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UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

May 4, 2005

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

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SUBCOMMITTEE ON FIRE PROTECTION

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WEDNESDAY,

MAY 4, 2005

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ROCKVILLE, MARYLAND

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The subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T-2B3, 11545 Rockville Pike, at 8:30 a.m., Stephen L. Rosen, Chairman, presiding.

COMMITTEE MEMBERS:

STEPHEN L. ROSEN, Chairman

RICHARD S. DENNING, Member

DANA A. POWERS, Member

WILLIAM J. SHACK, Member

JOHN D. SIEBER, Member-At-Large

GRAHAM B. WALLIS, Member

ACRS/ACNW STAFF:

HOSSEIN P. NOURBAKHSH, Designated Federal Official

PANELISTS:

DANIEL FUNK, EPRI-Edan Engineering

DENNIS HENNEKE, Duke Power Company

FRANCISCO JOGLAR, EPRI-SAIC

BIJAN NAJAFI, EPRI-SAIC

GARY VINE, EPRI

NRC STAFF:

JASON DREISBACH, RES

KENDRA HILL, RES

J.S. HYSLOP, RES

ALAN KOLACZKOWSKI, RES-SAIC

STEVE NOWLEN, RES-SNL

MARK SALLEY, RES

I N D E X

EPRI/NRC-RES FIRE PRA METHODOLOGY FOR NUCLEAR POWER FACILITIES

VERIFICATION AND VALIDATION OF SELECTED FIRE MODELS FOR NUCLEAR POWER PLANT APPLICATIONS

P R O C E E D I N G S

8:29 A.M.

CHAIRMAN ROSEN: The meeting will now come to order. Good morning.

This is a meeting of the ACRS Subcommittee on Fire Protection. I'm Steve Rosen, Chairman of the Subcommittee. Members in attendance are Rich Denning, Dana Powers, John Sieber, Jack, and Graham Wallis.

The purpose of this meeting is to discuss the NRC/EPRI Joint Work on Fire Risk Requantification.

The Subcommittee will discuss NUREG/CR-6850, EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities. The Subcommittee will also hear a brief presentation on verification and validation of fire models.

The Subcommittee will gather information, analyze relevant issues and facts and formulate proposed actions and positions, as appropriate, for deliberation by the Full Committee.

Dr. Hossein Nourbakhsh is the Designated Federal Official for this meeting.

The rules of participation in today's meeting have been announced as part of its notice of this meeting previously published in the Federal Register on April 20, 2005.

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

It is requested that speakers first identify themselves, use one of the microphones and speak with sufficient clarity and volume so that they can be readily heard.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's hearing.

We will not proceed with the meeting and call upon Mark Salley of the Office of Research to begin.

Mark?

MR. SALLEY: Good morning, Steve, and Members of ACRS.

We've got two exciting presentations for you today in the area of fire protection. Both were joint, collaborated projects with EPRI and I've got Gary Vine with me from EPRI. I'd like to turn it over to Gary to say a few words.

MR. VINE: Good morning. I'm pleased to be here. We've got a good team here to brief you on all of our work.

I'm going to cover a little bit of the

history here for those of you who may not be aware of the basis upon which EPRI and RES collaborate on research activities such as these. You may remember that back in the 1970s there was an extensive amount of collaboration between the industry and NRC on all kinds of research, but that kind of dwindled in the 1980s and early 1990s to the point that we weren't even cooperating at all on any research.

I think we were kind of driven apart by the lawyers who sensed that there was a huge independence problem if we were to work together on research. It was creating some very serious problems. There were issues that would go for decades without resolution because the industry couldn't -- and the NRC -- couldn't even agree on what the problem was and how to approach gathering the data to resolve it.

And it kind of game to a head during the direction setting initiative and strategic planning work that NRC did in the mid-1990s under the chairmanship of Shirley Jackson where there was a real focus on research. And the result of that was a recognition that under proper constraints, the industry and NRC could, in fact, collaborate on research.

The constraints that were established were intended to make sure that we work together on the data collection phase and not on working together on what the regulatory implications of that data might be. Those decision needed to be determined --

MR. WALLIS: Do you just collect data or do you analyze it?

MR. VINE: Well, it's an interesting question. The lawyers have parsed the word "analyze" very carefully. I think certainly the spirit under which the MOU that we operate under was created was that we would not collect data and just throw the raw data over the transom to NRR and NEI and let them fight it out.

The intent was to work on the data, once it's collected, to make sure that it's all there, that the work that is -- that has been completed was satisfactory to address the issue, to make sure that it's perfectly understood and really basically smooth it up so that it's ready for decision makers to deal with, but not to enter into any negotiations as to what it means in regulatory space.

So it's a gray area, but we're --

MR. WALLIS: Who developed all these fire models?

MR. VINE: We're going to cover that later.

MR. WALLIS: You guys did, didn't you?

MR. VINE: Some were developed by industry and --

MR. WALLIS: So industry must have done some analysis?

MR. VINE: Right. I'm really now trying to talk about where we're cooperating, okay?

MR. WALLIS: I'm concerned -- the model, where you guys produce data and then throw it at the NRC and they're supposed to figure out what to do with it. It's not a very good way to do work.

MR. VINE: That's why we were trying to cooperate.

MR. WALLIS: We'll hear more about it later.

MR. VINE: Yes. So under the ground rules under which we operate, there is no conflict of interest. There is no issue of independence and we do part company at an appropriate place where the data is ready for decision makers to use and then RES, of course, can work with NRR to answer any questions they have about the data as they go about their business and if NEI has questions about the data, then they'll come to us, but we're not collaborating any more at that point when it's in regulatory space.

The MOU was established in 1997 under the leadership of Ashok Thadani on your side and matured over many years under his leadership. I think he was in a six-month assignment up in the EDO's office, so he didn't actually get to sign it, but he was on the front and back end of the thing as it was being developed. We have had major successes under this MOU in a variety of areas. Fire is only one.

In the fire area we began cooperating and exchanging information around 2000. A lot of data exchange, we've worked together on circuit failure analysis issues and then began work -- Nathan Su and Tom King and others urged us to consider how we might work together on risk-informed approaches to fire and we started off, I think it was around 2002, but you'll hear the details later on a fire risk requantification effort. That's the focus on this morning's briefings.

Following that, and concurrent with the completion of that work, we've done an extensive amount of cooperation on workshops and training for both NRC staff and industry personnel involved in this type of analysis to bring them up to speed on what we've learned and accomplished and then we worked on fire modeling scenarios and then as you'll hear this afternoon, work now on fire model Code V & V. So there's been quite a bit of success in your fire under our MOU.

MR. WALLIS: I've got to ask the question because I'm going to leave for a short while, I assume.

I noticed that neither of the two pilot plants had completed the fire PRA. I always hoped that they would have done. Is this because it turns out to be too difficult?

MR. VINE: Not too difficult, but it was resource intensive. You will hear some more today about how far we got with both of those pilots and what we gained in both cases.

I think it was an adequate learning from those, but obviously there's some more demonstration to be done.

MR. WALLIS: The real proof of your work is when it's used. It's used all the way through to completion.

MR. VINE: Right.

CHAIRMAN ROSEN: And you'll give us some sense of what you think will happen in terms of industry use broader than just the first adopters like new power, but beyond that, what you think is going to happen, and how it's going to unfold?

MR. VINE: We will try, although some of that is to be determined.

Mark, do you want to take it from here?

MR. SALLEY: Sure. Fire-risk analysis is a somewhat technically complex project. It can get quite involved. With the fire-risk requantification, I believe there was a number of successes in the area. Oftentimes, where there was no methodology or way to approach a problem, I believe the team developed a reasonable approach.

Areas that we had been using, I think they looked at it and maybe made it a little better, that you'll see this morning in the presentation. The part of this was it filled in a number of gaps in the analysis and again, I think the team will present that to you.

