific to the PBMR. And there is one on licensing basis event selection. And it describes the acceptable methodology for licensing the PBMR demonstration plan in that country. So if you want a copy of it, we can make that available to you.

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MEMBER BANERJEE: Yes. That would be very interesting. Thank you.

MR. BASU: Okay. Well, I don't know that we really need the next slide, "Other Infrastructure Needs." These are names that in the course of licensing review, we always look for and we want to have.

Staff training and skill development turn out to be quite an important area because, like the LWR, for which we have plenty of experience, we don't for HTGR. So that figures prominently in our plans.

Okay. So where are we in terms of documentation? The strategy report is due to Congress August 7, 2008. I mentioned that. And that is a work in progress at our end. There is a technical basis report that supports the congressional report. That is also a work in progress.

I mentioned about the PIRT reports. It is in publication. And as soon as it comes out, you are welcome to have copies. There is a PIRT report on fuel that was published July 2004. That is also available.

So what is next? We are expecting to finalize the draft of the basis report, technical basis report, next month. We will have a first draft

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of the report to Congress March 2008. And we will come back to the full Committee in April 2008 to give you another status report.

MEMBER APOSTOLAKIS: That will be on what? Are we going to write a letter or we don't write a letter?

MR. BASU: I think the subcommittee chairman --

MEMBER CORRADINI: We are planning to write a letter.

MEMBER APOSTOLAKIS: Oh, really?

MEMBER BANERJEE: When is the letter due?

MEMBER CORRADINI: Our letter is due. It is hoped we have an opinion in the next five months.

MEMBER APOSTOLAKIS: An opinion we have now.

MEMBER MAYNARD: Let me make sure I understand what the licensing approach is. Basically we're going to take the existing regulation --

MR. COOK: We can't discuss that exactly in detail.

MEMBER MAYNARD: Okay. If we have to do a letter on this -- and most of this was discussed yesterday in the subcommittee.

MEMBER APOSTOLAKIS: Yes.

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MEMBER MAYNARD: I'm not sure how we as a full Committee write a letter on this if we're not covering the material.

MEMBER CORRADINI: So let me try. Are you asking me or are you asking them?

PARTICIPANT: He wants whoever has the answer.

MEMBER MAYNARD: I'm asking you. You may have to ask them.

(Laughter.)

MEMBER CORRADINI: My impression is there are three pieces that we can comment on at a level of detail that still has to be open. The letter I've got a hold on that. I have to think about that.

MEMBER APOSTOLAKIS: Why does it have to be open?

MEMBER CORRADINI: It doesn't have to be open necessarily. But if it were an open letter, we can comment on the PIRT process; that is, the results. We have all of the six or seven individual reports, one published, six that are in the publishing stage.

We have the work or the work or the discussion we have had here relative to what they are doing, what are the options. We will eventually get the staff's with management review recommendation.

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If we go forward with discussing that, I think then a letter would have to be closed. If we want to simply comment on that we're happy with the staff's efforts and the joint work and everybody is happy and we decide that is as far as we go, that could be an open letter.

MEMBER BANERJEE: Mike, can you explain why things have to be closed?

MEMBER CORRADINI: I can give you my interpretation, -- and then they will tell me I'm wrong -- which is that the original EAct 2005 requires cooperation, which means there has got to be an agreement between the Secretary of Energy and the Commission. And until the Congress hears and reviews that, it's pre-decisional. Anything we discuss is a recommendation within the structure.

MEMBER BANERJEE: Okay.

MEMBER CORRADINI: Did I do it okay?

MR. ELTAWILA: That is correct.

MEMBER CORRADINI: It was a test.

MEMBER MAYNARD: For the record, I was not at the meeting yesterday in the closed session. So when I started out my question trying to understand, I do not know what was discussed yesterday in that session.

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MEMBER CORRADINI: Right.

MR. COOK: For the record, I didn't mean to be rude. I just wanted to --

MEMBER MAYNARD: No. And that's fine. That was appropriate. That's good.

MR. BASU: If I can respond to you, we discussed pretty much the same thing that we have discussed today except for the fact that we did not --

MEMBER APOSTOLAKIS: Don't lead to it.

MR. BASU: No, no. I mean, we could not because this is --

MEMBER APOSTOLAKIS: I know. I know.

MEMBER MAYNARD: I understand. I was just trying to figure out --

MEMBER APOSTOLAKIS: I don't even think we can have an open meeting in April.

MEMBER MAYNARD: -- and understand what --

MEMBER APOSTOLAKIS: It's a waste of time.

MEMBER CORRADINI: Yes. I mean, if --

MEMBER APOSTOLAKIS: We have a closed meeting or nothing.

MEMBER BANERJEE: So we have a closed meeting.

MEMBER APOSTOLAKIS: Yes. I mean, you know, there was no meat to this, and this is not your

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fault.

CHAIRMAN SHACK: My understanding is we can have a closed meeting, pre-decisional, but we will check with our designated federal officials on this.

MEMBER CORRADINI: We will check with the designated federal official and work on this and get back to you.

MEMBER BLEY: What do you want from us?

(Laughter.)

MEMBER APOSTOLAKIS: It's important.

MEMBER CORRADINI: Other comments?

CHAIRMAN SHACK: We feel your pain.

MEMBER APOSTOLAKIS: I had a comment, but I forgot.

MR. COOK: If I could clear up something that I said, something that occurred to me afterwards?

On the gas turbine business, the gas turbine that GA was talking about was a big one, a big 600-megawatt gas turbine.

MEMBER SIEBER: Yes.

MR. COOK: So that I wouldn't feel comfortable without a full size prototype on a rig and really test that thing out. MHI has got designs for gas turbines, helium gas turbines, that they're willing to want at smaller sizes for the PBMR

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application in South Africa.

MEMBER BANERJEE: But has anybody ever built on?

MEMBER SIEBER: There have been HTGRs before that have had these.

MEMBER BANERJEE: Here is what I was asking. Because I know I have been to the gas turbine lab, actually, in Takasago, it's not that simple to build a helium gas turbine.

MEMBER APOSTOLAKIS: I remember. The previous Commission did not want the ACRS to comment on policy issues. Is developing a strategy a policy issue?

PARTICIPANT: Yes.

MEMBER APOSTOLAKIS: Then it's none of our business unless the Commission, the new Commission, feels differently.

MEMBER CORRADINI: So are you trying to escape out of this?

MEMBER SIEBER: No.

MEMBER CORRADINI: This is definitely --

MEMBER APOSTOLAKIS: Yes. They made it very, very clear. You are a technical Committee. We don't want your advice when it comes to policy.

MR. JOLICOEUR: Maybe I can clarify a

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little bit. I think, as a minimum, you would want to comment on our development of what technical tools we feel we need to develop the research and development portion of this.

MEMBER APOSTOLAKIS: But the most important thing is the proposed approach through licensing. You need analytical tools. You need them.

MEMBER CORRADINI: But if I could back up, I don't know whether this viewgraph was mentioned here. You can think about it that you were asking about what is partially risk-informed. To me that's a technical related issue in how we approach it.

We went through this whole technology framework discussion.

MEMBER APOSTOLAKIS: Yes, which I am not sure they are using at all.

MEMBER CORRADINI: Regardless, there are elements in what we were discussing today that very much ask the question.

MEMBER APOSTOLAKIS: Absolutely, yes.

MEMBER CORRADINI: And I think that is technical and that deserves some sort of comment.

MEMBER APOSTOLAKIS: Do we all have the white papers as Congress submitted for --

MEMBER CORRADINI: We were given them a

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few months ago.

MEMBER APOSTOLAKIS: Do we have all of them?

MEMBER CORRADINI: Yes. We were given it a few months ago by the staff.

MEMBER APOSTOLAKIS: I don't remember those at all.

MEMBER CORRADINI: Yes.

MEMBER APOSTOLAKIS: The selection of the license and basis events?

MR. JOLICOEUR: There were four of them. And then there are two more that I think we just received last months.

MEMBER BLEY: Maybe it was before.

MEMBER APOSTOLAKIS: You should get them, too.

MR. RUBIN: The papers were submitted by PBMR. And one was on the PRA.

MEMBER APOSTOLAKIS: Oh, the white papers.

MR. RUBIN: One paper on the PRA, how they were going to do the PRA.

MEMBER APOSTOLAKIS: Do you have that?

MR. RUBIN: We have that.

MEMBER APOSTOLAKIS: I mean, you have it? I don't.

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MR. RUBIN: We have it, yes. It's publicly available. It's docketed. We have slide on it, publicly available. We have another white paper on their approach to selecting --

MEMBER APOSTOLAKIS: Right.

MR. RUBIN: -- licensing basis events, another paper on defense-in-depth, and another one on the special treatment of systems and so forth.

MEMBER APOSTOLAKIS: Actually, I would like to have copies of those, too.

MEMBER CORRADINI: Maitri will take an action item to get us all four of these for all of the new and the old members in case they misplaced them.

MEMBER APOSTOLAKIS: On a CD.

MEMBER CORRADINI: Yes.

MEMBER BANERJEE: How many megabytes is it?

MEMBER POWERS: It's small.

MEMBER BANERJEE: Even my Google thing is getting overloaded with megabytes.

MEMBER CORRADINI: Said?

MEMBER ABDEL-KHALIK: Dr. Basu, if the April 2008 meeting were to be held as an open meeting, what information beyond what you presented today would be included in that meeting?

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MR. BASU: Well, I don't think there will be anything significantly new. You will, of course, have the benefit of the PIRT reports. I talked about PIRT reports. You can only talk about so much. But you will have the details.

And that does address two of the four elements of the licensing strategy. So you will have a very complete set of information to at least reflect on those two elements.

The fourth element is really resource needs. So, you know, that's -- well, I guess the only thing that you will not have is the licensing approach part because of the pre-decisional nature associated with that. Other than that, you will have everything.

MEMBER ABDEL-KHALIK: Thank you.

MR. BASU: Sure.

MEMBER CORRADINI: Other questions from the members?

(No response.)

MEMBER CORRADINI: Hearing none, Mr. Chairman, --

MEMBER APOSTOLAKIS: Very good.

MEMBER CORRADINI: -- I turn it back to you.

CHAIRMAN SHACK: I think we are actually

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ahead of schedule.

MEMBER BANERJEE: Maybe we can not come Saturday morning.

CHAIRMAN SHACK: We can have a longer lunch. We will be back at 3:15 to discuss CAROLFIRE.

(Whereupon, the foregoing matter went off the record at 2:26 p.m. and went back on the record at 3:15 p.m.)

CHAIRMAN SHACK: We are back into session.

MEMBER POWERS: Mr. Chairman, Mr. Chairman.

MEMBER BANERJEE: Point of order.

CHAIRMAN SHACK: What is your problem?

MEMBER POWERS: We are going to discuss this CAROLFIRE stuff now?

CHAIRMAN SHACK: Yes.

MEMBER POWERS: I've got to acknowledge that CAROLFIRE was a collaborative effort and included among the list of collaborators Sandia National Laboratories. And I am associated with that institution.

CHAIRMAN SHACK: We won't hold it against you.

MEMBER POWERS: Well, in this case, maybe you had better and not pay attention to what I have to

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say.

CHAIRMAN SHACK: What else is new?

(Laughter.)

MEMBER POWERS: On that note, I will slink off.

MEMBER BANERJEE: We love you. You can't go away now.

CHAIRMAN SHACK: Sanjoy, we will hand it over to you while Dana slinks.

MEMBER BANERJEE: All right.

MEMBER BANERJEE: We will let Dana slink away. We have to write a letter here.

CHAIRMAN SHACK: Okay.

5) CABLE RESPONSE TO LIVE FIRE (CAROLFIRE)

TESTING AND FIRE MODEL IMPROVEMENT PROGRAM

5.1) REMARKS BY THE SUBCOMMITTEE CHAIRMAN

MEMBER BANERJEE: The joint meeting of the Thermal Hydraulic Phenomena and the PRA Subcommittees met on January 18th to discuss three reports on CAROLFIRE. The first had to do with the test description and test data. The second had to do with, really, form of the data, which was for fire model improvement. And the third was on modeling.

We heard from both Sandia and NIST and the staff on all of these subjects. And then today we

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will just get a little bit of review for the full Committee, but the main thing is that they need a letter from us. And the letter should hopefully give our views on whether the three reports, which are three NUREGs, should be published or not. That is the issue up there.

We also heard from the group on some fire PIRT work that was done, but they don't need anything like a letter on that today. So we are not going to discuss that today.

So today we will strictly talk about CAROLFIRE. I don't know if I need to remind you, but this is some work that was, primarily the experimental work was, primarily done at Sandia.

There were a set of small-scale experiments which were called Penlight and some intermediate-scale experiments which were more representative of actual cable fires. And they found also some interesting things, got a lot of interesting data. And then they did a nice little model. And you will hear about that today.

So, with that, I think --

CHAIRMAN SHACK: From our principal presenters.

MEMBER BANERJEE: Well, I am going to turn

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this over now to Mark Salley, who is the fire chief -- not fire chief.

(Laughter.)

CHAIRMAN SHACK: He thinks he's the fire chief. He's really a fireman.

MEMBER BANERJEE: It's a Freudian slip, guys. Okay? Chief of the Fire Research Branch. Sorry.

5.2) BRIEFING BY AND DISCUSSIONS WITH  
REPRESENTATIVES OF THE NRC STAFF

MR. SALLEY: With that introduction, thank you for having us here today. I am Mark Salley. I am the Chief of the Fire Research Branch in the Office of Research. And we would like to tell you about the CAROLFIRE program.

As was stated, we are looking for a letter from you today. You've seen CAROLFIRE a number of different times before, but we're at the end of the line with CAROLFIRE. It's a completed project. And we would like a letter from the Committee endorsing the work we had done. So the key for this meeting is to get to that letter.

We've got a little presentation for you, kind of the highlights of CAROLFIRE. Remember, this comes from RIS 2004-03. And this is a RIS that

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risk-informs the circuit inspections for the inspectors who are out there doing it.

Quite simply, the RIS, you'll hear more about that. But when the RIS was performed, February 19th, 2003, I believe, there was an expert elicitation, the who's who of cables in the nuclear industry, and Appendix R was there.

We had the meeting. It was a facilitated workshop. It was based on some testing that was recently done then by NEI and EPRI that gave insights to how cables fail, how hot shorts occur, the things you should look at. And it basically prioritized or risk-informed how the circuits will respond in a fire.

In the process of that meeting, there was a group called Bin 2, which Gabe is going to tell you about, where the group could not draw a consensus. And one of the big reasons for not being able to do that was there was not research or testing done for specific configurations. So it was basically anybody's opinion.