The bottom line though is that we're trying to improve using our risk information in the regulatory process. This is part of the baseline work that gets developed to do that and I think when you look through, you've all seen the document. Appendix M was my favorite as a personal note. I think it really advanced the science a bit.

Without further ado, I'd like to bring the folks up that you really want to talk to here and J.S.

Hyslop, he's our senior risk and reliability engineer in the fire research team. He was also the project manager for this and headed up the NRC side. So J.S., I'd like to bring you and your folks up here and without further ado we can get on to your hard questions.

DR. POWERS: What I see in vu-graphs to be presented in the written material and things like that, is a lot of gee, we've accomplished a lot. We made some major jumps in improvement subject to the resource constraints. And it seems to come up repeatedly here, resource constraint here, resource, time constraints, things like that.

It all has smacks of kind of here's what we could do rather than here's what needs to be done and so what I guess I'm driving at is you've accomplished a substantial amount, but it looks to me like we're still quite a ways away from where we'd really like to be which is a complete, smooth, seamless union between fire PRA and event-driven PRA and what not.

Has this contributed to getting to that seamless union between the two studies or has this been a diversion?

MR. SALLEY: No, I think we're moving

forward. Any time you get in these projects, you get so far in -- as a large project develops you always learn something. You get a little hindsight. And if I could go back in time I would have done this a little better, a little different. But I definitely believe we're moving forward.

I think after you hear what they -- how they present the material in some of the areas they cover, I think you'll see that.

MR. WALLIS: Well, my colleague is asking are you moving forward. Where would you like to get to and how far have you got?

Why have you not got as far as you might have got because of the questions he's asking.

DR. POWERS: Well, and you're absolutely right. I mean what -- I'm coming from this perspective that we went out and did the IPEEEs and surprising to me, though not surprising to people like Mark, came back and said gee, fire is just as important and operational events. And so you would say gee, I ought to be just as good at analyzing fire PRA as I am at ordinary operational events, but I'm not.

And worse, when I look at how we do PRA, I mean fire has always been kind of a stepchild. It was a stepchild a long time ago. It's why you guys get hidden under external events because people forgot about you. But it strikes me what's even a little more surprising than that is that when you look at ordinary operational sequences, you never see a note that comes along and says "and while this was occurring, there was also a fire in this relay box or something like that." We can't do that sort of thing. And yet, that's the kind of smooth transition you would like to have.

And so I'm sitting here saying gee, are we not putting enough resources -- here we're saying we're risk-informed regulation. We got information. Here's an important area of risk and we're not putting the kind of resources into it that would be commensurate with that kind of read. Now, there might be a sound reason for doing that. You don't believe the results of the IPEEE, but when I ask you, like Mark or Nathan Siu, who I think have good insights on this, they say no, I believe the IPEEE as generally stated. It may be a little overstated and they undertook this to try to get a refined view on all of that. But it's not an order of magnitude off here.

So I'm wondering if -- I'm asking you basically is this kind of a stop gap, rather than a concerted thrust to get us up to the right level of competence and fire PRA from where we are and you're telling me well, we probably had to do this before we could do much more. And I'll believe that.

MR. SALLEY: As far as the resources and that, I believe the NRC is focused in on it properly. Just this past year, this past September, I came over from NRR into research because they had created the fire research team, so I clearly see that as something we're trying to pull together. And even to see that there's interaction between things like fire modeling and fire PRA and how we work it all together. So we've got a concreted effort to do that.

I guess after you hear the presentations today, at the end of the day, if you could bring that same question up, after the team has spoken --

DR. POWERS: What I'd like to get a commitment from you to do is at the end of the day address for us a little bit about the way forward on this and how you see -- do we always want to have you guys in the fire or PRA area being -- you're PRA guys with an asterisk besides you or do we have a smooth capability to go from soup to nuts and PRA and what not. It's not what I would like to see. Now maybe that's just because of my view is bad.

The other thing that I continue to see in visits to the regions is that everybody is happy to inspect until you get to the fire inspection module and then they all want to -- now we've got to bring in some experts from the outside on that and we don't know how to do this. We just don't have the risk information and specialized expertise going out that we really need to have out there. We've done a lot. You yourself have done a lot in this area, but we're still just not there yet. And so I'd like to see where you think we ought to be going and what should be done.

CHAIRMAN ROSEN: Well, I think that's three different takes on the same question, what's the view of the future beyond this and how good is what we've got --

MR. VINE: We'll talk about that at the end of the day. I just want to make one quick point and that is that one of the major considerations when we undertook these two major projects in the area of risk-informed fire analysis was a sense, a qualitative sense that many of the IPEEE results were, in fact, conservative, because we knew objectively that a lot of the assumptions and data that went into those were bounding. Now to me, that brings into question the quantitative results. Now whether or not once we really get into more realistic data and models, whether that drives those numbers way down or whether it doesn't, we're not --

CHAIRMAN ROSEN: Let me say --

MR. VINE: It was bounding.

CHAIRMAN ROSEN: What will happen and when you get done with this, by analogy with the shutdown risk, at the beginning, I remember everybody saying it's conservative. It certainly can't be as high as this. What we found out is it's higher in some places and quite a bit lower in others. It's heterogeneous and I think that same thing is true about fire.

MR. VINE: Now we'll get the experts up here.

DR. POWERS: Mr. Chairman, I have to acknowledge that Mr. Nowlen and I are acquainted and we don't really work together. I do make his life as miserable as I possibly can on a regular basis.

CHAIRMAN ROSEN: Well, I thank you for your acknowledgement of that, Dr. Powers, and I hope you continue to do that at this meeting.

(Laughter.)

MR. NOWLEN: I'll endorse that statement by the way. He does make my life as miserable as possible.

(Laughter.)

DR. POWERS: Well, maybe not that bad. Nowlen didn't even get billing.

MR. VINE: He will.

DR. POWERS: That's my job.

MR. NOWLEN: I at least made them put the logo up on the corner there.

DR. HYSLOP: Everybody is included. My name is J.S. Hyslop and as Mark said, I am the NRC project manager for this program. This is the -- what do I do now? Just click on the left side when I want to move?

I'm speaking about the joint program between EPRI and NRC Research where we've developed a fire PRA methodology. And this presentation is an overview.

My counterpart in this program is Bob Kassawara of EPRI. Bob is not here today, so Bijan is going to talk about a couple of slides. Bijan is the SEIC technical lead for this program and his counterpart is Steve Nowlen of Sandia National Labs who is the other technical lead.

I'm going to speak very briefly about the background because Gary's talked about that. First of all, Research and EPRI developed an MOU on cooperative nuclear safety research on fire risk. This program is one of several elements on that MOU. Another example is the verification validation of fire models that you're going to hear about.

I wish to remind the Committee that this MOU is a part of a much broader fire research program. We have other activities going on. The primary objective of this program is to develop, field test and document the state of the art. And you'll be hearing a lot more about that.

I've spoken before to the ACRS on this. The program has been identified and discussed briefly in prior briefings and as of April 2004, I presented a one-hour focus presentation on this topic.

The purpose of the presentation today is to brief the ACRS on the final NUREG CR6850 EPRI 1008239, EPRI NRC Research Fire Theory Methodology for Nuclear Power Facilities and that addresses public comments.

For the roles of the participants, Research and EPRI developed and tested the methods. The methodology consists of 16 procedures and associated appendices. All these procedures were tested, however, they weren't tested in an integrated fashion.

We have three volunteer pilot plants to support the testing. Basically, what happened was these procedures were tested for their viability via the PRA of these pilot plans. They're Millstone Unit 3, D.C. Cook and then we had an independent one, Diablo Canyon, who provided us feedback.

We had other participating licensees that provided peer review methods. The peer reviewers reviewed these procedures in many stages. They had a lot of helpful, constructive comments. They did not participate in the testing of the procedures. The peer reviewers would be Duke Power, Florida Power and Light, Exelon, Nuclear Management, Southern Cal and CANDU Owner's Group. Dennis was one of our more active peer reviewers in this program.

EPRI and NRC Research have reached consensus on this document and methodology. We had many collegial debates, but in the end, reached consensus.

Now for the expected use of this methodology, we expect it to support the new rule, 10 CFR 5048C which endorses NFP805. It's referenced in the draft Reg Guide. We expect it to support analyses under the current fire protection regulations, exemptions and deviations, as well as other plant changes such as risk-informed tech specs.

The basis for staff review guidance, the research developed for the changes under 805, it's also supporting the fire risk standard developed under the auspices of ANS. A lot of influence here. Many of the same people are working on this standard as has worked on this project. And it also support analyses and reviews of Phase III SDPs on fire protection.

I'm going to talk a little bit about the advancement to the state-of-the-art. Improvements were made in areas important to fire risk. However, we did consider resource constraints. I see Dr. Wallis has left, I'm sorry for that.

Now just because there was a lot of work, doesn't mean we didn't do it. We put a lot of work in circuit analysis, for example. However, fire, HRA, the state-of-the-art, at least for fire, was quite far out there. It's going to take a lot of resources. So what we did is we produced, we developed a screening approach for fire HRA, but we did not develop a detailed approach to fire HRA. That's one of the things that's out there and you'll see at the end of the day that we hold potential for additional research.

CHAIRMAN ROSEN: What are the aspects of fire HRA that make it peculiarly different from HRA for other internal events?

DR. HYSLOP: Well, there's the fire effects. There's the high temperatures, the smoke; whether or not you want to have activities in a fire-affected area. That's a no-no, for instance. So there's -- those special considerations --

CHAIRMAN ROSEN: But those are in the HRA already for -- under environmental effects, radiation, high temperature.

DR. HYSLOP: Well, but smoke -- I'm not sure smoke. They're in there, but in my view -- do you want to take care of that?

MR. NAJAFI: Fire -- this is Bijan Najafi. Fire introduces a whole new set of performance-shaping factors that you were not including in your internal event. In those performance-shaping factors, you will get an in-depth discussion of that list during our HRA presentation this afternoon. Examples are environmental conditions in addition to what kind of malfunction of instrumentation potentially a fire may have caused which you may not see it in a condition that is not driven by fire, so you may have instruments going wild. You may have -- basically, the difference is to define new performance shaping factors, understand the impact of those performance-shaping on the human response and how to quantify it.

DR. HYSLOP: So there are four ways in which we advance the state-of-the-art here. First of all, with consolidate existing research that had been done by EPRI and the Office of Nuclear Regulatory Research. That was seen in partitioning, for instance. We consolidated best practices.

We also analyzed more extensive data. An example there was we include the long duration fires for purposes to determine suppression reliability. We modified existing methods. An example there is the work that we did in circuit analysis and we developed new approaches.

As Mark said, there was no approach out there for high energy arc and fall. That was Appendix M. Now we have an approach that defines its zone of influence for physical damage as well as ignition. And you'll hear more about these in the presentation. I just wanted to give you a sample of these advancements.

So Research has several on-going analytical programs. One is the fire model V & V. You're going to hear about that later. Of course, there's a relationship between fire models and fire PRA. The fire modeling tools determine the equipment which is damaged and that's essential for any core damage frequency determination.

A fire model verification and validation which is a very formal extensive process is required for NFPA 805 applications. It's identified in the standard.

In limited cases, we have utilized empirical correlations in our approach. We did it to address cases where computational fire models were inadequate. We couldn't run a CFAST model and get an answer. And we felt there were gaps, gaps in the PRA approach where we needed to supply these empirical correlations to evaluate important risk considerations.

This PRA methodology document is not a reference for fire models per se. There's no ASTM standard. There's no V & V that's done by -- for an ASTM standard in this work.

The V & V, if necessary, is left to the analyst and that V & V would be for NFPA 805 applications. But I want to remind the Committee that this document serves a broader audience than 805. There are exemptions and deviations and there is fire protection SDP analyses. So we're not simply focused on 805 and its applications.

CHAIRMAN ROSEN: You gave us a list of what those things were, did you not?

DR. HYSLOP: Yes, I did in the beginning.

CHAIRMAN ROSEN: It's like your fourth slide.

DR. HYSLOP: Yes. Public comments, we received comments during the public comment period by industries and consultants, Duke Power, Florida Power and Light and then two consultants, EPM and RDS. We also got significant comments from NRR. No public comment required the team, Research and EPRI to significantly adjust our approach.

Now we did get a few comments on the state-of-the-art limitation. We got one comment, where's your detailed fire, HRA guidance? It's not there. Well, it's not there. And we talked about why that's not there.

The remaining comments were minor in the clarifications. And you're going to hear more about this public comment in each of the specific technical presentations.

Now for the model extension program, a

draft report for public comment was issued in October 2004. It was a 60-day public comment period. That's closed.

And we've addressed those comments.

Here we are in the ACRS Subcommittee today, so we have ACRS Subcommittee and Full Committee meetings. We have -- we're going to hold a fire PRA methodology workshop that's posted on the NRC public website. There's an ADDAMS for it. There's a lot of interest in this workshop and that's June 14th through the 16th of this year in Charlotte, North Carolina at the EPRI facility.

We plan to publish in August. We have an additional --

DR. POWERS: When you say "publish" you mean you're going to put out a NUREG report?

DR. HYSLOP: Yes, a NUREG/EPRI report final.

DR. POWERS: And that's great. Good.

DR. HYSLOP: Thank you.

DR. POWERS: But you're not reaching the community that I think you need to get the kind of extended period you would like.

DR. HYSLOP: And what community would that be?

DR. POWERS: I think that's the people who are involved in fire, but not in nuclear.

DR. HYSLOP: Hm.

DR. POWERS: Or the people involved in nuclear that are not involved in fire. Either one of them, you need to start making contact with them. And so do you have a strategy to go to the archival journals?

DR. HYSLOP: Go ahead.

MR. NAJAFI: You mentioned two different communities. Let me take one at a time. The communities in the nuclear PRA and not fire, we've had most of the peer review team that reviewed the draft of this, they have extensive experience in internal event PRA. Most of them were not involved in the fire PRA per se. I mean they had experience, but that's how we covered the people with internal fire experience.

With the review and expertise of fire community, in general, non-nuclear, I can say that I sit on a committee for SFPE to write a risk guideline, fire risk assessment guideline. The rules and the methods and even I venture to say the data to be used in what I call greater fire protection community, is so different from what we do in the nuclear industry that argument can be made almost the two are completely day and night.

Many of the approaches, technical issues, that are of interest to us, for example, Circun, is of no interest to greater fire protection community. Some of the things that is of interest to them, it's of interest to us, but not to that level of depth, life safety, risk to the occupants.

DR. POWERS: I guess we've encountered that for 10 years, that the larger community worries about the same people out of burning hotels. I mean that's their motivation, number one. You're the one wanting to save a core. And that's your number one.

Still it seems to me that you guys have been isolated in your own world for so long you've come to think that that's the way it ought to be. I think when you write down publication, don't get me wrong, publication and NUREG reports are an essential thing to do and I hope you have a good cold one for me when you do it.

But I think you need a strategy to reach out to the rest of the pertinent technical community and mainstream. And I think the way to do that, the vehicle for doing that is well, it's an engineering field so certainly conferences are applying, general conferences I'm thinking of here. But I think you ought to reach out to the nuclear technology, as an example.