Well, we didn't want to risk-inform based just on opinions. So those were put in a parking lot or captured and referred to as the Bin 2 items; i.e., there needed to be more research in those areas. That was the prime thrust, the focus of CAROLFIRE. That

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was the user need in volume 1.

When we did this, when we saw this, we also have efforts that you saw; for example, 1824 that was the V&V for fire models. And we know what the inspectors were using. We know what the licensees are using. We know about the 805 transition. And from that, we learned that one of the things is the uncertainty in predicting cable failure was going to be a key issue.

So we had known that from parallel project that we thought, hey, with CAROLFIRE, why don't we take the opportunity to while we're looking at the circuit failures and the hot shorts, let's also collect the thermal data and let's put that in a volume. And when we have time, we can marry the two together and see if we can gather some insights and hopefully someday be able to reduce the uncertainty of predicting this and maybe develop that into a model. That would be done with the collaborative partner of ours, NIST.

The program worked very well. The team worked very well together. And we actually expatiated the work, which turns into volume 3, which is now where NIST, the primary fire researchers, can take the electrical information, the thermal data, put it

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together, and start to reduce this uncertainty in predicting cable damage.

So the program went very well. That's kind of the whole thing in a nutshell. Like I said, the two principal presenters will give you a little more insight on that.

Another thing with CAROLFIRE that we're going to talk about today is the review. As I look at this journey we have been on for a couple of years, this is the last train stop here and George will blow the whistle. This is the last stop on the train.

Because CAROLFIRE has an implication in the regulatory world of how did cables fail and what is risk-significant and risk-informing, we have tried to exercise every check and balance to make sure that we've got a good report. We have gone through a peer review for the Office of Research's protocol. And you will hear about that peer review.

The document was out for full public comment. We noticed it in the Federal Register. We received public comments. We addressed those. We submitted this document to the ACRS for a quality review to make sure that we were doing quality research. So a number of the members have reviewed this document in depth as a part of the quality

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research.

We also came back. And, as Sanjoy was saying, we did the presentation, basically the best part of the day presentations, again to the subcommittee, to make sure that we're getting it right. Of course, the final stop on this is to ask for a letter endorsing a product from the Committee. So that is the purpose of today's meeting.

The two principal presenters will give you the highlights and the overview. Mr. Steve --

MEMBER BANERJEE: You still have the principal wrong.

MR. SALLEY: Yes. I know. I'll let you get me for something.

MEMBER BANERJEE: It's a common mode error, right?

(Laughter.)

MR. SALLEY: Yes. It's "principal," instead of "principle." My bad. I take full responsibility for the improper use of the word "principle."

MEMBER BANERJEE: All right.

MEMBER APOSTOLAKIS: They have principles.

MEMBER BANERJEE: We stand by our principles.

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MR. SALLEY: It's scruples.

MEMBER BANERJEE: Presenting principles.

MEMBER SIEBER: The principle is your pal.

MR. SALLEY: I've got to remember that, Jack. Can I write myself a note here?

MEMBER SIEBER: Yes.

MEMBER BANERJEE: You could put a "P" on there.

MEMBER CORRADINI: As opposed to political presenters, right? As opposed to political presenters?

MEMBER SIEBER: Maybe I could offer a comment by asking --

MEMBER APOSTOLAKIS: This is a very innocuous slide that I'm sure these guys would present. And we're spending five minutes on it.

MR. SALLEY: Yes.

MEMBER APOSTOLAKIS: Who are these people, Mark?

MR. SALLEY: You're familiar with Mr. Steve Nowlen. You've seen Steve 100 times up here.

MEMBER APOSTOLAKIS: Where is he?

MR. SALLEY: Steve is sick. Well, even if he isn't sick, he has a 102-degree fever. He got the flu out there in Sandia. But even if he weren't sick,

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he would have been on an 805 inspection at Harris. There are a number of 805 inspections. So we weren't getting Steve anyhow.

So I've got Mr. Gabriel Taylor is going to present the part that Steve basically gave to you the last time in the overview. Gabe is a recent graduate of our NSPDP program. He's an electrical engineer by background from Penn State. He's a member of the Fire Research Branch.

And I thought we would break him in today by throwing him into the ACRS piranha tank.

(Laughter.)

MR. SALLEY: We will see how well Gabriel can swim as he gets thrown into the piranha tank. He's a graduate of my class. Gabe will give you the overviews. And I think he will cover the material for you.

MEMBER APOSTOLAKIS: Dr. McGrattan is a veteran.

MR. SALLEY: Yes. Kevin already has been through the ACRS a time or two. So Kevin will be here. And the key that Kevin is going to talk about is that volume 3. And that's kind of, I guess, the newer part.

Like I said, the work we had done -- and

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NIST is such a good, collaborative partner. They put a very big effort on it with us. And what we looked at was going to be a year down the road. It actually got sped up.

And the thing is we will be able to release CAROLFIRE as a complete package. Okay? It will kind of be like the trilogy, all three volumes, nice collector's set. You can take it, put it on the bookshelf there, kind of like the Star Wars movies.

We got the thing as one whole package. And this part of the package is complete. So it will go as a set.

MEMBER ARMIJO: Is this the end of the line on cable fire research --

MEMBER SIEBER: No.

MEMBER ARMIJO: -- or is this just the end of this -- it's the end of this project for sure, but what happens next on cable fire? What are the big open questions? Are there still --

MEMBER SIEBER: Let me interrupt your question by asking a more fundamental question.

MEMBER ARMIJO: A better question?

MEMBER SIEBER: No, not a better one, but it just precedes yours. Dr. Banerjee sent all of us an e-mail to suggest to him things he ought to put in

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his letter that weren't there. And I thought to myself after having reviewed this all at once that I have a bunch of comments.

And so I went and read all three NUREGs again. And I thought, "Well, there are lots of areas where it could be improved. For example, are the tests representative of, really, fires? Why don't we look at a distribution, rather than point values, and make those comparisons?"

The answer to that, which, Mark, you can fill in a little bit, is why you did the research in the first place. And the reason is because the staff wants to make some decisions. And those decisions are pretty fundamental and don't require a great amount of precision.

You may want to amplify on that just a little bit so everybody is starting off at the same level as to what we should expect and what you produced. Could you do that?

MR. SALLEY: Wow. Yes, I think I can. And I'll try to answer your question with that. When you go back in time and you go back to 75 Brown's Ferry, of course, where it all begins with the cable issues, the Brown's Ferry fire occurs.

Reg guide 1.75 was in place. Obviously it

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didn't do everything that folks at the time in the '70s thought it was going to. They looked at the event.

And four years later, in 1980, appendix R was promulgated. And appendix R, you know, you'll hear the utilities talk, but it's a very prescriptive requirement. And it's very inclusive. And if you really have had not had enough pain at that point, go talk to OGC and get their take on it. And they will finish giving you the pain.

But when you read it, what they want to tell you is you will protect all circuits and everything. And, you know, you get this panacea of "I'll protect everything in safety." You can't do it, especially in a plant that was built. And you need to get realistic levels.

The whole concept of risk-informing to focus the inspections on the pieces that really matter was the thrust of RIS 2004-03. And also history gets lost in time. You know, I, believe it or not, was once a young man doing appendix R stuff. And I'm getting a little gray.

But the lessons learned at Brown's Ferry -- some of the cable technologies have changed. When Brown's Ferry was built, it was primarily a

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thermoplastic cable, which we know about the failures.

Brown's Ferry instituted the whole cable industry to start going to the thermosets and to the values that that added in there. And the cable are advancing today into the Vitalinks, which we will mention, and different things.

I think that the more we do and the more -- you know, the nice thing about risk-informing, I'm not in any camp. Whether it's the prescriptive or the risk-informed, I fall in no camp.

But what the risk-informing forces you to do is it forces you a lot of times to ask harder questions. And I think that's a big part of what CAROLFIRE is. You know, what about a thermoplastic and a thermoset or what about two thermosets or what if one is silicone and one is PVC? It forces us to ask those hard questions that programs like CAROLFIRE attempt to answer. So we're trying to --

MEMBER SIEBER: Cable trays and conduits.

MR. SALLEY: Cable trays and conduits. That's a good one that Jack brings up that we all know from practical application that if I have a cable that's exposed and I get in a tray or an air drop and I have one in a conduit and I put a fire against the two cables, I would think that the one that will last

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longer will be the one in the conduit because we have to heat the conduit up to transfer the heat into the cable.

And we have known that, and we have used that qualitatively for 20-some years, but have we ever performed an experiment to say, "Well, how much? For a given fire, is it one minute, 2 minutes, 10 minutes, 30 minutes?"

CAROLFIRE in the work, especially that NIST did today, that piece, we can start answering it with good quantitative numbers today. So by asking the harder questions, the programs tend to push the science.

I think that answers yours, Jack, but --

MEMBER SIEBER: Well, yes, in a way, but what you're doing is the staff is trying to find direction as to where to focus their attention.

MR. SALLEY: Yes.

MEMBER SIEBER: And the outcome, particularly of volume 3 of the three NUREGs, gives enough data and insights so that they can decide what needs our attention first, what kinds of circumstances, situations, configurations are most important as far as cable failures are concerned. And really what this is is a direction-setting for the

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staff to be able to move forward on cable fires.

MR. SALLEY: Yes.

MEMBER SIEBER: And on top of that, in my view it doesn't need to be super accurate or super sophisticated because it's just going to be used as guidance. And the testing that was done, in the analysis that was done, including the formulation, is certainly sufficient for that.

But if you don't know that in advance, you could pick these things apart from the standpoint of configuration. Does the configuration match what's in the plant or are the formulations used to describe the data appropriate or are they too simple?

I think that if you keep that concept in mind, what it is used for, then it all sort of fits in place or at least it does for me.

MR. SALLEY: I see the point you're making, Jack. And Jack is absolutely right. If you look at -- let's take our inspection program. Okay? Back in the late '90s, we started going into the SDP, significance determination process, with inspections.

MEMBER SIEBER: Right.

MR. SALLEY: So it wouldn't be just you have a violation or you don't. But the question was asked, what was the risk significance of that

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violation? Was it a big deal? Was it a little deal?

Yes, it's a violation. But, you know, what wasn't?

The NRC's approach was to develop the SDP.

And that was a good thing. And we started proceeding down that risk-informed path. When you look at the fire piece, again it gets down to the cable damage.

And I can remember I was still in NRR at the time doing the early ones back in the late '90s when the program first went in. And we had to say, "When were the cables damaged?" That was the question.

Well, we looked at some things. We saw there were the two families: The thermosets and the thermoplastics. And generally we knew that around 400 degrees Fahrenheit, the thermoplastics would begin to fail and around 700 degrees Fahrenheit, the thermosets would begin to fail.

So the inspections that were done in that late 1990s time frame, 2000, if we saw fire that could produce a temperature of greater than 400 and you had thermoplastic cables, we could say, yes, the potential for damage is there. And that's where we were at the time.

We said, "That's good, but that's kind of a really rough cut." When we did 1805, we say, "We

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have some data. Let's lay it out."

Naimic Falls, Steve Nolan from Sandia, myself, we graphed it out. We gathered all of the available data. We said, "Hey, when cables fail, there's a mass." It's a thermal sink. It takes some time to heat the mass up to get it to fail. So it's not as simple as you've hit 700 degrees, you instantly fail.

We took that data, and we made a bunch of charts up. We said, "Yes, there is a time delay here." So that came out in about the 2003-2004 time frame.

Today we're taking another step forward with CAROLFIRE. And that's where we brought in the experts, like NIST, who can now go and do a predictive model for that.

So in a short span of let's call it eight years, you can see how we have taken the phenomena of cable failure and how we have tried to advance the science. And each time you do that, you get a little closer to reality. You know, the first cut of did the temperature see 700 degrees Fahrenheit? That's very conservative. That meant that as soon as the temperature saw that, instant failure. We know it didn't work that way. It's conservative, realistic

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conservative for the time.

But then we started advancing more. We start working the conservatisms out. We still have some margin in our calculations. And that is the point today.

So in science space, eight years, we have covered a lot of ground in my opinion.

MEMBER SIEBER: Well, time is important, too, because the results of this come out as, how long will the cable last? There is an assumption that if the cable will last for 20 minutes, it will have performed all of its safety functions in that amount of time. And the operator can then take them one by one as they come. That means thermosets are the cable to have.

Thermoplastic if it fails in less than 20 minutes, you'll get a spurious actuation. And the operator is going to be pulling his hair out. And so those are the ones of greater regulatory concern.

That concept helped me to understand why you did what you did and what you are going to do with the results when you get them. And I just thought I would pass that along because it modifies to some extent what I thought of the program, which is overall pretty good.

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MR. SALLEY: Thank you.

And, yes, a cable is not a cable. It does start breaking at the thermoset.

To answer your question --

MEMBER BANERJEE: Sam, why don't we do this? If you don't mind, hold your question to the end because we will get a picture of what was done.

MEMBER ARMIJO: Okay.

MEMBER BANERJEE: And then we will just try to address the question "Where now?" after this.

MEMBER SIEBER: And I'll keep quiet.

MR. SALLEY: We don't know all the answers.

MEMBER BANERJEE: Is that okay? All right.

MR. SALLEY: You can ask us at the end.

MEMBER ARMIJO: I expected something like that. And I just wanted to know what's next.

MEMBER BANERJEE: Yes.

MR. SALLEY: Yes, we do have some answers.

So, with that, let's turn the program over to Gabriel. And he is going to give you the kind of Readers' Digest version of the CAROLFIRE program.

Gabe?

MR. TAYLOR: Thanks, Mark.

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Good afternoon. My name is Gabe Taylor. I work in Mark's branch. And I will be giving you a brief description of the CAROLFIRE project.

Now, RIS 2004-03, as Mark mentioned, in two items was where this research was focused. The two items were items that when the expert elicitation panel met, they had a number of circuit configurations that they weren't certain the likelihood or even if they were possible failure modes. So they deemed those Bin 1 and Bin 2, circuit configurations that needed more research.

At the same time, as Mark previously mentioned, we also were lacking information in the fire modeling realm. And through combining the two needs --

CHAIRMAN SHACK: Next slide. Next slide.

MR. TAYLOR: Combining the two needs, we could then provide data from both areas in one test program.

Before I get into the Bin 2 items, I just wanted to find some terms so everybody is on the same page. We talk about intra-cable shorts and inter-cable shorts.

Now, an intra-cable short is a short within one single multi-conductor cable. You have one

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cable, got a bunch of conductors inside. It fail thermally and shorts within the single conductor. That's intra-cable.

Now, inter-cable is between two multi-conductor cables or two cables. They fail thermally or there is a thermal exposure. They fail electrically together, two cables, inter-cable shorts.

There is also a difference between thermoplastics and thermosets and how they fail in a fire. A thermoplastic --

MEMBER APOSTOLAKIS: Before you have the inter-cable, you must have an intra-cable failure?

MR. TAYLOR: No, not necessarily.

MEMBER SIEBER: You can have a single strand.

MEMBER APOSTOLAKIS: A single strand doesn't do it. A single conductor can --

MEMBER SIEBER: Yes.

MEMBER BLEY: They had some examples where --

MR. TAYLOR: Actually, the intra-cable for both a thermoplastic and a thermoset material, that's already in the Bin 1 of the RIS. And Bin 1 is the high-likelihood configuration. That's a good comment, though.

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As I say, the thermoplastic and thermoset, thermoplastics when they fail, they tend to soften and melt and drip. And I will have a picture later showing you.

Thermosets, on the other hand, when they fail, there is no melting. They just char. They blister, crack. That is their type of failure mode. They also void and --

MEMBER SIEBER: They keep their spacing.

MR. TAYLOR: Yes. They keep their spacing. It's not when --

MEMBER POWERS: They give off noxious chemicals that really play hell with the fission product chemistry.

MR. TAYLOR: Right.

MEMBER ARMIJO: But they don't ignite?

MEMBER BANERJEE: It depends whether they give a --

MEMBER ARMIJO: I don't know anything about fires. So these things don't actually ignite?

MR. SALLEY: Yes, they do. The cables do burn. The cables are combustible.

MEMBER ARMIJO: Okay.

MR. TAYLOR: And sometimes they --

MEMBER SIEBER: Not the wire.

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MEMBER BANERJEE: They are basically --

MR. TAYLOR: And the majority of the failures that we saw where the cables burned, they ignited right around when the electrical failure happened. So it seems that there is some relation to the electrical spark or the extra energy that ignites the cable.

MEMBER BLEY: Gabe, as I recall, most of your failures, you had electrical failure before you actually had flames, right?

MR. TAYLOR: Yes. In the majority of the tests, that did happen. There were a few tests where the cables did ignite before the electrical failure was monitored. So those are the two differences between the thermoset and the thermoplastic failure modes.

Let's look at Bin 2 items. There are six items in this research. Items A and B were for intra-cable shorts between two cables coming together, short electrically.

Item A was for two thermoset cables. Well, two thermosets come together and short. And, remember, they're the cables that tend to void and keep their physical configuration.

Item B was thermoplastics and thermosets

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because the thermoplastic tends to fail sooner than a thermoset will. How does that interrelate to the timing of the failures?

Item C was configurations requiring failures of three or more cables. Basically what this is asking is how many cable failures should I consider during a test. And the current guidance is to consider two cable failures.

MEMBER BLEY: Can I ask you a question? I hadn't looked at this closely.

MR. TAYLOR: Yes.

MEMBER BLEY: First, which kind of cable is this? This is --

MR. TAYLOR: The black cable is a seven-conductor thermoplastic.

MEMBER BLEY: Okay. They're both thermoplastic.

MR. TAYLOR: Yes, they're both thermoplastic.

MEMBER BLEY: And internally you can see that some of the conductors have moved together. So I guess as it begins to melt, they just shift?

MR. TAYLOR: That's typical of the failures of thermoplastic. And there are also internal stresses. The way the cables are

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manufactured, there's typically a center core cable and then six cables on the exterior, but they're spiral the whole way down. So it puts some internal stresses on that. As the cable is degrading that, it provides forces to push them together.

MR. SALLEY: As a side note, I'm sorry. I can't resist, Gabe. I've got to interrupt. That's a piece of history that you gentlemen are passing around there. Let me tell you a little bit about that cable.

That's a piece out of the NEI testing, which doesn't make it historic. I mean, I'm not too proud to dive in a dumpster after a test and cut some cable. That's obvious where that came from.

(Laughter.)

MR. SALLEY: But what is very special about that cable -- and, of course, I'm ex-TVA -- that is what TVA calls PJJ, which we had our own unique identifiers. What it is is a polyethylene-insulated conductor in a polyvinyl chloride jacket.

That cable is off the reels from the mid 1970s that TVA saved after the test. So those are the actual cables or the whole deal of the Brown's Ferry fire.

And TVA had saved a number of those for future testing. They were kind enough to give some of

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that up as the typical thermoplastic cable to NEI when NEI did the testing. So that's kind of a cool little piece of history that Dana has in his hand there.

MR. TAYLOR: And I would just like to mention Dana has those two thermoplastics there. The other cable specimen that is being passed around, there is a thermoset in the middle. And the other two cables are thermoplastic cables. You can kind of see the different failure modes.

So back to the Bin 2 items.

MEMBER POWERS: All I see is fission product chemistry being --

(Laughter.)

PARTICIPANT: One-track mine.

MEMBER BANERJEE: Well, the polyethylene may not do as much damage as the polyvinyl chloride.

PartiCIPANT: I forgot about that. That's right.

MEMBER POWERS: It depends on what chemistry you are looking at. The polyethylene is not an alkene. You could even go aromatic on the alkenes.

MR. TAYLOR: Okay. Item D is looking into how to control --

MEMBER BANERJEE: It would get aromatic. What is the temperature?

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MR. TAYLOR: How do controlled power transformers affect the likelihood of multiple spurious operations? Item D was looking at how long.

If you get a hot short, how long does it last? And that's used for different types of circuits and like a motor-operated valve. They have a certain stroke time.

So you can get a spurious operation that completely opens the valve or completely closes it or something that only lasts long enough where it ends up in an intermediate value. So timing is more circuit-dependent.

There is also item F in the Bin 2's. That was spurious actuations for cold shutdown circuits. Now, item F was not included in the CAROLFIRE project because there is no data that would be needed to resolve this item. It's more of an analytical problem.

It was a collaborative effort. The Office of Nuclear Reactor Regulation was the user need. They had the regulatory application that they needed the information for.

The Office of Research spearheaded the program. We have provided guidance and oversight of the project throughout its entirety. Sandia National

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Laboratories, they conducted all of the tests. They drafted the test plan. And they also wrote volumes 1 and 2. The principal contributors there were Steve Nolan and Frank Wyant, Sandia.

National Institute of Standards and Technology, NIST, and the University of Maryland had similar roles where they both were interested in collecting data that would help them through their fire models.

MEMBER APOSTOLAKIS: Which group at the University of Maryland?

MEMBER BANERJEE: Modarres.

MR. SALLEY: Modarres' Ph.D. students. We had two Ph.D. students involved.

MEMBER BANERJEE: We have the copy of the thesis.

MR. SALLEY: There was one successful thesis that came out of the research at CAROLFIRE for undergrad students.

MEMBER APOSTOLAKIS: The other guy failed or what?

(Laughter.)

MR. SALLEY: Kevin, you were working with him on 2D heat transfer. I don't know where --

MR. McGRATTAN: He disappeared and went

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back to Israel.

MR. SALLEY: Okay. As with most research, large research, projects, go through a peer review process. And CAROLFIRE is no exception. Early on in the project, after the test plan had been developed and in its final form, we sent it to the peer review process. You know most of the members up there.

One important contributor to this was Dan Funk from EDAN Engineering. Now, Dan, he was the individual who wrote the NEI EPRI report on the tests that they conducted in 2001. So he had a lot of insights that he provided to us of how you might do the experiments differently, what went wrong with his, what could you do to make a better program basically. So it offered a little continuity between the two programs.

The CAROLFIRE approach, two scales of testing: small scale, where we use radiant heating; and large scale or intermediate scale is what it has been classified as, where you use an open flame environment, burning environment. Both scales, they both provided data for both need areas: the fire model improvement and the Bin 2 items.

Now, the small scale, we used a facility called Penlight. It was formerly known as SCETCH, or

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the severe combined environmental test chamber, as used back in the environmental qualification base to qualify various electrical components.

So the Penlight structure is basically an Inconel shroud surrounded by quartz lamps. The quartz lamps heat the shroud, which acts as a gray body radiator that provides radiant heating of the specimen, in our case cables that were located within the shroud. For the experiments, we can put cables in trays, conduits, or air drops.

Fire modelers, as Kevin will present later, really liked the small scale because it provided a well-known thermal environment for the cables. Sandia actually uses this facility to calibrate some of their heat flux gauges. So it's a very controlled environment.

Penlight also afforded us to conduct a lot of experiments quickly and cheaply, so economics. In total, there were 78 tests conducted in the Penlight facility.

This slide here shows some of the configurations. One point I wanted to make out is that if you look at the figure on the left, there are two cables running through there. But this is only considered a single cable test.

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Why the two cables? Basically we found out before that if you wanted an instrument for thermal and electrical failure, you couldn't put it in the same cable because the thermal system would interfere with electrical and electrical system would interfere with the thermal system and you would get erroneous data.

So basically what we did is one cable would be monitored for electrical. In this figure, it's the one on the left. The other one would be monitored for thermal response. And we tried to put them in symmetrical locations within the same.

We also ran conduit and air drops. I might mention that the cable tray in the previous figure was 12-inch standard steel galvanized cable tray that's found in a lot of nuclear plants.

Now, here is where we get into the failure modes of the two different classes of cable. Thermoplastics, when they fail, they tend to melt and drip, just as it shows in the picture and the samples that were passed around.

Thermosets char, flake off, void. And also the temperatures that they fail at, as Mark mentioned, the thermoplastics fail at a lower temperature than the thermosets typically. Within

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each class, there are variations of the robustness of the different types of cables.

All right. On to the intermediate scale.

Now, the intermediate scale was more representative of what we find in the plants, basically trays of cable in stacked orientation.

It was very similar in size to what NEI conducted their tests to in 2001 and in the intermediate scale really get to the heart of answering the questions of RIS 2004, the Bin 2 items.

In total, there were 18 tests conducted in this structure.

Now, it would have been really nice if we could just go out there and grab IPEEE standards and an ASTM standard and use that to test the cable functionality of the different cables we wanted tested.

To our knowledge, there is no standard out there that we could use. So what we basically had to was develop our own standard to conduct our tests.

We based the room size on the ASTM 603 room fire test. We made it a little higher, which allowed us to have a four-foot-high hot gas layer. So if you see on the figure, the top portion is enclosed to capture the hot gases to create the hot gas layer.

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Now, the different locations where the cables could be located at, if you can see location A, which is right above the flame, that would be exposure to the flame range. And the two locations above that would be plume exposure, and the four exterior locations would be more of a hot gas layer exposure. So in one test, we could possibly get all three different types of exposure. So that gave us a lot of versatility in running our tests.

The fire source was located in the center of the structure. And this testing rig was located within a larger room to reduce the environmental effects: Wind, that sort of thing.

For our tests, we used propene gas. It's also known as propylene. It gives you a very sooty, smoky fire, typical of what might occur out in the nuclear plants, oil spills, plastics burning, cables burning, that sort of fire.

We typically started out the fire at 200-kilowatt. And as the cable is damaged in the center locations, we would increase the temperature exposure to induce some more thermally damaged hot gas layer for the exterior locations.

MEMBER ABDEL-KHALIK: Was there any attempt to quantify the luminosity of the flame?

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MR. TAYLOR: That's a good question. Kevin, do you have --

MR. McGRATTAN: No, no, although typically sooty fires like this tend to be fairly luminous. But there was no measurement of it.

MR. TAYLOR: The next slide just shows some of the different configurations that we could run in this test, single cables, bundles, filled trays for the cable, air drops, conduits.

One point that I want to mention that I didn't bring up previously, any of the locations where we didn't run because not all the locations were used in every test. The locations where we didn't run tests, we would block the opening up with some kind K/o wall to maintain the gases in there, in the hot gas layer.

MEMBER STETKAR: Gabe, just my own, you said you ran 18 of these intermediate-scale tests? How many of those use what you're classifying here as random fill trays?

MR. TAYLOR: I believe there were four. Is that?

MR. McGRATTAN: There were four incidences. I think that there were two tests, and in each test there were two trays randomly filled.

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MR. TAYLOR: And those tests, I believe that they were in location A, which was the bottom configuration, A and B --

MR. McGRATTAN: Well, A is just about --

MR. TAYLOR: -- or A and C.

MR. McGRATTAN: So the random filled trays were here and here.

MR. TAYLOR: And they would ignite and provide more heat source.

So what cables did we use? You could go out. And there are just literally thousands and thousands of different cables that you could use. So how did we get to the 15 that we tested? Well, you could go out and just get a thermoplastic cable, polyethylene-insulated, polyvinyl chloride-jacketed, get a whole reel of it and just use that for your thermoplastics, get a cross-linked polyethylene with a hypalon jacket and use that for your thermosets. Just do that.

And you know you can say, "Well, this cable is a thermoset, failed like this. And so, therefore, all thermosets fail like that." That's really not the case because there are different levels of robustness in each family of cable types.

So what we did was we looked. We picked a

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cable that would provide the most robustness to thermal failure, something that was right in the middle of the road, and something that was a weaker performer for each class. That was one of the ways we determined what cables we used.

We also picked cables on its popularity. What is out in the plants today? What is the highest percentage of what cables are being used? Traceability. A lot of these cables are qualified IEEE 383, which is considered nuclear-grade cable. So we wanted to get a cable like that.

Now, we did run into a problem here with the traceability that a lot of these cable manufacturers have either gone out of business, been bought out by another conglomerate, or just don't make that type of cable anymore because there's no longer a demand. So we only found a couple that had a really long history.

The fire models were interested in the physical composition, basically looking at the copper-to-plastic ratios. A power cable, three-conductor, would have more copper in it than plastic and, say, an instrument cable, even though that their diameters were similar. So they wanted to see how this difference would affect the failure of

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the cable.

We also had to worry about cost. The manufacturers specify a minimum purchase order. And you might be 1,000 to 5,000 feet when these cables run \$18 a foot, some of them, not all of them.

MEMBER SIEBER: You use three feet.

MR. TAYLOR: Yes. It gets pretty expensive. We had to consider that in our --

MEMBER POWERS: The purchasing the cable is an inspiration because there's a copper surcharge based on it. Plus, you buy a spool. Okay? If you went 5,000 feet and there's 5,100 feet on a spool, you just bought 5,100 feet.

The funny thing is they never end up with 490 feet on here. It's always 550 feet.

MR. SALLEY: But Dana doesn't tell you the real story. When Sandia calls in to any cable manufacturer, immediately red lights go off.

(Laughter.)

MR. SALLEY: "Why do you want cable? The last time we sold you cable, this little thing called 50.49 appeared in the regulations. Why are we going to sell you cables?"