I think you ought to be reaching out to some of the fire journals, even if they don't like what you're talking about. I think you need to acquaint them and I recall 20 years ago the National Academy of Sciences and a review of NRC Research made the point that you never know when that fire protection engineer from Bangladesh reading a journal article might have a brilliant idea that will save you a lot of work in the future.

I just don't think it will hurt you to make an aggressive -- the other thing that going into the archive of journals if you will make it possible for people to build on your work and quite frankly, when you put things into EPRI reports or NUREG reports, people will not build on your work. They'll do their own and publish parallel studies and what not and so you've had a success here. I mean create a foundation for the next step. I think there has to be a next step. I still think you're a long ways away from where you want to be.

DR. HYSLOP: At the end of the day we'll talk about areas of potential research and thank you for your comment.

Okay, so the BWR pilot, we have another pilot plant and one of the major purposes of the pilot plant is to get that full integrated testing and that's going to happen in 2006. We recognize the deficiency and we feel it would beneficial. If necessary, then we'll revise the methodology. We think we've got a good thing here. We certainly expect any modifications to be minor, but if necessary, we will modify it. So we're holding that open to a possibility.

DR. POWERS: I'd like to see Ginna run this methodology.

DR. HYSLOP: I'll turn it over to Bijan now.

MR. NAJAFI: In fact, a BWR pilot that we're working on is within the same utility that Ginna is. At some point maybe they decide it's good enough that they can use it in Ginna as well.

What I'll be talking about on a couple of slides here, I just want to talk, introduce the project team to you and maybe the overall process of this methodology to set the stage for the technical discussions on each task that will come later.

One of the critical -- I mean when we

started this project, this effort in 2002, one of the critical steps was to assemble a team, assemble a team to accomplish something that we felt that it's going to be of an important milestone, both in terms of the cooperative work and in terms of the quality to support its ability to support a risk-informed fire protection.

There were two criteria that we basically used to assemble a good team. One was to make sure that we bring together enough of depth of experience in all the disciplines that it's involved in a fire-risk assessment, enough experience that can deal with the fire hazard, fire modeling, fire science, electrical engineering, Appendix R safe shutdown, risk assessment, human factors and all different situations.

And the other factor was that we also wanted to take maximum advantage of the two research programs that had been in existence for over one or two decades or more, one at EPRI, one at NRC. So that we basically take maximum advantage and try to collectively get the two benefits of both research programs.

So the team that was assembled basically, has been involved in the development of the methods that has been in existence at least in this country for the past 20, 25 years and then also what I would like to mention after what J.S. said about the consensus building, we did have a vehicle and in our program plan we created a mechanism through which not only we can reach consensus, but at the same time if a consensus is not reached we can maintain and document different points of view.

But fortunately, that's one of -- my criteria for the success in addition to the quality of the document is that we were able, as a team, to reach consensus, if we needed to find additional information to help us to reach that consensus, we did make an effort. An example of it being HRA, that it was a challenge for us. We had to make one or two additional plant visits, interviews with plant operators to reach that consensus, so we did reach out and made a significant effort to reach that consensus.

So that was basically, I mean that is something that we can build on for the future. Next, please.

The next slide, I would talk about the process, overview of the process for this methodology. The message that we describe in this document is presented in the form of a process and technical task procedures for the conduct or instructions for each one of the elements of that process. The process that you see here, it remains for the most part similar to what was in the past. There's not a significant difference from the methods, that it was all the way from 1150 to 5 and fire PRA implementing guide that EPRI developed in the 1990s. However, there is significant differences and changes in improvement in each one of these boxes.

The remainder of our presentations, we will go through each one of these basically boxes. We would not go separately in each box. We have separated these technical steps or discussions into three categories. The categories are the fire related categories. Those are the ones that deal with the initiation of a fire; characterization of an initial fire; and how the fire would grow and what kind of damage will it cause. So that is basically all condensed into one set of presentations that Steve Nowlen and myself will go through.

The second presentation that you would see will cover all the areas related to PRA and HRA. That's the part of a fire risk assessment that takes the effects of a fire and creates a plant response model and what that means is that which systems are called upon to respond, how do they respond and how the operator responds to those sequences of events that it's caused by the fire.

The third major technical discipline is electrical in Appendix R. That's the piece that comes in between. That's the unique piece related to the nuclear facilities that says that once a fire has caused its damage, what kind of an electrical response do we need, do we expect from the plant to happen? How would the plant and its safety function behave in an electrical response so that we have separated these technical discussions that will follow into these three pieces and you will hear this for the rest of the morning.

CHAIRMAN ROSEN: Hold on. I'm a little troubled by the idea that the rest of the world is not interested in nuclear and we are not interested in the rest of the world. I think that the latter is clearly not true in the sense that there are large volume fires, large volume combustible fires in the rest of the world, for instance, oil fires. And we are very much interested in large volume combustible fires, oil fires, for instance, in turbine buildings or perhaps from a reactor coolant pump supply.

So I just don't want to leave that --

that's too facile for me to say that.

DR. HYSLOP: Steve, for example, in our heat release rate distribution development, my understanding is we looked at literature beyond nuclear power plant, right, Steve?

MR. NOWLEN: Yeah, that's very true. This is Steve Nowlen, by the way. We did look at general industry data as well. For example, in high energy arcing faults area and in some of these larger fires, we looked at what was available in the general industry. That was a part of our reasoning in developing pieces of the fire modeling approach, for example.

The one thing that we ran into in terms of general industry is to use the information directly in a statistical sense is rather difficult because you have very little information about populations and lifetime experience, for example, which is what we need to get to our statistical frequencies.

So there's a limit to what you can do with some of the public, general fire protection information, but to the extent we could, we used it. I think the point that Bijan was making is that when it comes to general fire protection, this one critical thing for us, the electrical circuit, failure modes and effects and analysis is they are just not interested.

CHAIRMAN ROSEN: I agree with that. What I'm thinking though, the phenomenological effects of large fires is something that's directly translatable.

MR. NOWLEN: Oh, absolutely. And one of the things that I think you'll hear later today, I should be careful, but in the area of the fire modeling V & V, the nuclear community actually represents a very small piece of the pie. The broader community is huge, compared to the nuclear community. So it definitely comes into play there.

And it's an issue that I think you'll hear them discuss this afternoon. We have the same interest in information about fire characterization and the behavior of fires and much of our information does, in fact, come from general community, for example, our fire protection system reliability estimates are based largely on general community data because our community is relatively small. Their community is very, very large in terms of the number of fire protection systems out there and given that failures are extremely rare, we use their data.

So there are various pieces that come in from the general community. I don't think -- there is a bit of a line and I think we've been, in terms of Dana's question earlier, I think we've been better at reaching out to the PRA community that's non-fire than we have been at reaching out to the fire community that's non-nuclear. I think we've done a fair amount of both, but I think we've been better at reaching out to the PRA community.

But again, I don't think you should walk away with an impression that we're ignoring what's happening in the general community of fire protection. That is not correct.

MR. NAJAFI: I'd like to clarify one thing I said earlier. What I meant is that the methodology and the definition and the objective that they do for a risk analysis out there is drastically different, does not mean that the issues at a lower level of interest there is no coherency between them.

We both use similar tools to assess the fire effects and progression. They use DTACT. We use DTACT. These are computer computational codes that calculates the response of a detector. We use CFAST, codes like that and they do the same.

When it comes to the data for suppression, reliability, when we -- EPRI -- tried to develop this 20 years ago, we felt that the data potentially is applicable, so we should use it. I did not mean to say that the interest in dealing in the data and assessment of individual characteristics, there's no interest or relevance. What I meant is that the process of doing risk assessment for -- I mean they follow an approach that it's completely different than the process that we set for ourselves, beyond just the electrical stuff. I mean the issues -- their undesired event is different than ours. Their critical issues are not the same as ours. So -- but at times we use the same data and the tools, a consistent set of tools and data and in those cases we have tried to assess or investigate or survey or research what they do and determine its relevance to what we do.

DR. HYSLOP: Is that it, Bijan?

MR. NAJAFI: Well, basically, it's the same thing. All I wanted to say is this is the process flow chart and the color coding will show you the three technical areas that we have structured our technical presentations around.

And then before we get to those technical presentations, I think the next presentation we had a peer review team that was assembled from seven or eight utility members that they reviewed various manuscripts of this document, provided comment to us and the key participant to that effort was Dennis Henneke from Duke Power who is here today and he's going to basically present the views of the peer review team of this project.

CHAIRMAN ROSEN: Okay, thank you very much.

Dennis?

MR. HENNEKE: I believe my presentation is up here. For those of you who don't know me, I'm Dennis Henneke. I'm the corporate fire PRA person for Duke Power. And as such, I fill a lot of roles, especially right now. I'm the chairman of the ANS Fire PRA Standard Committee and a lot of the members on the requantification project are also on our fire standard.

As Bijan said, I was one of the main people in the peer review team for the project for the last two years and as many of you know, Duke Power is also committed to transitioning to the NFP 805 risk informed fire protection, so we'll be the first penguin off the ice, as we say, for risk-informed fire protection and as such, with regard to 805 is to make sure that there's a fire PRA method out there that is usable that we can perform a fire PRA in our lifetime and within some sort of reasonable budget and that it makes sense. And so a lot of what I'm going to say today was with regard to trying to get to that, to get to that point.

First, I'm going to talk about the positive aspects of the project from an independent viewpoint and it really has to do with mainly the team and the way the team work together was pretty interesting to watch. And in a couple of areas for improvement and there are a lot of areas. We could spend research dollars on this until we run out of money. There are a couple of areas that we kind of looked at with regard to the accuracy of the results, the usability of the results and I'll go through those and basically to summarize those areas for improvements in a series of recommendations that peer review had put forward.

The positive aspects. It really focuses in on the team. Outside of the team, I kind of joked that there are -- besides the people on the team, there are three other fire PRA people in the industry. It's not quite that bad, but there are not a lot of fire PRA folks around, even from the old days of the IPEEE. A lot of those people have moved on or are not doing that any more and so even as far as utility folks, there are only a handful of really qualified folks that work in the utility and outside of that in the area of consultants, not a lot of folks beyond the team we had.

The team that was put forward on this project, really was the best in the industry and part of it which is really hard to quantify was that nobody on the team, as far as when I worked with them, really had any sort of an agenda or just was totally inflexible in what they wanted to do and really everybody was just trying to do the right thing and get the right answer and they really should be commended for that. Except Steve.

(Laughter.)

I'm just kidding. Actually, Steve was probably the -- at the forefront of that type of thinking, really trying to get the right results, so we all like to give Steve a hard time, but he really did a great job. On the record.

Really, in the process that was developed, it did take a little extra time, but because of the collaboration and the different viewpoints, it worked pretty well, so the extra time was really worth it in this type of project, as long as it can be kept separate.

As far as the final product, there was a step change in a number of areas. You've heard a couple of them. One area that will become significant in risk-informed fire protection is in the area of control room fires. This seems on the surface to be an excellent method. It is untested as of yet and no one has run an entire control room PRA analysis. It will be key, I'm telling you. We've seen a lot of risk numbers come out and like the number 2 over number 3 fire area. We get into spurious analysis, manual actions, any of the areas that we're interested in, control room will be the center of the world. So really keying in on this and testing this out will be important.

A lot of improvement in the area of fire ignition frequencies, both in the methods and in the categorization. Just some slight changes in that regard, but it does make a big difference on being able to get accurate and usable results.

A step change in the area of circuit analysis, a multiple spurious and there was a lot of stuff that preceded this that helped in this area including NEI001 and the testing, the fire testing that went on to get spurious operation probabilities. But definitely a marked improvement over the previous methods and I do have a comment on that and it still needs some work in that area, but I'll talk about that in a minute.

Marked improvement in scoping fire modeling, fire HRA, you know, again, the method with regard to screening it's been used, but not fully used, so we'll have to see how that works.

Personally, I'm not so worried --

DR. SHACK: What's your concern? Is it just too difficult to use as a practical tool?

MR. HENNEKE: I have really no concern at this point. IN fact, with regard to present HRA methods, we use present HRA methods in our fire PRA. We find no issue with it at Duke Power. The screening method will help in that regard, so help you do the HRA much more rapidly, not so much different than the screening methods we use now, so I think it just documents a lot of the typical HRA stuff we're doing for other things and so in that regard it's an improvement and truthfully, I have no concerns on the HRA.

CHAIRMAN ROSEN: It seems to me it would fit very nicely into the area of forcing context protocol. It's just different, as I think we said before, different or more severe area of forcing context.

MR. HENNEKE: In fact, most of the human actions that we do are the same sort of procedures, emergency response procedures and so on that are procedure driven. A lot of them in the control room, a lot of accidents we have, all sort of instrumentation going off anyway, so a lot of the human actions are important, are very, very similar and we've already done the stuff on it anyway.

So it's -- the only concern I have is that the whole procedure is a pretty big document is untested. There may be a paragraph in one of these procedures that says go out and test all your HRA on the simulator or something. We didn't realize I was in the procedure and now we've got to do it and we can't meet the procedures, so there may be something lying in there just because it's untested, that's all.

And in the area of fire risk modification, and I guess this is one of the areas I've been pushing for the last couple of years. In the old method, we would go in a fire area, pick an initiating event, run the sequences, add in the human actions, spurious operations. That's not exactly right. In a lot of cases there are new accident sequences and those are new initiating events, those are initiating events as a result of the fire response procedures in closing the PORVs and turning pumps off and things like that.

So the procedures that they developed now have discussion in that area. May be able to improve in that area, but it's really the focus of the unknown right now in fire risk is are these new accident sequences as a result of the fire or as a result of the fire fighting procedures that we really need to get a better handle on from a risk standpoint.

CHAIRMAN ROSEN: Let's come back just for a minute to the beginning of this discussion where we talked about where are we headed. Let me tell you where I would want to head and let's see if we have agreement.

You're there when you have done an analysis which allows you to change your emergency operating procedures to incorporate the effects of these kinds of fires because right now they probably don't. Is that a fair statement?

MR. HENNEKE: Every plant operates differently. A large percentage of the plants have, when a fire occurs, have the emergency operating procedures on the left side and the fire fighting procedures on the right side. I doubt we will ever get to where they're the same procedure. There are just some so specific actions with regard to fire that they won't specifically go in emergency response procedures.

A lot of it can and a lot of it already has for a number of plants. But I doubt we can ever do that.

CHAIRMAN ROSEN: Well, I'm not so sure I care about the actual format, but just the logic that comes out of a good fire PRA that may not now be in the procedures, whether they be EOPs or some other kind of procedure that says you can have an effect like this, if you see this, if I hear and you see this, then you need to take these actions and the embodiment of that in the procedure is the final step.

MR. HENNEKE: This is a little off track, but let me talk to a concept that maybe will be a better concept and that is if it's in the fire PRA, or let's say it's in the fire safe shutdown analysis, it is in the fire PRA. If it's in the fire PRA, it's in the fire safe shutdown analysis. They match 100 percent and if those then are put into the procedures. So for example, if you have a low risk multiple spurious sequence, extremely low risk, no problem with defense-in-depth, you take it out of the safe shutdown analysis. You take it out of the procedures.

PRA shows you have a sequence with regard to seal injections, seal cooling wasn't in the analysis, wasn't in procedures, it goes in. Those should match 100 percent and that's the concept we're going forward in risk-informed fire protection at Duke. I think that's a better model to think about. Now how the procedures specifically look with regard to other accidents, I think that's with regard to how you want to focus your procedures and how much you want to integrate fire into those.