MR. TAYLOR: We basically ended up taking 15 cables. Nine of them were control cables. The

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instrument and power cables were used for the fire modelers' purposes. The heart of the Bin 2 items really dealt with the control cable.

And we didn't include any armored cables in our tests. It originally was in the test plan, but we learned that Duke Energy was conducting these tests at the same time. So we didn't want to duplicate their efforts.

This is a picture of the cables that were just passed around, 15 cables. Item 15, that --

MEMBER BLEY: I'm sorry. I think you said something the last time. But are those Duke results done? And have they published? And are they --

MR. SALLEY: The Duke stuff we were lucky enough that Duke informed us. We looked at their test plan. As a matter of fact, Gabriel went on and witnessed the whole Duke program.

Talking with Duke, when they had approached NEI and wanted to do some collaborative effort, they didn't get any partners. So Duke had to go it alone. And part of the uniqueness is with the Duke configuration.

With the Duke plants, they have used armored cables throughout the plant. So you won't find any of the common jacketed that the rest of the

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utilities use. You'll find armor all throughout the Duke plants.

So the fact that they had to go it alone, they looked for partners, they didn't get any, it became a Duke proprietary test. So we went down. We witnessed it, and we did a report on it.

We then followed up with Duke. And they requested that we keep that information proprietary to Duke. So there is an NRC proprietary report that you can get. And there is also one that has been redacted that is out there for public consumption.

So, like I said, Duke had made attempts to get partners. They couldn't get any partners. So they basically took it all on.

MEMBER BLEY: And do other plants use the armored cable to an extent?

MR. SALLEY: You won't find the armored cable to the extent that Duke did. Like I said, they did the whole plant wholesale with armor.

MEMBER BLEY: Yes.

MR. SALLEY: Where other plants you may find it is if they went for like an equipment drop where they were worried about vibrations. They might have come out of a junction box, put an equipment drop on to the connection on a motor for vibrations. So

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there are pieces of it.

MEMBER BLEY: So it's very limited, yes.

MR. SALLEY: Yes. And I guess what Duke's strategy is or their thoughts are are that if somebody finds this in a lot of appendix R-type analysis, then they're going to have to talk to Duke and see if Duke gives them it or if Duke sells them, much like we did with pen seals 20 years ago where we were in the industry trading and selling pen seal-type data from proprietary testing.

MEMBER ARMIJO: Mark, this kind of cable is probably more expensive. Is it superior from a fire standpoint, just generally superior?

MR. SALLEY: That's a good question. Boy, I'll tell you when I saw the NEI test, did I get an education on armored cable. The armored cable, of course, has the metallic jacket on it.

MEMBER ARMIJO: Yes.

MR. SALLEY: And the idea is that if you run the armored cable, you don't have to run it in a conduit because of the physical protection that is already on here. Of course, there are trade-offs. It's a lot harder to work with. It's harder to fasten. But you get back the property.

What we saw in the NEI test that really

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fascinated me was some of the armored jacket you can cover with PVC. Okay? And you now make it watertight because it's now wrapped in PVC.

Of all the tests we saw with the NEI stuff, that was the best burning cable. And the dynamics of it were amazing because you had the PVC burn, much like this would, but you had that armor under the skin. So as the armor got hot, it conducted heat inward. So those were the best burning ones.

MEMBER BLEY: Best in terms --

MR. SALLEY: Excuse me. I'm talking like a fireman, instead of a fire protection engineer, there. They were the most rapid burning or the most combustible.

MEMBER ARMIJO: Interesting.

MR. SALLEY: The point that Gabe told me when he came back from the Duke testing and the Duke engineers had learned is that they then took the bare armored cable. So all you would see is the armor.

But, then again, if you think about how combustion and pyrolysis works, when the interior was getting hot -- and it's not airtight. So the vapor started coming out in the armored cable was burning away. So that panacea of "I've got armored cable. Therefore, it's noncombustible" is not a true

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statement.

Sorry. Yes. Go ahead. It got carried away there.

MEMBER POWERS: By the way, the fission product chemistry suffers.

(Laughter.)

MR. TAYLOR: The cable specimen has been passed around. They're shown in this photo here. Cable 15. That's a very important cable. That was our core thermoplastic cable, polyethylene-insulated and a polyvinyl chloride or -- yes, polyethylene-insulated, PCV --

CHAIRMAN SHACK: This is the TVA special?

MR. TAYLOR: Exactly. This is what started it all: the thermal process core cable for our test program. Number ten was the core thermoset cable. This is the Rockbestos Firewall 3, very popular, nuclear-qualified. And this was our core thermoset here.

Mark mentioned when Sandia orders cables from any manufacturer they start to think, "What's going on here?" And we got a call from the Rockbestos regional sales manager requesting, "Well, what are you guys doing here?" So we told him what was going on.

(Laughter.)

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CHAIRMAN SHACK: Updating something at the lab. We've got more cable.

MR. TAYLOR: So we let them know what was going on. And they actually had a new product, this Vitalink. And they supplied us some samples for free. And we actually conducted a few tests to see how it compared to what is out there now.

This is a cable that you might see in plants that come in the future, very robust. We had trouble failing it thermally. We did finally fail it when we suppressed it with water, but thermally --

MEMBER CORRADINI: Suppressed it with water?

MR. TAYLOR: Yes. In the intermediate scale test, in some tests where we --

MEMBER CORRADINI: So you burn it, douse and burn it?

MR. TAYLOR: No. We burn it. And if it didn't fail after a certain time, we would turn off the burner and douse it.

MEMBER CORRADINI: And that's where it fell apart?

MR. TAYLOR: That's where it failed.

MEMBER CORRADINI: So by some sort of thermal stress fracture.

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MEMBER POWERS: That is part of the standard tests.

MEMBER CORRADINI: There you go.

MEMBER SIEBER: The idea is never put the fire out.

MEMBER CORRADINI: Maybe not.

(Laughter.)

MEMBER CORRADINI: You're talking about Browns Ferry.

MR. TAYLOR: Very robust cable. The advertisement for this cable says that the chemical properties when this cable becomes heated, the insulation turns into a ceramic or it ceramifies. I don't know the properties behind that, but that's what they're advertising.

MEMBER CORRADINI: That makes sense, then, when you go out.

MR. TAYLOR: So how do we know when these cables stop performing their function? We use the Sandia insulation resistance monitoring system, or the IRMS. This is a very detailed system. It gives you a look at the resistance between conductors and between the conductors and ground. It's not circuit-dependent. It gives you the resistance of the cable.

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This was developed for report of the NRC, Sandia-patented. It was used in the NEI test. And there's a test report, NUREG/CR, that documents those results. And, actually, this summer this piece of equipment is going to be shipped to France for some IRSN testing that is being conducted over there. So we're going to educate --

MEMBER CORRADINI: Are the Sandia people going with the --

MR. TAYLOR: Sandia people are going to help with the tests. So we're going to educate the world on how we conduct cable functionality testing.

MEMBER POWERS: You weren't here, Mike, but --

MEMBER CORRADINI: I wasn't.

MEMBER POWERS: -- IRSN has a prior testing facility of some magnitude.

MEMBER CORRADINI: Cadarach?

MEMBER POWERS: In Cadarach. And Mark set up some sort of collaboration with them. I think it holds good promise for the future.

MR. TAYLOR: This slide here shows some of the detailed results. What is important with this graph is it's showing an inter-cable short between two thermoset cables. That's item A in the two items.

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So basically you can see on the vertical axis, you have resistance in ohms. And in the horizontal, you have time. Basically, the blue line is showing that cable C and cable B have a failure with insulation being reduced to less than 100 ohms at that bottom portion.

When we instrumented the test, we wanted to use the IRMS system on a lot of different cables. And to do that, we ended up ganging conductors together in different channels.

So you can see on the bottom portion of this figure we ganged three, five, and seven into one channel and two, four, and six into another channel. By doing it in that way, we could tell between intra-cable interactions and inter-cable interactions.

The IRMS system was used in all tests: Small-scale and intermediate. When we went to intermediate scale, we also introduced the SCVU system, or the surrogate diagnostic unit. Just call it the circuit simulators. It's based off the MOV circuit that NEI tested. And it basically is shown in the figure.

You have your power source. In our case, we tested various control power transformers. We had various source conductors, two source conductors,

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three targets, and one return.

Typically in a seven-conductor cable, one conductor is not used. So it's left just floating there. That's typical practice in the nuclear industry to not ground that conductor.

Each channel was monitored for current voltage by self-powered transducers.

MEMBER BLEY: Gabe, I am just curious. When these things start to fail, you start getting some big, huge current, probably is distributed over some area of failure. When you report ohms, you are just doing that by an Ohm's law calculation based on the leakage current.

MR. TAYLOR: Basically we're measuring the current going into one conductor. We're measuring the current coming out of a different conductor. And then we're switching it.

MEMBER CORRADINI: So they are going back and forth?

MR. TAYLOR: Yes.

MEMBER CORRADINI: Okay.

MR. TAYLOR: Back and forth with those four voltage measurements and well-known shunt resistors, we are able to calculate the current. And then using Ohm's law, we can find the resistance.

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MEMBER BANERJEE: Are you going to talk a little bit about the CPTs and the oversizing and stuff?

MR. TAYLOR: Yes, in the results section.

MEMBER BANERJEE: Yes. We'll do it then.

MR. TAYLOR: So thermal response, how do we instrument that? And this is really where the fire modelers came in and provided a lot of information on what kind of temperatures they really needed to help refine their models.

So we measured the exterior surface of the cable, the interior surface, or just below the jacket, so the temperatures that the insulation of the conductors are experiencing and also the core of the cable.

Now, for the sub-jacket thermal response, we actually made an incision in the cable and push the thermocouple up in through the cable four to six inches away from where the incision was made and get a more representative temperature. And the incision was later caused with the fiberglass tape.

MEMBER CORRADINI: And this is just below the jacket.

MR. TAYLOR: We also instrumented the raceways, the conduits, the cable trays in the

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intermediate scale. We had some thermocouples measuring the hot gas layer. Also you had some subcalorimeters in there, in the intermediate scale and that sort of measurements.

The data. One of the questions was, "The data is not in the report. Are you going to include it?" We had comments like that. Yes, we are going to include it. There's just so much data that we couldn't put it all in to the NUREG or it would just be too voluminous. So we are going to put all of the data on CDs that will be included with the final NUREG.

They are basically cell spreadsheets that provide a lot of information how the test was conducted; interpreting results; what failed when in chronological order; thermocouple map, where the thermocouples were placed; cost of electrical and thermal data; as well as we're also going to include the process data and the raw data. I don't know how much use the raw data will be, but it's in there.

MEMBER POWERS: It's good to know because bright values can come along in 20 years and have a better way of reducing data. You just never know. I mean, sometimes people say, "What do I do with all of this raw data?" And sometimes that is actually what

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they want.

MR. TAYLOR: Okay. In that case we are putting it in there. Actually, there is so much data it fills up a whole CD. It's really a lot of information.

MEMBER BLEY: Of course, in 20 years, it will be like having a mag tape now and convert.

MEMBER CORRADINI: Let me just ask a different question. Is this an open release NUREG so that anybody that orders it will get the whole shebang, including the data, --

MR. SALLEY: Yes.

MEMBER CORRADINI: -- including all of this data?

MR. SALLEY: Yes. That was our thought, that when we do put the paper NUREGs that you guys have reviewed in the back of each one, we'll have a CD. When we take that CD out, we get it. And it's going to be a public release.

MEMBER CORRADINI: So, just for pure curiosity, why not just put it on a Web site and you log on the Web site and download the data that you want?

MR. SALLEY: Our NUREGs will go on the Web site electronically.

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MEMBER CORRADINI: And the data, too?

MR. SALLEY: We can put the data on there also.

MEMBER CORRADINI: I mean, the only reason I am saying that is I am trying to think. It was the LOCA tests from ISPR. I can't remember now what they're called, LOBI, the LOBI tests. And they had essentially a protected Web site where you could download all of the data from all of the loss-of-coolant accidents, equivalent of semi scale, all of their data, once you were authorized to do it. So you could get pressure thermocouple measurements all the way along in terms of whether you want to do calculations and comparisons.

So that's what I was thinking, it was a complete -- I'm now trying to remember the name of the investigator at ISPR that developed a whole technique of doing it. His name is Annunziatto. And it will come to me the name of the technique in terms of the database he uses.

So you might want to look at that to just minimize the effort and use their approach to data filing.

CHAIRMAN SHACK: He's got an Excel spreadsheet, ain't going to move it anywhere.

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MEMBER SIEBER: Well, the NRC Web site has some size restrictions on it, how much stuff you can put out in one request.

MEMBER CORRADINI: But the only reason I mentioned this is that they started with the LOBI data. And then all of their severe accident data for FARO, for KROTOS, for these experiments for melt spreading, all of them entered on the same data sheet, same approach so that if you wanted to look at test X and you wanted to get all the thermocouple data, all the pressure data, you could just download it as needed, so just a thought.

MR. SALLEY: Yes, yes. We can look at that. And, like I said, this will go up on the public Web site. Funny story that you bring that up. The first time we ever tried putting an Excel spreadsheet on the Web site, it was quite interesting. If you remember back, NUREG-1805, we had the spreadsheets do the calculation. When we submitted that, they took all of our Excel spreadsheets and made .pdf files out of them.

(Laughter.)

MEMBER CORRADINI: The librarian you mean?

MR. SALLEY: Yes. Everybody downloaded these nonworking .pdfs as spreadsheets, and they

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wouldn't do anything. It took an act of Congress to get them to actually load an Excel spreadsheet up on there, but we can do a similar kind of approach and maybe break it out by tests so people can go into a certain test and just --

MEMBER CORRADINI: The only reason I know this is because I know the Europeans in terms of capturing knowledge from old experiments. OECD and NEA are now looking at this in a broader scheme, Carlo Vitanza and I'm trying to think of the other individual there in Paris. And, actually, they are trying to develop a very slim way of data sets, databases so that you can go in and then download what you want from various experiments because to me I think Dana's point is very well-taken. These experiments are key. And if you can now have them in some form that you can continually download and look at the data, it's excellent for future analysis and future development.

MR. SALLEY: All right. We'll take a look at that and make sure that we load this up.

MEMBER BANERJEE: You can give them the names, Mark.

MR. SALLEY: Yes.

MEMBER CORRADINI: Sorry.

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MR. SALLEY: No problem.

MR. TAYLOR: Thanks. Also public comment wanted some pictures put on there. So we're going to have another CD with a lot of pictures of the different experiments and how they are run that will also be included in the final NUREG report.

Now I just want to provide you with a quick refresher of the NEI test. I know I have been talking about them a lot here. This slide shows basically their testing configuration.