CHAIRMAN ROSEN: I think that's a fair response.

MR. HENNEKE: Another positive aspect is that the flow chart that Bijan showed here really flows into the standard, so if it says you're doing a qualitative screening, there is a section in the fire PRA standards that says qualitative screening. So unlike a lot of -- let's say the external events PRA standard where it says you're going to do something, but there's no document to point to.

In this case, the PRA standard will have multiple documents to point to for qualitative screening, quantitative screening and so on. So it's very usable in that respect.

So let me talk about a couple of areas for improvement. Basically, as I mentioned, these procedures are untested. There's 600 plus pages and maybe a handful of us in the room have read them fully. And maybe one person outside the room has read it fully. So it's a tremendous amount of paper.

There is another pilot. There is also a second pilot which is not a formal pilot and that's Duke Power. We'll be using it at our Oconee plant. We will be providing by this time next year a full set of comments on the procedures and I think that's the real key is when these procedures are used a couple of times, we'll find out how usable they are and whether they can be done with a reasonable budget.

So that's really just continue on path there and then look for the folks that are going to 805. Wait -- and EPRI has a really bad reputation. If it says they're going to revise it December of next year, they will revise it December of next year. You really need to wait in that regard until we've gotten enough use and enough feedback to be able to say that the product is reasonable. So it shouldn't be on a deadline. We should wait until we get the positive feedback or the comments back.

In the area of initiating events, you see that I've listed that in my areas that were very positive and a step change. On the other side there are still a number of categories such as electrical cabinets which are kind of key to us where the categorization of whether it's a fire and a challenging fire was conservatively performed. A lot of it has to do with the data and it just -- maybe three words in the description and you have to take those three words and try to figure out whether it was a challenging fire or not.

The result was that it was always categorized conservative in the initiating events. Twenty five percent of the overall results were put as undetermined of a challenging fire and that meant it was half a fire. It was assigned as half a fire.

And then --

CHAIRMAN ROSEN: Well, it's counted as half a fire. You needed two of them to get a whole.

MR. HENNEKE: Yes. Of the ones that were challenging --

CHAIRMAN ROSEN: Half a fire is a curious language.

MR. NOWLEN: Well, it's a statistical exercise. It all has to do with how you calculate the fire frequency and if we categorized an event that is potentially challenging, it went it as a one. That's one fire, two, three, four. If we came to one that was non-challenging, it goes in as zero. We say that doesn't count. But these ones that were indeterminate we treated them statistically by saying instead if we can't tell whether it's challenging or not, we just said well, we'll count it as a half a fire, so those went in as a half, a half, half, half, half, and then at the end you add them all up and come up with a fire frequency on that basis. So yeah, the unknown events went in as one half of an event because we couldn't tell.

MR. HENNEKE: Of the 34 percent of fires that were labeled as challenging, again, they were conservatively assigned and I just put an event 1322 there, in the description hot sparks and it was labeled as a challenging fire.

It wasn't a large percentage of the 34 percent that were not challenging, in my opinion, but it was enough to make a difference.

Now what keyed me in is some of the newer data is a little worse than some of the old data from say the EPRI 5 and fire PRA methods from before and then the other thing is the more recent data say that the past four or five years, we have a lot better descriptions, a lot more accurate data and we're showing lower fire frequencies. A lot of these are not transient fires. These are cabinet fires. I would not expect cabinet fires to decrease in frequency a tremendous amount, but they were showing that occurring and a lot of that I'm going to attribute to the categorization aspect of it, the conservative categorization based on poor descriptions of the earlier data.

In the area of electrical cabinets and some of the other keys, I think some of the data may be as high as a factor of 2 conservative as a result. So electrical cabinets, remember that one. If you look at 805 in risk-informed applications, that's going to be the key. I think other areas like explosive fires and so on, those are not so conservative. I think if it's an explosive fire, it's in the data. You'll understand it. So again, it's just a couple of the categorization are somewhat conservative in that regard. It's not a big deal to start with, but when you look at the other areas, we'll show you how it can affect the final results.

In the area of suppression, the method is quite interesting. I have not personally been comfortable with this method and that has to do with the use of a generic duration curve. In the old method, we used to take our fire drills and do timing to various fire areas and we have a nonsuppression probability based on the timing curves of our fire brigade.

The aspect of that is it can be nonconservative in some cases, so they chose a different method, a duration curve. The problem with that is we have no way to incorporate plan-specific attributes such as continuous fire watches, occupied spaces. We also, if there's an area right outside the control room or if there's an area down in the bowels of the earth, of the plant, the lowest levels of the plant, they have the same suppression probability.

So we had recommended some aspects be looked at with regard to looking at upper bound or lower bound or being able to incorporate plant specific suppression and the present methodologies just do not do that. So I think that's definitely an area for improvement.

The suppression curves, the other aspect of suppression curves are that they are based on fire duration and the duration is in the data. It is very common and the Oconee turbine building fire, for example, we had to switch 7 kv switch gear fire lasted 45 minutes. The fire brigade was controlling that fire in 10 minutes. It lasted 45 minutes until they were able to get the plant in a position where they could down power the switch gear and the switch gear was the cause of the fire and they didn't want to try to put people in the middle of the fire, open up the cabinet, put a hose stream on a powered up electrical cabinet.

So there is a difference, a large difference between duration and control of a fire. We did make a comment on that, but there was nothing with regard to changing the methodology. It was listed in the Volume 1 of the fire PRA report as an issue going forward.

CHAIRMAN ROSEN: Well, that's a data reporting issue, too, is it not? You may not have that clarity.

MR. HENNEKE: But we should be able to at least take some simplified models with regard to control of a fire and plant specific aspect of controls for various types of fires and be able to put that in the PRA model. It should not be something we can't do even without the data.

MR. SIEBER: It's bound to be subjective, don't you think?

MR. HENNEKE: I think we could come up

with a new objective method.

MR. SIEBER: Okay.

MR. HENNEKE: And kind of mix in the old method where we had the time to get the brigade, a time to get a brigade response and a duration curve. I think that would be an excellent way to go.

Do you want to rebut me on that one?

MR. NAJAFI: No, I just wanted to add one clarification. Some of the -- the previous methods EPRI had two methods, 5 and 1, that was published in 1995. EPRI Fire PRA Guide. The 5 methodology is more along the line that Dennis is talking about based on the brigade response time. The FIRE PRA Guide methodology in 1995 was more along the line of what it is here, was not -- I mean -- so there are multiple ways of dealing with the same issue and each one has advantages and disadvantages.

MR. HENNEKE: Last area for improvement is the area of circuit analysis probabilities. Again, it's a positive and negative. It's definitely a step change. Along with that step change, I think we have over-estimated the probability of spurious operation for a number of -- based on a number of aspects.

First, the original spurious operation probability is that it was performed by the EPRI testing, did not analyze the data very well. In fact, and Dan Funk can probably speak to this a little better, but there were two -- there was an open and closed coil in the circuit. When either of those actuated, it was called a spurious actuation, but it may have been an open valve going in the open position or closed valve going in a closed position and in that regard, it's not a spurious operation. It is an operation of the circuit, but it doesn't change the position of the valve. That did not come into play in the spurious operation, probably was what was put forward in the tables that you've all seen.

So in a lot of aspects, we are conservative and could be as high as a factor of 2 conservative as a result of the way we counted it and did the data. Also, where it ends up, it may go open, maybe have a close, go open and then it may eventually go closed again. So in that regard, you could end up in the correct position, even with the spurious operation.

There is, however, the possibility of being nonconservative. And we have seen circuits where the only possibility is the spurious operation in the wrong direction. More commonly, if there's not a light on the circuit, you could have a spurious operation in either direction and the valve can go open, go closed, go open, go closed and so ending up in the wrong position is a 50-50 probability.

That is not in the method and that is not in the data at this point. Now there was an alternate method used that Dan Funk created which kind of goes to that, but really to be able to -- to go into that complicated analysis and apply the right probability, I think there's a lot of improvement in that area.

Overall results, if you take, for example, we're looking at in risk-informed fire protection, one of the keys that we're looking at is to rebaseline our Appendix R, multiple spurious licensing basis in that if it's greater than 10^{-6}, no matter if it's a single multiple, 3 spurious, whatever, it's in our licensing basis. If it's not risk significant and it doesn't have any issues with the defense-in-depth, it's outside of our licensing basis.

That's one of the key aspects that Duke is using going forward in the area of multiple spurious and if you're conservative, then your licensing basis, your new licensing basis is greatly affected. So if you had an electrical cabinet with one of these duration curves applied and you had a multiple spurious, you could easily be a factor of 10 conservative in that regard.

So we would hate to see all the conservatisms, even though minor, like factor of two type of things continue going forward when they can be additive and end up with a fairly large conservatism in the end.

That's why the final slide here is the area of recommendations and that is to assure that we continue having multiple feedback, not just the single BWR pilot, but also from the Duke plants and whoever else is using 805, that these are considered and incorporated. That is part of the process and I continue to recommend that to EPRI.

And in the areas I've discussed above in the are of fire ignition frequency, fire duration, and spurious operation, probably additional research is considered.

Questions?

CHAIRMAN ROSEN: Okay, no. I think unless we have any we can go on to keep on schedule and try and finish up on or about 10 o'clock. We've got another 20 minute presentation scheduled. Let's try that.

Alan?

MR. KOLACZKOWSKI: Okay, I'm Alan

Kolaczkowski of Science Applications International Corporation, part of the technical team. And I'm going to talk about part of the methodology and it will cover part of what we classified under the PRA/HRA heading, if you will, in terms of a major discipline and in particular, Task 2, 5 and 12 and then I'll come back later in the series of presentations and talk about some other PRA/HRA aspects of the entire process.

In particular, I'm going to talk about the component selection process, what it is and again, what the major advancements are and basically what the nature of the public comments were.

I'll also talk about the building of the PRA model, if you will and then we'll talk about the subject about HRA.

Again, just to orient people in terms of the entire process flow charge, this part of the presentation I'll be talking about some early phases of the entire process that come under the PRA/HRA heading of this. The component selection process which really sets a lot of the scope of the fire PRA analysis, again, talking about the fire modeling and then talk about HRA.

The PRA component selection process, it's a process primarily of defining what am I going to ultimately include in the model, what components am I going to address, what failure modes, accounting for fire effects and so on and so forth. So it sets much of the fire PRA scope. It really addresses, this is what I'm going to potentially credit and for that matter, what could be adverse that I need to account for in the fire PRA safe shutdown model.

Because it's a PRA model, much like the internal events model, really at one level it's no different and so really this task is in some respects, not much more than a consolidation of past practice. And now getting to Dana's issue about the seamless issue of PRA and fire PRA, one of the things that this task does is strongly recommends that we take the internal events PRA model as our starting point and then build upon it and change it rather than, if you will, going off and building a separate model from the start, trying to get a little bit at that seamless issue that we were talking about before. So that hopefully, at some point when all is said and done, you have a single model that can address both internal events, as well as fire events.

Key advancements over what was done in the IPEEE program or prior fire analyses is that again, as part of this seamless effort, I think we've gone to great lengths to try to not only start with the internal events PRA, and try to, as I say, try to make this PRA/fire PRA be a little bit more seamless than it's been in the past, but also as a systematic process to include the Appendix R, if you will, or fire safe shutdown analysis insights directly into the modeling process.

So really your two basic inputs in coming up with the things that you're going to address in the fire PRA, the components you're going to address and their failure modes, is the internal events PRA and the fire safe shutdown analysis or the Appendix R analysis, if you will, and then using those as two major inputs to create the fire PRA ultimately.

Two basic advances that I think we need to mention and you'll hear it over and over again throughout the day is that we are addressing multiple spurious actuation events which have generally not been previously addressed.

So we're allowing the likelihood of two, perhaps even three, spurious actuation events occurring at the same time as opposed to looking at only a single spurious event during the fire, for instance.

And the other thing that we've done is we're looking at instrumentation in a way that's not been looked at, I think, before.

In internal events PRA, and in particular, when you address HRA, you pretty much assume that the instruments for the most part are functioning as they're intended to, unless the initiating event or some support system failure would affect the instrumentation you pretty much assume it's there. Fire is a unique kind of animal because it could spurious actuate an alarm, spuriously affect an indicator.

Remember, we have symptom-based procedures and the operators are using those indications to tell them what the status of the plant is. If that information in part is due to spurious actuation, the operator may think the status of the plant is State A, when in fact, it's State B, and the operator is going to perform actions on the basis of the instruments and what those are telling him.

We're including those effects very, very rigorously in the modeling process.

MR. WALLIS: I would think the timing of these spurious actuation events would be important, that some fires make this happen before that.

Sometimes it's the other way around.

MR. KOLACZKOWSKI: Absolutely, and to some extent, Dr. Wallis, obviously, we're trying to handle that. I don't want to sit here and say that we have a perfectly dynamic model that it can account for all those permutations, but certainly in the procedure it does address, recognize the timing of these. Sometimes spurious activities could happen well after that component needed the function. It's already performed its safety function. If it's spurious after that, the operator may not even care.

Obviously, also the converse could be true and so we do warn the user to try to be aware of the potential timing issues.

Basically, the public comments had to do with some additions, but most clarifications, one of the points that Dennis Henneke pointed out. We have tried to emphasize a search for new scenarios and therefore associated components that perhaps has not been rigorously looked at before. Fire can introduce new scenarios that aren't covered in internal events PRA now.

We've added more on unique manual actions and looking for those actions and their potential effects. We've clarified guidance on searching for and identifying initiating events and again, I've talked about the treatment of multiple, spurious events, as well as we have a step in the procedure where we basically say do a systematic search for what we call high consequence events, such as what if the fire, in part, causes a high/low pressure interface to fail so that now you can potentially go to core damage and containment bypass at the same time.

We have a process for making sure that those aren't, if you will, prematurely screened out of the process. And then there were other minor clarifications and editorial comments.

That's all I'm going to say on the component selection. As far as the model, really not much to say here. It's the typical PRA thing. You're looking at trying to calculate core damage frequencies, large early release frequencies and so on and so forth and so really nothing drastically new here other than again a focus on modeling unique operator actions that are going to occur as a result of now you introduce not only is the control room following the EOPs, but there also, as Dennis pointed out, sort of at the same time, taking actions based on their fire emergency procedures. That requires, therefore, the modeling of unique events that are unique to fire and the model obviously, needs to address those.

And I've already talked about key instrument failures. We do have to include instruments --

MR. WALLIS: What about crossing system boundaries? There's something in the text of your report about not expected to cross system boundaries?

MR. KOLACZKOWSKI: I can address that.

MR. WALLIS: Spurious operation of HPI and the AFW valves at the same time. Can you address that?

MR. KOLACZKOWSKI: Yes, and that really gets to the last bullet that's on here on the slide. The search process, as it's indicated in the procedure, Dr. Wallis, is basically within a system or within a procedural activity. You look for multiple spurious that could affect that system and its function. You do the same thing for the next system and the next system.

The procedure, while it kind of is a little bit perhaps fuzzy here and says if you are aware of potential across system effects that you think could be important, certainly it doesn't preclude the analyst going and finding those.