Mark likes to call this chamber the iron maiden. It's a quarter-inch steel chamber, square, eight-foot high. It's only got one door open on the typical sides. You see on the right there they have tested with a bend in their tray and conduit. They also tested with conduit. And that's something that we did not test because the bend puts extra pressure at the location, extra forces at the location, where the bend is.

We wanted to take a different look and see how these results compared to straight runs. You have both in the plan trying to complement the results of NEI.

MEMBER BLEY: You guys actually observed these tests, right?

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MR. SALLEY: Yes, yes. Research observed. They even commented on their test program, and they incorporate a lot of our comments.

MEMBER BLEY: Were those comments public?

MR. SALLEY: The original NEI ones? I do not know. I do not remember.

MEMBER BLEY: Would we learn anything looking at those?

MR. SALLEY: I think if you wanted to really see something, the report that Dan Funk put out in our library, the SCETCh report, this is probably the best single thing that had come out of it. That's what I go to when I want to look back.

MEMBER BLEY: Okay.

MR. TAYLOR: The Duke armored cable test that we mentioned earlier, they ran in the same configuration as the NEI test.

CHAIRMAN SHACK: In the same facility?

MR. TAYLOR: Same facility, yes, same chamber.

MEMBER BLEY: Same kind of problems with limited temperatures that I think --

MR. TAYLOR: No. In the NEI test, they tested with hard gas layers. So they elevated the cable tray to a lot higher off the ground. And that's

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where they ran into problems with sufficient hot gas layer to damage the cables.

What Duke did was they lowered the cable tray right into the flame region. So they had a little bigger burner. And the flames were impinging on the cables so you had cable failure a lot quicker.

MEMBER BANERJEE: There are a lot of slides to get through here. And you have about 35 minutes, including Kevin, --

MR. TAYLOR: All right. I'll try to sum up.

MEMBER BANERJEE: -- or less than that, 25 minutes.

MR. TAYLOR: So the results of this program, thermoset, thermoset, can it happen? I showed you the plot of the IRMS. It can. Thermoset, thermoplastic. There's one test where we use the surrogate circuit to monitor thermoset to thermoplastic. And it happened. So that's also a plausible configuration.

Item C. This is basically asking, "How many failures should we consider?" In all the test programs, there were four out of four failures in a test. So you had four circuits, all spuriously operated during the test.

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So our test report pretty much points out that there's no limit to the amount that you need to consider. There are other parameters that you need to consider, like the risk significance of the circuit being analyzed, the different way that the physical layouts are of the cables in the rooms and various other aspects.

Also, concurrent spurious operation is given properly sized CPTs. Now, we did look in the different sized CPTs. NEI used 150 percent of what their nominal circuit was. We looked in 100 percent, 150, and 200 percent.

In actuality, because of the way the electrical manufacturers specified their ratings, our CPTs were slightly higher than what we anticipated. So we ended up testing CPTs that were more like 160 percent of the nominal voltage.

Our research has shown that the CPTs didn't have any effect on reducing the likelihood of spurious operation, but they were a higher rating than the NEI test.

MEMBER STETKAR: Do you have any idea whether that would also apply to NEI if they looked at the -- nominally NEIs were 150 percent, but you thought yours was 150 percent also until you went back

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and looked at it.

MR. TAYLOR: Yes.

MEMBER STETKAR: Did you get any feedback from NEI regarding relative ratings of their CPTs? I'm just curious because your --

MR. TAYLOR: No. That's a good point.

MEMBER STETKAR: I mean, your results show that, at least in your test, there wasn't any effect.

MEMBER BLEY: And there were a lot more tests here. I guess reconciling the two things here, I haven't heard anything yet that completely makes sense to me.

MEMBER STETKAR: On that, that's right. And I was just curious because the NEI results make a big deal about whether you have --

MR. SALLEY: Yes, the NEI results, I'll take a shot at that. With the NEI results, you've got to remember, again, that the years had gone by since Brown's Ferry. And when the NEI program initiated and started up, their question was, we don't believe that you can have these hot shorts.

MEMBER STETKAR: Right.

MR. SALLEY: That was the premise that they went in with. The appendix R was fictionary. It was overreaction to Brown's Ferry. The reality -- and

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I can remember going to a RIC meeting. And there was some consultant they had. And he was telling us how overconservative we were if you remember that RIC five, seven years ago, whatever it was. So they went in with the premise that that wasn't going to happen.

When they started running their tests, if you look at the first half of the report and the initial tests, they were getting failures much more than they ever dreamed. And it's like, you know, what are we doing wrong?

So they stopped the test program halfway, you know, time out, and looked at it. And with all the electrical engineers, he said, you know, one of the things that we're missing is we're coming off line power, off the load center.

In reality, in the plant, we typically have a larger voltage that will step it down through a CPT. And that forms a control circuit for that. We need to put in CPTs.

And they studied it. And, of course, they put in a very close 150-volt amp CPT at the second phase of the testing. Now, what happened was when they went and ran similar tests in the first phase, you all of a sudden started seeing really chatter because now you would have enough amperage leakage or

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voltage that you wouldn't get enough to pull in the coil. You would have it chatter. So it became as a silver bullet that these CPTs are a magical device that, you know, take the 50 percent failure and get it down to 25 percent failure. So that is a good thing.

So that was why they had made those adjustments for it.

We wanted to explore that a little further. I believe the language that was used in the NEI stuff was a properly sized CPT. Just what does a properly sized CPT do? We bought a number of them here. In hindsight, I think we would have gone with tighter CPTs to try to prove their phenomena. But with the larger CPTs, we did not see that.

MEMBER SIEBER: Well, it's a design flaw to just a control power transformer as a fuse.

(Laughter.)

MR. SALLEY: Thanks, Jack. And it also follows on to the question you asked earlier. What did we learn now that we solved every problem? No because the second thing that I will throw on the table -- and Gabe is an electrical engineer. He can speak to it much better than I, but you've got to look at the end device and how the end device is rated for the polling coils and such.

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What you find in the manufacturer is there is a variance. And you can find very tight ones or ones that are somewhat less restrictive.

MR. TAYLOR: Item E was hot shorts lasting longer than 20 minutes. And our research has shown this is unlikely. When cables begin to fail, they tend to fail quickly and over a short period of time.

All the tests along this hot short lasted 11 minutes in the NEI tests.

So public comments. We had industry providing us some comments through NEI and also ACRS comments. As mentioned earlier, this went to the joint subcommittee on January 18th. And the NRC staff also provided extra comments that were incorporated into the report, final report.

MEMBER APOSTOLAKIS: I don't think we supplied public comments. Is that accurate? The ACRS comments are not public.

MR. SALLEY: No. These were separate, but we included them. We were in the process of doing public comments --

MEMBER SIEBER: These are all comments.

MEMBER APOSTOLAKIS: We just wanted to put us down, I think.

MEMBER BANERJEE: That is not a joke.

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MEMBER SIEBER: We have been downgraded,  
but --

MR. SALLEY: No, no, no, no, no, no, no,  
no. The point of that slide was while we were doing  
the public comment process and the team was resolving  
them, we also had the set of ACRS comments. And we  
said, "We'll resolve these also at the same time so  
they were" --

MEMBER APOSTOLAKIS: I understand that.

MEMBER BANERJEE: I think he knows.

MR. TAYLOR: Some of the key public  
comments that were resolved, we amended one of the  
tables in volume 1 to include some copper and plastic  
ratios by volume and by mass.

I know the ACRS was interested in the  
various thermal properties of the cables, the  
k-rho/C's. Actually, the University of Maryland  
students tried to contact the manufacturers to get  
these numbers. These are just proprietary. They  
don't give them out. So, unfortunately, we couldn't  
get a hold of these numbers. And the scope of  
CAROLFIRE didn't allow us to test the specific cables  
to find those values.

We also added a summary table to Penlight  
results and provided some new --

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MEMBER BANERJEE: Are there nominal properties for these materials available?

MR. SALLEY: Yes. And Kevin will explain that in detail.

MEMBER BANERJEE: Well, Kevin used some sort of homogenized properties and stuff like that, but if in the future somebody wants to actually use whatever are the nominal properties for polyethylene or PVC or whatever, is that available anywhere?

MR. McGRATTAN: No. These materials come in various several flavors. And there's no one set of data for, say, polyethylene.

MEMBER BANERJEE: But is there something which gives a range?

MEMBER SIEBER: You could search for it.

MR. McGRATTAN: Yes. I mean, if you look through the heat transfer literature, yes, you will find ranges. But we had a difficult time getting numbers for the models, quite frankly.

The manufacturer is none too eager to give that kind of stuff. In fact, I am not sure they are even measuring it.

MEMBER SIEBER: This guy was.

MR. TAYLOR: The second-to-last slide shows the new pots that were added to show the

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different types of configurations, tray, conduit, air, and then the temperature that they failed. The bottom one shows the different types of material and the temperatures that they failed. So you can compare between the different parameters.

The one on the right shows -- they see the one electrical failure happens when the cables ignite and the thermal response to the cable, Penlight shroud in this case.

MEMBER BANERJEE: Now, these are all sorts of things, like thermosets and thermoplastics and so on?

MR. TAYLOR: That's right.

MEMBER BANERJEE: Can you sort of tell us if there is any trend based on that as to the temperature failure?

MEMBER SIEBER: Between thermoplastic and thermoset? Yes, a graph that showed the different response times in volume 3.

MR. McGRATTAN: Thermoplastics fail at somewhere between 200 and 250 C. And thermosets fail somewhere between --

MEMBER SIEBER: Four hundred.

MR. McGRATTAN: -- 400 and 450.

MEMBER SIEBER: Yes.

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MEMBER BANERJEE: Right. So that is quite different.

MEMBER SIEBER: Oh, absolutely. And when the ramp temperature increases, that translates into time.

MR. McGRATTAN: Yes.

MEMBER BANERJEE: So those high points, they would be thermosets, right, or what are those?

MR. SALLEY: Those are in cable burnup.

MEMBER SIEBER: That is temperature.

MEMBER BANERJEE: I can't see very clearly.

MR. SALLEY: What you are looking at, quite simply, on this graph, the key is around if you look at the 600-second mark. See the dotted lines coming down? That is electrical failure superimposed on here.

MR. TAYLOR: That's on this one here?

MEMBER BANERJEE: Yes.

MR. TAYLOR: That's when the cable units.

MR. SALLEY: Is that the ignition? And the electrical failure is that one next to it? You can see how close they are. And, of course, isn't that runaway here when the cable is burning on temperatures.

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MR. McGRATTAN: Yes.

MEMBER BANERJEE: Right. But I'm talking about the left.

MR. TAYLOR: Some of these, like this one here, that was a preliminary Penlight test. In the preliminary Penlight test, we buried the exposure to try to find what temperature will fail the cable in a certain amount of time.

So I think the variance of the test influences the results. And that relates to your comment in the beginning using different heat exposures and how does it affect the failure.

MEMBER BLEY: I think in the subcommittee meeting, we talked about this. These plots are a little deceptive because of that because you don't see those underlying differences in the test when you look at these little dots on the boxes.

You had good stories about them, but the stories weren't associated with the pictures.

MEMBER BANERJEE: Well, it becomes even more important to deal with it when we come to the model. But, in any case, this would be useful to sort it by thermosets and --

MEMBER SIEBER: I was under the impression modeling was done correctly based on picking the right

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data to plug into it.

MEMBER BANERJEE: Yes. Modeling was fine.

MR. McGRATTAN: The models have been used.

This is an input.

MEMBER BANERJEE: Where the failure will occur.

MR. McGRATTAN: Right

MEMBER SIEBER: Right.

MEMBER BLEY: I've got a question going back to the very beginning. I forgot to ask this before. Bin 1. From your expert elicitation, Bin 1 is where the thing is most likely to fail.

MR. SALLEY: Yes.

MEMBER BLEY: That is probably obvious. Those things have probably happened for the most part. Bin 2 is where all of the effort is. Bin 3 were the things they felt uniformly were unlikely or least likely to fail. Did you look at any of those or do some of these tests give us some confidence that, in fact, those judgments are really solid?

MR. SALLEY: We focused on Bin 2. Bin 2 was the main focus. I believe when the RIS was revised to the current revision, they actually took Bin 3 out.

So what Bin 3 had is two armored cables,

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for example. They have a hot short between them. Is that back in there?

MR. TAYLOR: The original document still has the Bin 3 items in it. The revision has removed the Bin 3 items.

MR. SALLEY: Removed them? The Bin 1 items were basically the intra-cable shorting.

MEMBER BLEY: Yes.

MR. SALLEY: NEI saw that a lot. And all the expert panels agreed on that. This gets to the data that Dana was talking about. We saw a lot of that in CAROLFIRE.

MEMBER BLEY: Yes.

MR. SALLEY: That wasn't the focus of CAROLFIRE. So we gathered that data. We captured that data. And that's in the report. So we saw a lot of that Bin 1 stuff, but that wasn't our focus. So we didn't go back and beat a dead horse, if you will. They were Bin 1. They --

MEMBER BLEY: The only thing I was asking is the Bin 3 was things that the judgment says won't happen essentially, --

MR. SALLEY: Yes.

MEMBER BLEY: -- weren't worth thinking about. I'm just wondering if --

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PARTICIPANT: Have somebody check that.

MEMBER BANERJEE: Are there any Bin 2's there?

MEMBER BLEY: Yes. Effectively, yes. How confident are we of that or are we just buying into it or you guys --

MR. SALLEY: Actually -- and Dan Funk I see is here from NRR, and Dan can speak to this better than me -- the idea was with Bin 2 when we started this journey was that things would either migrate into Bin 1; i.e., they are risk-significant and you want to look at them or they wouldn't happen and they would migrate to Bin 1.

Dan, as far as that goes, insights from NRR?

MR. FUNK: Sure. This is Dan Funk again from NRR.

As Gabe just explained, these Bin 2 items were generally considered plausible but generally considered less likely than the Bin 1 items. There's one example of this within 20 or 30 tests, one example of that within 20 or 30 tests. So we don't foresee moving the CAROLFIRE results at this time into the inspection program.

And I am going to actually take one of

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your questions and pass it back to Mark because I think he knows the answer. One of the items in Bin 3 was open circuits. I don't believe that open circuits were found in any of the testing.

The other items are things where a hot probe must go through a grounded conduit or grounded armored cable. That wasn't tested, but even it's very unlikely.

MEMBER SIEBER: That's two failures together.

CHAIRMAN SHACK: So the Bin 2 items all moved to Bin 3?

MR. FUNK: Well, I wouldn't say the Bin 2 items all moved to Bin 3. Relative to the risk, relative to inspection, yes, we are not putting the Bin 2 items into the inspection program at this time.

We also have the additional issue of quantifying them. We haven't quantified them. CAROLFIRE hasn't quantified them. There's probably data in this vast pile of data that can be used to quantify them. But that doesn't mean that there isn't a potential risk-significant configuration with these depending on the systems and functions and so forth.

So, although from an inspection standpoint they are not included, from a compliance standpoint

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there is a possibility that there could be issues that get picked up in the ROP.

MR. TAYLOR: So, in summary, CAROLFIRE contributed to both need areas, resolution of Bin 2 items, and also the fire modeling improvement.

Now, Dan made a very good point. There's a lot of data. And we have only been able to scratch the surface. This data is going to be used in the years to come to provide better risk insights to prevent fire and to circuits.

So if there aren't any other questions, I would like to introduce Kevin McGrattan from the National Institute of Standards in Technology. Kevin is going to be presenting volume 3, the THIEF model.

Kevin?

MR. McGRATTAN: Thanks. I don't have much time. And I will probably fly through a few slides just to motivate what we're trying to do. But stop me if you have any questions since you haven't seen this before.

The goal in the modeling was to try to come up with a model of cable failure that's going to be consistent with the kinds of models that are used in practice.

There are basically three types of fire

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models shown on this slide: anything from hand or empirical correlations; what are called zone models, which is where you essentially just have for any given compartment an average lower layer temperature and an average upper layer temperature. And, of course, now the CFD models, which are being used more heavily in this field.

Most of you were at the ACRS hearing where NUREG-1824 was reviewed. This was the study of these different types of models, looking at the verification and the validation work that was done by NRC, NIST, SAIC, EPRI, and various other organizations.

This slide is a busy slide, but it just kind of sums up the types of results that we got from the study. It shows comparisons, for example, for hot gas-layered temperature predictions, comparisons of measurements, and model predictions. The different colors that you see represent the different types of models. So you would tend to see more scatter with the hand calculations. These are simple models, which are known to be fairly conservative in their predictions.

Then the next level of accuracy comes with the zone models. And then, finally, the most accurate types of models are the CFD models shown here.

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MEMBER ABDEL-KHALIK: Now, do the CFD models predict the distribution of soot concentration?

MR. McGRATTAN: Yes. Assuming that typically now, unless you have some way of predicting the soot production, which is a very difficult thing, all of the CFD models will transport the smoke throughout a compartment.

MEMBER ABDEL-KHALIK: The production part is not included? So you don't do the kinetics part?

MR. McGRATTAN: No, typically not, although some CFD models have specialized subroutines that do it. But the models that are used in practice typically don't.

They typically take a fixed production yield of smoke. So for any given fuel, we typically know the fraction of the fuel that goes into smoke. It's known as the smoke yield.

MEMBER ABDEL-KHALIK: I mean, obviously the other two types of models don't even do that.

MR. McGRATTAN: Right.

MEMBER ABDEL-KHALIK: And that's why you have a much, much bigger scatter in the radiation heat flux. I mean, this is sort of a --

MR. McGRATTAN: Right. And the other problem with the radiation part of it is oftentimes in

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these tests, the radiation comes from the hot gas layer. And if you're only predicting a uniform temperature upper layer, then the radiation at any given point is subject to the fact that you're looking at an average heat source.

MEMBER APOSTOLAKIS: Now, if I look at, say, the heat flux and I pick a number for the measured flux and I go up, sometimes I find four or five, six red dots, zone models. These are different zone models?

MR. McGRATTAN: No. These dots represent either different experiments or different measurement locations within a given experiment. There are two zone models represented here. There are two sets of hand calculations. And there is one CFD model represented here.

So all of these points represent individual measurements throughout the 26 experiments that were used in the study.

MEMBER APOSTOLAKIS: But for the same measured flux, why do I have five zone model results?

MEMBER CORRADINI: Five zone or five model results?

MEMBER APOSTOLAKIS: Well, the red is zone models.

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MR. McGRATTAN: No.

MEMBER APOSTOLAKIS: So if I go up, say,  
at around five --

MR. McGRATTAN: If you look at one of  
those, --

MEMBER APOSTOLAKIS: Yes, those.

MR. McGRATTAN: -- that point right there  
--

MEMBER APOSTOLAKIS: Yes.

MR. McGRATTAN: -- is one measurement in  
one experiment, let's say five kilowatts per meter<sup>2</sup>.  
And it's one prediction by one of the zone models.

MEMBER APOSTOLAKIS: Right. But for the  
same measured flux, why do I have four dots?

MR. McGRATTAN: It's different measurement  
locations, different experiments.

MEMBER BANERJEE: But it is strange that  
you should measure the same heat fluxes identically  
for the --

MR. McGRATTAN: If you had a fire in this  
room and you had a gauge over there and a gauge over  
there, you have two different measurements. And you  
might have two different predictions. And those dots  
--

MEMBER BANERJEE: I guess what George is

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suspicious about is why those are vertical lines. Well, your point is well-taken. Do you want to pursue that right now, George?

MEMBER APOSTOLAKIS: I am trying to understand it, but I guess I --

MEMBER BANERJEE: I don't understand it exactly either.

MEMBER APOSTOLAKIS: You are saying they are two different --

MEMBER BANERJEE: Yes.

MEMBER APOSTOLAKIS: It is the same measured flux, right?

MR. McGRATTAN: No. Each one is a different experiment. This point and this point can be two completely different experiments and two completely different locations.

MEMBER BANERJEE: It can, but what is coincidental or seems too much of a coincidence is that the measured fluxes in some regions give you nice vertical sort of scatter there. See, they --

MEMBER APOSTOLAKIS: You go up. You heat a lot of points.

MEMBER BANERJEE: You go vertically up. You hit -- go to the right. Take the most right-most.

MR. McGRATTAN: You're saying here?

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MEMBER BANERJEE: Wherever. I mean, it doesn't matter. It's the same sort of thinking.

MR. McGRATTAN: In a lot of these experiments, you had similar size fires, which gave you similar upper layer temperatures, which gave you similar heat fluxes. And I think that's why you're seeing that. But these are in some sense independent measurements and independent predictions. These all represent pairs.

Now, given what we know about these models and their accuracy --

MEMBER ABDEL-KHALIK: And the independent variables in the model for the same measured conditions result in such large variability in the heat flux?

MR. McGRATTAN: Right, because, as I said before, with, for example, a zone model, a zone model will predict an average upper layer temperature. Well, in that case, that's not the right thought. I can't explain it.

MEMBER BANERJEE: Are you sure the axes aren't mixed up?

MR. McGRATTAN: No, no, no.. I've gone over these plots many, many times.

MEMBER APOSTOLAKIS: What you are saying

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is that the variability we see on the vertical axis is experiment to experiment or environment to environment.

MEMBER SIEBER: Right.

MEMBER APOSTOLAKIS: For the same heat flux. That's what you're saying.

MR. SALLEY: Back that slide up, Kevin. I'll take a shot at it.

MR. McGRATTAN: Do you want to take a shot at this?

MEMBER APOSTOLAKIS: If I go to, say, five and a half, about five and a half, if I go up, there is a series of dots, those all the way. So this variability there, the vertical variability, is a variability due to different experiments under different conditions perhaps, all of them having the same measure, the value of the measured flux?

MR. SALLEY: Yes. And there are some preferences here, George. It's been a while since we've done 1824. But when you're looking, for example, at zone model, for each experiment, we have two models that are running. We have CFAST that came out of this. And we had MAGIC that came out of EDF.

MEMBER APOSTOLAKIS: Right.

MR. SALLEY: If you take all of those

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models apart and get down to their working cores, they're basically using the same equations, the same algorithms, the same physics. And a lot of times they will predict very close together. So you will see the double hits because that's two runs for two models.

MEMBER BLEY: For the same experiment?

MR. SALLEY: For the same experiment. Now, this is a very busy graph. It is to be illustrative here. But this was the whole program, 26 experiments.

MEMBER APOSTOLAKIS: Yes. I remember it was --

MR. SALLEY: They're all rolled up and, of course, how they all scattered over. The same is true with the hand counts. The same equations that I coded in 1805 are the same ones that EPRI coded in theirs. And it's just how far we took things to accuracy. So it gives you a lot of like -- what was the thing in the floor, the hanging chads?

PARTICIPANT: Yes.

MR. SALLEY: You're going to see a lot of hanging chad results here.

MEMBER APOSTOLAKIS: The question really is, what does this "plus or minus 20 percent" mean?

MR. SALLEY: What this means in this graph

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--

MEMBER APOSTOLAKIS: And if you change the environment and the experiment, then it really doesn't mean much.

MR. SALLEY: What this means, George, if you go back in time again -- and, Kevin, you jump on me when I go wrong. What we recognized in the 1824 program was that what most people were doing for V&V's was when they were in an experiment and they got a reading -- I don't care what it was, a temperature reading, a slip production reading, a heat flux reading, they took that as gospel. And they said, "How well can my model go and predict what the experiment did?" This is the gospel-type approach.

When we were doing this program, we started it. And we talked to like Dr. Hammetts from NIST, who are the experimentalists who do the experiments. What we said was, "How well can you measure this?"

And for this particular parameter, Dr. Hammetts came back and said, "Okay. When I do that measurement, I can get you plus or minus 20 percent."

So we set our premise up on the V&V and said if the models are predicting somewhere in that 20 percent because we don't know the exact answer, that's

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as good as that model can predict. So that's why we got that scatter.

MEMBER BANERJEE: I think the confusion -- and I'm also conflicted. If you take around six, there are three CFD points there. Now, you're only using one CFD calculation. So there are three experiments separately done which give you almost identical heat flux, which seems too much of a coincidence knowing any experiment that I have ever done scatters like hell all over the place. So that's what --

MR. McGRATTAN: A number of these experiments were replicates and the --

MEMBER BANERJEE: It's a terribly good replicate.

MR. McGRATTAN: Well --

MEMBER POWERS: Of course, you don't know how well they do experiments at the University of --

MEMBER BLEY: You don't know which one is replicated.

MEMBER BANERJEE: We are certainly not able to replicate.

MEMBER APOSTOLAKIS: Maybe the best way to proceed is to ask Kevin, why are you showing this?

MR. McGRATTAN: I was going to get to

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that.

MEMBER APOSTOLAKIS: Because the message is different from --

MR. McGRATTAN: This was to motivate why we designed the cable failure model the way we did. We want the cable failure model to live within all of these different fire models. And we know we have a good idea of what kind of uncertainty we can expect from the fire models.

Now, the cable model is going to be no better than the fire model that it is embedded in. So in order to design a cable failure algorithm, you have to understand the uncertainty --

MEMBER APOSTOLAKIS: When you say --

MR. McGRATTAN: -- in the fire model; that is, the model that is predicting the thermal environment of the compartment. You have to understand the uncertainty of that model first before you can look at the model of the cable itself. You need to know what the uncertainty of the inputs to the cable failure model are. That's what this was for.

I didn't mean to dwell on this too much. I just wanted to emphasize that we have looked at the different types of models that this cable failure model will be embedded in. And we have a good

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understanding now of what we can expect these models to provide us in terms of a thermal environment that these cables are going to see.

MEMBER BANERJEE: So what they will eventually want to do, George, is get the time to failure of a cable so it's in a fire. You try to predict environment around the cable using this fire model and then --

MEMBER APOSTOLAKIS: Yes, absolutely. This is a very noble endeavor.

MR. McGRATTAN: Now, we are not the first people to try to look at what we call targets in fire.

A cable is, as far as I'm concerned, as a fire modeler a target. It's something that's going to heat up. It's going to do something, much like a sprinkler or a smoke detector.

And if you look at the conventional models for these devices, they're relatively simple. They're simple because you often don't have a very accurate prediction of the environment surrounding these devices. And you also don't have a lot of information from the manufacturer about these devices. Smoke detector manufacturers don't tell you anything about their device other than it passed the test at UL.

So over the years, a few researchers have

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come up with relatively simple expression of these devices that just rely on, for example, an RTI for a sprinkler. That's just an expression of its thermal inertia or L/u for a smoke detector. That just gives you a lag time, the time it takes for the smoke to kind of penetrate the inner workings of the chambers.

So when Mark first approached me about the cable failure model, I mean, these are the things he was educated in when he went to school and said, "I want something like this to describe cable."

So, with that in mind, we developed what we now call the THIEF model, the thermally induced electrical failure. We say "thermally induced" because this is nothing more than a heat transfer model, has nothing to do with electricity. It just simply predicts as well as we can the temperature within a cable.

And to keep this simple, we made some pretty severe assumptions about that cable. One is we assumed that we're just going to look at 1D heat conduction into the cable. We're assuming that the cable is homogeneous.

Now, those of you who saw the cables being passed around know it's not homogenous. That was a first pass at trying to simplify the model. We're

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going to assume a constant thermal conductivity; a constant-specific heat; and a bulk density, which we can get simply by knowing its mass per unit length and its diameter.

MEMBER ABDEL-KHALIK: And this set of properties is inconsistent inasmuch as the density represents an average density --

MR. McGRATTAN: Yes.

MEMBER ABDEL-KHALIK: -- while the conductivity and specific heat do not.

MR. McGRATTAN: And I've got a slide just for you. I'm going to address that question.

MEMBER ABDEL-KHALIK: All right.

MR. McGRATTAN: Okay? Hang in there.

Okay. So we're going to assume the thermal conductivity and specific heat based on the polymer. And we're going to take a lumped density based on the polymer and the copper combined.

Just 1D heat transfer. You can see the equations here. You all are familiar with this sort of thing. Let me jump right to the results. I was skeptical at first that this model would work. I thought it was too simple. But we decided anyway to look at the data using the simplest possible approach. And, lo and behold, this model worked really, really

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well, I mean almost too well. And that question came up. And I'll address it.

(Laughter.)

MR. McGRATTAN: Okay. So here we have --

CHAIRMAN SHACK: It is just a homogeneous cylinder, George.

MEMBER APOSTOLAKIS: Which models the seven-conductor.

MR. McGRATTAN: Yes, yes.

MEMBER POWERS: George, it's completely wrong to have instantaneous heat transfer here. They should have the telegraph equation.

(Laughter.)

PARTICIPANT: You're just trying to see if he can know what that is.

MEMBER APOSTOLAKIS: I have used it in exams.

MR. McGRATTAN: A typical experiment would go like this. You would put the cable into the cylinder. You would heat up the shroud or the boundary of the cylinder, hold it steady, and then measure the interior temperature of the cable. What you see by the solid line and then this dashed line, those are the actual measured temperatures just inside the cable jackets on either side.

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You can see here where the cable fails electrically. You can see here where the cable catches on fire. And you can see here the prediction of the simple model.

MEMBER ABDEL-KHALIK: Now, let's go back one slide. Now,  $q^{ii}$  in this equation, you say this is predicted by the fire model?

MR. McGRATTAN: Yes.

MEMBER ABDEL-KHALIK: Now, in the validation work, the comparison between the model and the experiment, you have a very good handle on this  $q^{ii}$ ?

MR. McGRATTAN: Yes, yes.

MEMBER ABDEL-KHALIK: And, yet, if you look at the slide before this one, the two before,  $q^{ii}$  is the one thing that the models don't know how to do.

MR. SALLEY: No. That is apples and oranges. You've got to remember here that what these experiments were were full-blown large compartment, room-type experiments. What Kevin is modeling there is the --

MEMBER SIEBER: Ideal.

MR. SALLEY: -- very ideal situation of the internals of Penlight.

MEMBER ABDEL-KHALIK: Absolutely. And

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that is the point I'm trying to make.

MR. McGRATTAN: Right. And this is the whole idea why I put this up here, because I want to emphasize that this model that I am describing is only as good as the fire model in which it is embedded. So if you want to know how good your prediction by this simple model is going to be, you've got to first start here.

MEMBER SIEBER: So if the THIEF is good. The fire models aren't?

MEMBER ABDEL-KHALIK: You can only test this fire model --

MR. McGRATTAN: I do the CFD modeling. And I am fairly fat and happy sitting in here. So I am going to be comfortable with this model. If I am using a more conservative estimate of the radiation and the temperature, I am going to under-predict the failure time. Okay. I under-predict the failure time. As long as we understand the degree to which we're under-predicting things --

MEMBER ABDEL-KHALIK: The fact that you're getting good comparison between the predictions of your model and these controlled experiments is great, but it's misleading in a sense that when this model is actually going to be used in any of these models, the

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driving boundary condition is totally --

MR. McGRATTAN: But don't we need to evaluate the model first in the ideal situation just to understand whether our model of the cable is any good?

MEMBER ABDEL-KHALIK: I agree.

MEMBER BANERJEE: Yes. What I think you have constructed is a one parameter, well, at most a two-parameter model, which, instead of being in -- you could probably solve this analytically, and you get some sort of a heat flux boundary condition there. And so he's got a two-parameter and not only a break model but a PD basically, which fits the data.

MR. McGRATTAN: Right.

MEMBER BANERJEE: That's how you should look at it.

MR. McGRATTAN: Right.

MEMBER BANERJEE: Don't give it any great theoretical significance.

MR. McGRATTAN: While we're on the subject, let me address the other question that you had the last time. And that is why does this model work? And I went back to my office, and I thought about it.

The first thing that came to mind -- and

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this is what I had been assuming all along -- is that if you look at the specific heats and the densities of the copper and the polymer, the first thing you'll notice is that it's not the individual value but, rather, their product that matters, which is it's  $C$  times  $\rho$  that shows up. So there's somewhat of an offset there because one is high and one is low.

But that wasn't the whole story. I thought what I would do is I would put together a more sophisticated model than what I had done originally. So I next envisioned that I would have a two-layer model, one layer of polymer with the polymer properties that I actually know for one or two of these cables.

And then for the interior, inside the jacket, I would take a mixture of the copper and the polymer and take a mixture of the properties based on the mass and volume fractions. Okay?

When I did that -- now, that's a better model than the model I first introduced. That's a better description of the cable. It's a more faithful representation of the thermal properties.

My results are shown here in green. I got a worse result. Why? Well, actually, if you look down here, for the first couple of minutes, my more

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sophisticated model is a better result than the THIEF model.

But look what happens at about 200 degrees C inside the cable. The temperature levels off: here for this one thermocouple and then here for this other.

What is going on? Well, the thing is starting to decompose. Reactions are occurring. It's melting. It's charring. It's whatever. I don't know. I don't know what is going on in there. All I know is that all of the measurements that Sandia made have these kinks in them.

MEMBER BLEY: Yes. It is cooling, heat infusion.

MR. McGRATTAN: It is cooling. I mean, basically the energy is being sucked out of the system by some --

MEMBER SIEBER: Yes, by causing the reaction.

MR. McGRATTAN: -- endothermic reaction that is going on in there.

MEMBER BLEY: It is looking more like an average.

MR. McGRATTAN: Right. Now, the standard trick in the business of heat transfer, at least what

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I do is if you don't know much about these reactions, you lump into the specific heat all of your ignorance.

So the fact that we're using the specific heat of the polymer, which is greater than the specific heat of the copper, is essentially saying that we don't know what the reactions are inside, but we're going to overestimate the specific heat to make up for the fact that we're neglecting these reactions.

So there's a bit of offsetting errors here. That's why it works.

MEMBER ABDEL-KHALIK: If I am just working on it and calculate a time constant based on one deconduction  $L^2$  over alpha, I get only a couple of seconds.

So it's hard for me to imagine that you're getting a response time of several hundred seconds.

MR. McGRATTAN: Well, remember, we are using the thermal conductivity of the plastic that's very small. So that slows down the thermal waves.

MEMBER ABDEL-KHALIK: I'm getting the time constant based on these homogenized fictitious properties, --

MEMBER SIEBER: Yes.

MR. McGRATTAN: Right.

MEMBER ABDEL-KHALIK: -- calculating a

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corresponding thermal diffusivity and then, calculating a time constant of  $L^2$  over alpha, use L as one centimeter, the characteristic dimension. And I would get a time constant of only a couple of seconds.

How are you getting there a response time of several hundred seconds? I don't know. You know, your --

MEMBER BANERJEE: I think it's driven by the boundary condition more because it's essentially as you're saying. The time constant is an order of magnitude faster.

I think you should look at this as a purely empirical fit. I don't think you should --

MR. McGRATTAN: I have compared our numerical solution against the analytical solution. It's dead on. I've done the grid sensitivity. I mean, we have done all of that kind of verification work.

I mean, I can take another look at the time constant, but for me what was puzzling about your question the last time was why it works. And you said it was a hodgepodge of different things. Indeed, it is, but what finally sort of dawned on me was the fact that we're neglecting those reactions in the model, but we're using a specific heat, which is larger than it should be. And these are offsetting --

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MEMBER BANERJEE: To say my view of things

--

MR. McGRATTAN: It's typical of any lumped parameter model. I mean, that's what you're doing. You've --

MEMBER BANERJEE: Purely heat flux.

MR. McGRATTAN: You're offsetting errors.

MEMBER BANERJEE: What you are seeing as it is going up like that, the temperature between the shroud and whatever that is, you know, it's going up to the fourth power. So the boundary condition is changing.

And as you are getting up to the top there, which is sort of saturating because in a sense, the whole problem is boundary condition-driven here. The time constant is so fast, as you pointed out, that part of it is irrelevant.

MR. McGRATTAN: If you look here, I mean, the slope here is certainly greater than the slope here because the heat flux, the net heat flux, in the beginning is greatest. And then the heat flux decreases.

MEMBER BANERJEE: Right.

MR. McGRATTAN: And this eventually will approach the shroud temperature.

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MEMBER CORRADINI: Isn't the time constant, though, the difference between the dotted line and the solid line? Said's estimate of the time scale is right, but it is the difference between the dotted line and the solid line because it is a heat flux-driven boundary condition.

MR. McGRATTAN: Well, the dotted and solid just refer to the model on experiment, not in terms of collars.

MEMBER CORRADINI: No. I'm talking about your reds. Forget about the black. No, no. The red.

MR. McGRATTAN: The heat flux is going to be a function of the difference between the --

MEMBER CORRADINI: Go down to the red.

MR. McGRATTAN: -- black and the red.

MEMBER CORRADINI: Right. Go down to the red.

MR. McGRATTAN: Yes.

MEMBER CORRADINI: Don't you have two red measurements that are data?

MR. McGRATTAN: Yes.

MEMBER CORRADINI: Okay. So I'm saying there is a difference in time for a given temperature. And that difference in time for a given temperature is more akin to the time scale he's talking about

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because I basically have a heat flux-driven boundary condition.

So I pump up a heat flux. The surface responds. And then it takes some time scale for some interior point to respond. And that difference is the time scale he's talking about.

MEMBER BANERJEE: You essentially lump everything in a parameter. It is heating up. It is heating up. The heat flux is decreasing. And, you know, it's heating up more slowly as it goes along.

MEMBER APOSTOLAKIS: So from the perspective, then, of the heat assessment, you're telling us that we should really focus on the uncertainties in calculating --

MEMBER CORRADINI: Right.

MEMBER BANERJEE: What we are saying --

MR. McGRATTAN: What we have done here, in the most ideal of conditions, what we're showing here is the comparison of the measurements versus the model predictions. Okay? So under the best of circumstances, this is how good the simple model can be. So you have to add to this the uncertainty in the heat flux that your overall fire model can give you.

MEMBER APOSTOLAKIS: That would overwhelm.

MR. McGRATTAN: What's that?

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MEMBER APOSTOLAKIS: That would overwhelm.

MR. McGRATTAN: Yes. And that's why we decided to go with such a simple model because to try to make this model more sophisticated and build in the reactions and the thermophysical properties wouldn't buy us anything.

MEMBER SIEBER: Actually, the bigger --

MR. McGRATTAN: Yes, yes.

MEMBER SIEBER: -- in a ring of fire, as opposed to this experiment.

MR. McGRATTAN: Yes. And that's true of all target models.

MEMBER SIEBER: This is why I made the statement right in the beginning you have got to see what NRR is going to do with the is information. Now, if you're going to be very scientific about it, you're probably going to get an answer that's not correct.

MR. McGRATTAN: Yes.

MEMBER SIEBER: On the other hand, for decision-making, this is probably good enough.

MR. McGRATTAN: Right. And since we last talked, Dave Stroup, sitting in the back here, has coated this all up in an Excel spreadsheet. So you can within seconds just for a given compartment temperature very quickly assess how sensitive the

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model is going to be, how sensitive your failure times are going to be, --

MEMBER SIEBER: Right.

MR. McGRATTAN: -- the errors in your compartment model predictions.

MEMBER SIEBER: And we can hook it right to fire dynamics tools, which is another strange --

MR. McGRATTAN: Well, that is what this is going to be. It's going to be one of the fire dynamics tools.

MEMBER SIEBER: Great. I've used it. It works.

MEMBER BANERJEE: And basically it's a one-parameter model because  $k$  comes out of there. And it's just  $C$  divided by  $k$ .

MR. McGRATTAN: Yes. The only thing you need to know about the cable is its mass per unit length and its diameter. I mean, we feel that this is even better than the typical models, like for sprinklers and smoke detectors, because there you actually have to take the device and you have to test it in a rig. And that's not cheap.

For these cables, we just need to know the bulk properties and where we're ready to make predictions.

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MEMBER BANERJEE: Let's go on.

MEMBER SIEBER: But a sprinkler actually responds the same way that these cables do.

MR. McGRATTAN: Yes except for a sprinkler we assume that the heating element is thermally thin.

MEMBER SIEBER: Yes.

MR. McGRATTAN: And we wanted to do that with the cable, but that was an assumption that pushed it too far. We didn't think that that is a very good assumption.

MEMBER SIEBER: But you're still looking at it as dynamic?

MR. McGRATTAN: Yes.

MEMBER SIEBER: This would be the same shape.

MR. McGRATTAN: Yes. Oh, yes. But we thought that given the simplicity of this model and the fact that you can code it up in a spreadsheet, why not go and solve the PD, as opposed to the OD.

MEMBER SIEBER: I agree.

MEMBER BANERJEE: Kevin, I have a different question. I think I understand your model. It is with regard to the failure points. For example, for the thermosets there, you are using the same failure points, same point when you say thermoset

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point A and thermoset point B.

MR. McGRATTAN: The A and the B simply refer to the two measurement locations within a given cable. Since Sandia measured on either side of the cable jacket, we thought we would just use them as two measurement points.

MEMBER BANERJEE: Right. But when you are using the failure criterion to establish this curve, --

MR. McGRATTAN: Yes.

MEMBER BANERJEE: -- it's failure at a certain temperature, right?

MR. McGRATTAN: Yes. We call it a threshold temperature.

MEMBER BANERJEE: And that threshold temperature is 400 degrees?

MR. McGRATTAN: I use 400 for thermosets, right, and 200 for thermoplastic.

MEMBER BANERJEE: All right. So that needs to be clarified, I think, somewhere because you have used that on the basis of fitting the data. And it would be good to show how it fits the data because that is a crucial point of this.

MEMBER SIEBER: You did graph the

MEMBER BANERJEE: Well, that was a little

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bit confusing: the graph that he showed earlier.

MEMBER SIEBER: Do you have another graph?

MR. McGRATTAN: A graph in what sense?

MEMBER BANERJEE: Of the failure  
temperature --

MEMBER SIEBER: Between thermoplastic and  
thermoset. It's about ten slides back.

MEMBER BANERJEE: Yes, but it was a little  
--

CHAIRMAN SHACK: Yes. I mean, you had to  
interpret his data to get the 400 and the 200 out.

MEMBER BANERJEE: Yes. It would be nice  
to clarify that. It was the one that he was showing,  
right?

MR. McGRATTAN: Yes.

MEMBER BANERJEE: And I said you should  
show the thermoset separately.

MR. McGRATTAN: Right. I took that slide  
out just for brevity.

MEMBER BANERJEE: All right. Okay.

MR. McGRATTAN: But it's still in the  
report.

MEMBER BANERJEE: All right.

MR. McGRATTAN: One question you had the  
last time --

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MEMBER BANERJEE: Was the scatter, yes, --

MR. McGRATTAN: -- was the scatter.

MEMBER BANERJEE: -- which now I understand because the heat flux ruined boundary conditions.

MR. McGRATTAN: Right. If you remember this plot from the last time, we had plotted these six cable bundles all the same way. And I went back and took a look. And now you will see these little blue circles --

MEMBER BANERJEE: Right.

MR. McGRATTAN: -- and these green squares are all six cable bundles. But the blue circles are the ones that are actually in the fire.

MEMBER BANERJEE: That's the point we had.

MR. McGRATTAN: We suspected that was the case. And, indeed, that was. So we're seeing here that the model is going to under-predict the failure time the most when the cable is in the fire because that is a very rapid heating and the model isn't taking into account the fact that these cables are protected by the neighboring cables; whereas, when you look at a more slow heating case, which is more typical of these points, then the fact that you've got neighboring cables isn't as important. And the model

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works fairly well in that case.

MEMBER BANERJEE: Correct.

MR. McGRATTAN: But we're not too concerned by the fact that we are under-predicting failure times.

MEMBER BANERJEE: It's only the red or the blue above there that you might, above that place.

MR. McGRATTAN: These? Yes.

MEMBER BANERJEE: Yes.

MR. McGRATTAN: Well, there were a number of experiments in which, I mean, failures occurred that were hard to explain. If you look at the graphs in these more realistic settings, --

MEMBER BANERJEE: Right.

MR. McGRATTAN: -- it's sometimes difficult to interpret some of these points.

MEMBER SIEBER: Yes.

MEMBER BANERJEE: But, by and large, I think you can attribute the shielding effects or whatever, yes.

MEMBER ABDEL-KHALIK: I would like to point out something. Dr. Powers pointed out to me that I have an error in my units. And if you calculate the time constant, it is indeed several hundred seconds.

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MR. McGRATTAN: Oh, good. Okay. Let's end on a high note. Was there a question?

MEMBER ABDEL-KHALIK: I think, again, the burden has now shifted to essentially the ability to predict the heat flux correctly.

MEMBER BANERJEE: Yes, yes. I think you've done as good as you can do here because basically you did exactly what we asked you to do, explain why that scatter was there. And we had the feeling it would be doing sheathing effects when you have a fire. So that explains it.

MR. McGRATTAN: Yes, but it was a good point to be made because I didn't pick up on that when I first made this graph. I was just focusing on 6 versus 12 versus 3 versus conduit. And that's a good distinction to make, whether you're in or out of the fire.

MEMBER APOSTOLAKIS: Remember when we given a NUREG report with the models that we asked you to look at it to quantify the certainty. Is that work going on or --

MR. McGRATTAN: Yes.

MR. SALLEY: Yes, it is, George. There's a fire model users guide. Hopefully you'll see that December or the beginning of next year.

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MEMBER APOSTOLAKIS: Very good.

MEMBER BANERJEE: There was one other point that I think implicitly we were making whether this is possible or not. But there was a feeling that it would be nice to heck these in an integral sense, where you use your fire models, yours or anybody else's, to predict the environment around it and then close the loop and put this model in and see what happens.

MR. McGRATTAN: Right. Well, Gabe talked about the experiments that are upcoming in France. One of our objectives there is to do exactly that from soup to nuts, model the fire in the compartment with the cable and predict the failure time.

MEMBER BANERJEE: But here you could presume something about the fire.

MR. McGRATTAN: We tried that except in the Sandia experiments, the intermediate scale, all of the cables in every test were burning, the cables that were intimate with the fire. And they were increasing the heat release rate significantly. And since we can't predict that very well because we don't have any information about the thermophysical properties of the cables, any model prediction would be overwhelmed by the error in the thermal environment. So we wouldn't

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be able to assess the heat model.

MEMBER BANERJEE: What does that mean about postulated fire scenario? Let's say if you wanted to find out time to failure in a fire scenario.

If the heat flow due to burning cables become significant, then your fire model has to take into account the --

MR. McGRATTAN: Oh, absolutely. And that's also on the list of upcoming work in the next few years is to try to get a better handle on the heat release rate from these burning bundles of cable.

There is a lot of empirical data lying around. Our ability to predict this is still very, very limited. We're relying mostly on actual test burns that have taken place with different types of cable burn and different configurations. The trouble there is that there are basically a million different combinations of cables, configurations, and so forth.

So to actually put together a comprehensive chart that you could pull heat release rates from is --

MEMBER BANERJEE: Will the French experiments will try to clarify what these heat release rates are or --

MR. McGRATTAN: Yes. The heat release rates should be very, very well-characterized. So

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we'll at least know how much energy is being put into the compartment, be tracking that smoking heat throughout the compartment, and then making a prediction of the cable failure based on the prediction of the thermal environment surrounding the cable. See, in CAROLFIRE, we were --

MEMBER BANERJEE: Including the cable burning, right? Including the cable burning?

MR. McGRATTAN: No. The French tests do not involve cable burning. They involve a specified heat release rate that will be dialed directly into the model.

What the model is going to be doing is predicting the smoke and heat transport near the cable and then using THIEF making a prediction of when that cable is going to fail.

MR. SALLEY: Yes. Jason Dreisbach is here. Hey, Jason, you work in the IRSM. Can you give us a quick description?

MEMBER BANERJEE: I guess this is going to answer your question in some ways.

MR. DREISBACH: I think it has been characterized pretty well. Kevin mentioned it's going to be a well-characterized pool fire in these experiments. And there will be no cable burning.

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That's a specific goal of this test. We don't want these extra combustibles to be burning because they're not as well-characterized.

The whole point of this test series is to provide data for validation of more complex fire modeling because there's a lot of other utilization and environmental conditions in these tests that haven't exactly been evaluated, like forced ventilation effects and different types of wall materials that are more representative.

But the key piece is there are not going to be any other combustibles burning, including cables. It's just going to be evaluating the conditions of the room from this well-characterized fire. And we're going to use that information to validate.

MEMBER BANERJEE: The real problem, the real fire scenarios, you have to have these cables. At least the heat release from the cable is part of the problem, right?

MR. DREISBACH: If it is determined that the cables start burning.

MEMBER BANERJEE: Right.

MR. DREISBACH: I think we're a little bit before that in the scenarios that we're considering in

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this situation. We're considering a fire starts from an oil spill from a pump or something like that. It creates a fire environment in a room. And we want to see what the effect is on a cable in the overhead, not necessarily by the effect of cables burning in the overhead. That may have ignited some other way.

We're looking at a fire that starts in a room effecting a cable in the overhead.

MR. McGRATTAN: There are two objectives. The first is just predicting when that cable is going to fail. And that's what CAROLFIRE addresses.

MEMBER BANERJEE: The first cable, yes.

MR. McGRATTAN: The first cable, the first failure. After that, I mean, we would like to eventually be at a point where we can predict the admission and the fire growth and spread in a complicated configuration of many trays.

But we thought that the first thing to tackle is just cable failure because a common question that's asked during every fire analysis that I've ever seen in a nuclear power plant is, when will the cable fail.

MEMBER BANERJEE: I guess if we go back to that fire model prediction, those are without actually some of the surrounding cables catching fire, things

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like that.

MR. McGRATTAN: Right.

MEMBER BANERJEE: So this is only accurate to the point of the first cables stop to catch fire.

MEMBER SIEBER: Right.

MR. McGRATTAN: Absolutely. And most analyses, most fire analyses, take a postulated fire. We talked about that during NUREG 1824. I've got a switchgear cabinet. And I'm assuming that it's going to produce 200 kilowatts of energy. And that's what is dialed directly into the fire model.

Rarely is the fire model used to try to give you that or predict that 200 kilowatts. We're more comfortable at this stage of the game taking the cabinet, putting it under an exhaust hood, and actually measuring the heat release rates.

MEMBER BANERJEE: Okay. Try to answer Sam's question. So do you need to pursue that a little bit more? Are you happy with it? Any other comments?

MEMBER POWERS: There are two major issues, Mark, that I'm dying to hear about. One is, when do I get my aerosol particle size distribution? And the second one is, when do I get my unsaturated vapor contribution?

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MR. SALLEY: Kevin, have you covered all of your slides?

MR. McGRATTAN: Yes.

MEMBER ABDEL-KHALIK: Given the fact that this model, essentially K and C are fixed. They're empirically fixed. I mean, you can translate this into a table look-up.

MEMBER SIEBER: Table look-up? Yes.

MEMBER ABDEL-KHALIK: Because, you know, the only two parameters would be just the density and the heat flux.

MR. McGRATTAN: Right, right. But the temperature is going to vary with time. So the compartment temperature will ramp up as the fire grows and as the compartment gets hotter.

MEMBER SIEBER: And that is the important --

MR. McGRATTAN: And, as I said before, Dave Stroup, sitting in the back there, has coded up in a spreadsheet both the ramp-up of the fire temperature or of the compartment temperature. And embedded in that is THIEF.

So it's not a very difficult calculation to make. It's pretty much done.

MR. SALLEY: Kevin, if you have your

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slide? I don't know if we blew over it or not, but the one with the conduit I think is definitely worth taking a look at, too, because that throws the complexion in. Another thing we learned out of Kevin's work was the conduit effect, if you will. And, Kevin, I think you could give us just a minute.

MR. McGRATTAN: A simple add-on to the model is to say that if your homogenous plastic cylinder is surrounded by a thermally thin steel cylinder. That's equally easy. And we embedded that into the spreadsheet as well.

So here what we have is in Penlight, the hot shroud heats up the steel conduit. Then the steel conduit is essentially the exposing source. And the cable heats up based on the conduit that it sees.

This is valuable because a number of engineers that I have talked to have asked me, "I use conduits. How much does that buy me, like what credit do I get for wrapping my cables in a conduit?"

And now we can quantify that effect. It's fairly straightforward. It's just knowing the thickness of the conduit and the properties of steel. And you can just simply add that right into your calculation.

MEMBER SIEBER: It depends on the fire

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model.

MEMBER POWERS: And I get more alkenes.

MEMBER ABDEL-KHALIK: I am sorry. The boundary condition in this case is still the heat flux outside the conduit.

MR. McGRATTAN: Well, in this case, though, there are essentially two calculations going on. One is the smoke or the hot shroud in this case is heating up the conduit. We assume the conduit is thermally thin.

So its exterior and interior temperatures are the same. So the cable, even though it's actually sitting on the floor of the conduit, we just assume that the cable is dead down the middle and it sees this hot wall and  $\sigma T^4$  and off you go.

CHAIRMAN SHACK: It doubled the time.

MR. McGRATTAN: What's that?

CHAIRMAN SHACK: It doubled the time.

MR. McGRATTAN: Yes. And that's simply based on the thermal inertia of the conduit.

MEMBER BANERJEE: It's the difference between  $2T^4$ .

MR. McGRATTAN: Yes. That is exactly right. That is exactly right. Yes.

MEMBER BANERJEE: All right. I think if

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we don't have any questions, I'll turn it back to you, Bill. Thank you very much for your presentation, very useful.

MR. SALLEY: Follow-up question I promised to answer at the end was, do we know everything about cables?

MEMBER SIEBER: No.

MR. SALLEY: No.

MEMBER ARMIJO: Well, I will change my question. If a guy who is going to build a new reactor came to you and said, "What kind of cabling product?"

PARTICIPANT: Fiber optics.

MEMBER ARMIJO: You know, that's maybe the right answer, but, you know, if we're going to use power, is there any superior product?

MR. SALLEY: Yes. The Vitalinks and the silicones, we saw those were very robust. For example, in CAROLFIRE, we could not fail electrically the silicone and the Vitalink.

And silicone, as you remember from the EQ days is what you saw a lot in containment for other reasons than fire. And that's a good one we couldn't fail. We had to go and add water, which after the insulation and jacket had fractured, that we could now

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get the shorting paths with the water. So we did see that.

What else we saw was two other points that I want to make reference to of answering the questions. The more we delve into this and we start exploring things, like CPTs, like end devices, we saw that that circuit design, the circuit that you're looking out in the plan for the spurious operation, you need that electrical engineer to really study how that circuit responds along with this data, the uncertainty in the devices.

MEMBER ARMIJO: It's just a quick fix.

MR. SALLEY: The other thing is when we started this, we went along with where EPRI had -- and EPRI and NEI originally started the program. And when you look at the risk significance from the fire to the plant, it seems that the MOVs always want to percolate up to the top, that somewhere you're getting a valve that's diverting flow or shutting off flow. And that seems to get to be the real safety significance. And this program proceeded down that path with the AC circuits because that's how most of them are set up.

A lesson that Gabe brought back from the Duke test is when you put DC power to it, this changes for a number of reasons, again electrical engineering

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reasons, how the DC circuits are configured.

For example, a lot on the DC circuits are the ungrounded DC. When you now make this circuit an ungrounded DC circuit, they started getting different responses.

The fusing in a DC circuit is much higher than this. So you don't see the early fuse blows. You also see the greater potential for that. So the next piece that we're looking at right now, CAROLFIRE is complete, but how does DC interact with this?

MEMBER SIEBER: Well, you have to get two failures on the ground.

MR. SALLEY: Right. So the --

MEMBER SIEBER: The protection doesn't come in until the second one occurs.

MR. SALLEY: Right. Ungrounded DC, which we originally brought out of the chemical industry, is cursed every day by electrical engineers out there in the field. And from the fire standpoint, it does make it worse.

MEMBER SIEBER: You will get a lot of grounds in normal operation, you know, a dozen a year.

And you can't have the plant tripping off every time you get one. So you use that signal to go hunt for it and clear it.

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MR. SALLEY: Right. So those are some of the things that -- I hate to sound cliché-ish, but the more we test and the more we learn, the smarter we become, the more we see out there that is important that we go and look if we are ever going to have a true understanding of this phenomenon.

And, as a final thing with that, the PIRT, George, you missed the PIRT. We had a couple of hours on the PIRT in the last meeting. The idea like, hey, what is the heat release rate from cable trays and the flame spread and how when you take the fire model, you have the secondary fires, those were the very issues that the fire model experts were hitting at the point as, hey, this is very important phenomena and you know very little about it.

So I think when you guys get to read the PIRT, you're going to see a lot of these very concerns that you brought up where the items that were percolating up in the fire modeling PIRT, which is --

MEMBER SIEBER: But there are --

MEMBER BANERJEE: Clearly there is stuff burning that we don't know much about, how it burns, how fast it burns, and how these things propagate. That's the source term, you know.

MEMBER APOSTOLAKIS: Didn't we identify

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those when we first started using cumber? All of these parameters were identified, heat release rate.

MR. SALLEY: And now we validated it.

MEMBER APOSTOLAKIS: And the model we used for cable failure was the one-dimensional cylinder that made a seal for that.

MEMBER BANERJEE: Good man.

MEMBER APOSTOLAKIS: For his Master's thesis --

MR. McGRATTAN: That's why we call --

MEMBER APOSTOLAKIS: -- without all of the eloquence we saw here.

MR. McGRATTAN: That's why we call it a THIEF model because we stole it from him. Actually, I got the idea from the Swedes. They were doing these calculations several years ago. I saw him give a talk, stole it from him.

MEMBER APOSTOLAKIS: It's a very simple idea.

MR. McGRATTAN: It is.

MEMBER BANERJEE: Shall we? Mr. Chairman, it's up to you now.

CHAIRMAN SHACK: I think that ends our business for the day. Again, thank the presenters. It was an interesting discussion, the subcommittee

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meeting. You got through an awful lot of material here at the full Committee. I'm amazed. We can go off the record at this point.

(Whereupon, the foregoing matter was concluded at 5:25 p.m.)

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