However, I guess I would say it's not expected. What will happen though when you solve the model is that you will get spurious actions in one system and spurious actions in another system, along with perhaps some other independent failures, leading to the potential of core damage. So you still will get a cross system of facts, but it's coming about as a result of solving the model and not so much that you're systematically searching for those up front. So to that extent --

MR. WALLIS: It just appears later in the process?

MR. KOLACZKOWSKI: Yes. Again, a few changes. I won't belabor the point again, we're using the common event tree fault tree, whatever approach in PRA modeling that's used before. Not surprising, we did not get drastic public comments or had to make drastic changes. Again, I think the main points is making sure that we're modeling unique actions that resolve the fire and also we've got the multiple spurious events in there and looking for new sequences.

Now a few words about the last subject, HRA. Basically the task covers identifying human failure events and obviously, there's a combination here. You've got to look at the human failure events that were in the internal events model before, such as failure to go to feed and bleed or failure to depressurize a boiling water reactor, to be able to go to low pressure cooling and you have to look and make sure, first of all, are those events still relevant, should they be there. And for the most part, the answer to that is yes. But then you're going to have unique actions as a result of the fire emergency procedures. That's unique or new potentials for inappropriate actions or whatever and so those need to be included in the model.

So there's an identification phase in this task and then the two perhaps major improvements that are included in the procedure is that we do have a series of four sets of screening human error probabilities that range from being able to use values that are 10 times what the internal events PRA HEPs, Human Error Probabilities were, up to having to use a screening value of 1.0 as the failure probability.

And it depends primarily on how significant the fire scenario that you're modeling is, what its potential effects are and what the potential effects might therefore be on the human.

So there's a set of screening values,

etcetera that as Dennis pointed out, has been partially tried out, but I think until it's totally integrated with the rest and tried out, it's still a little bit untested.

And then finally, we do address these performance-shaping factors. Bijan pointed out the fact that fire causes some unique effects on the operators. There are -- suddenly, when the environment before was just a typical main control environment and maybe at most you worried about is the control room hot because you've lost ventilation, well now you may have to worry about the fact that the fire is right outside the door and some smoke is managing to get into the control room or I've got to worry about an ingress/egress path, even though I don't have to take the action right where the fire is.
Just the workload is different.

Dennis pointed out, the control room staff are now working in the EOP still, but there are one or two people in the control room dedicated to also following the fire emergency procedures. In its totality, that's a different workload to some extent. People are now having to do some other things that they didn't have to do in internal events. So workload issues, etcetera. There are new PSFs or at least the effects of existing PSFs are somewhat different.

We address those. We talk about those, actually at great length in the procedure. What the procedure does not do, getting to the last bullet, we did not develop a new fire HRA method with numbers, etcetera and so forth. We basically say here are the PSFs that you need to address. Here's some guidance on how we think it should be addressed. But we basically said look, licensees are already using existing HRA methods, be it ASEP, be it CREAM, but it ATHEANA, whatever. And we expect that that's going to continue. And we think that those methods can be used and suggest that they do be used, but you have to look at the performance-shaping factor is different because of the unique fire effects.

So we do not develop a brand new HRA method with numbers. We talk about using existing methods, but in a different way.

Again, public comments. Probably one of the major things that we did, we used to have a section in here that addressed pre-initiator HFEs, latent errors, if you will. That is now generally being handled by the data that's available in terms of things like well, what's the probability that a fire barrier has been defeated inappropriately or whatever. Rather than going out and asking plant licensees to do a plant-specific analysis of that, we primarily rely on the industry-wide data to address barrier degradation, other fire protection elements, what's the likelihood, the transient combustibles would be brought into the room. We basically don't require an HRA analysis to address that probability. We rely on industry data to give us that probability right up front.

So a lot of the preinitiator HFE stuff is now out of the procedure. And as I said, we've talked at great length about the use of existing HRA methods, but in a different way to look at these fire unique effects, but we did not again come up with a unique fire, HRA method.

I believe that's it.

DR. DENNING: Let me ask Alan a couple of questions that I think he's probably would have the best risk perspective and that is, I guess the first question is when people now would undertake fire PRA using these methods versus the simpler, older methods, what's the change in effort that's required? Is it a big impact on it or modest impact?

MR. KOLACZKOWSKI: In terms of having done fires before or?

DR. DENNING: Well, relative to what they did with the initial fire, if you're starting from scratch, I guess.

MR. KOLACZKOWSKI: I guess -- I don't know how to answer how big is big or whatever. I guess -- let me try to answer it this way and see if it gets to your point.

Clearly, fire being a spatial issue, this is any spatial PRA method, be it flooding, be it seismic, whatever, it means you have to know where things are and if I assume a fire in this compartment, I need to know well, what could affect it. Which means I need to know what these cables are and what they can potentially do and whatever.

Clearly, that part of the effort is considerable. I mean you have to go out and you have to do a search for where the cables are, etcetera, actually building the model and then ultimately quantifying it is probably not a lot more work than building the internal events model from scratch, etcetera. But clearly, we are adding a lot more information to the model because of the spatial effects than you have to do in an internal events PRA.

MR. NOWLEN: If I could add, I think Alan has it just right. The thing that has, from our perspective increased the level of effort implied by this method, versus, for example, an IPEEE and we do believe there is an increase, it's primarily associated with the increase in the number of components and cables that the procedure asks you to track down.

And especially cables. Depending on the amount of information that a specific plant has relative to its cable locations, will make a huge difference as to the level of effort that they're going to have to put into to implement this method. If their information is sparse, they're going to be spending a lot of time hand over handing cables through the plant. And it's very tedious. It's time intensive.

If they have very good information about their tracing of their cables, then the difference between what they would have done at IPEEE is rather incremental.

DR. DENNING: But your feeling would be that as far as the quality of the results concerned that there's substantial difference between the quality of the PRA of an older versus with this more enhanced approach?

MR. NOWLEN: Yes.

MR. KOLACZKOWSKI: I think it will add a lot of confidence to the results. I can't tell you right now whether the results will be drastically different or not. I think Dr. Rosen's point is well taken. We may find for a few plants the CDF or the LERF actually goes up and we thought we were conservative, but we weren't because when we consider multiple spurious, all of a sudden we've got new problems that we hadn't addressed before.

On the other hand, hopefully, a lot of them will go down because we were very conservative in a lot of our analyses, but I think the fact that we will have gone through this rigorous process, whatever the results are, I think we'll have a lot more confidence in those results when we're done.

DR. DENNING: As we look at risk-informed regulation, where we're involved and the thinking today is mostly driven by internal event considerations, but here we have fire as perhaps an equal contributor and who knows in some cases maybe more, as we look at our -- as we look at risk-informing, is it essential that we always go back and look at fire PRA element as well as the internal events element?

MR. KOLACZKOWSKI: I think that will depend largely on what the licensees do with the information. I suspect that if licensees, those who are -- who want to do a reasonable effort at this, find that they have vulnerabilities in the fire area, quite frankly, I would expect and hope and I think they will do something about it so that those fire risks are low. And when they do something quote about it, then maybe they don't have to go back and address the fire risk each and every time they want to make a plant change in any very detailed way because they would have already made the risk low.

I think a lot will depend on what they do with the information.

MR. NAJAFI: Let me add something to that too. I would like to second that based on the evidence that the IPEEE provided that the range of the contribution that the fire had in the IPEEE went anywhere from 1 to 95 percent of their total risk being driven by. So when it comes to fire, it is extremely, I would even venture to say more than internal event is unique to the plant because it's not only a factor of your strategy for safe shutdown, is your spatial. I mean if your A/E decided that it was easier to route a cable through straight than to go from across, the same A/E may make one plant more vulnerable to fire than the other plant next door.

So it has another layer to make it even more plant specific and therefore needs to be decided on a case by case basis, whether to include your fire as part of any decision making, for example, for configuration risk management. It is important for fire risk to be part of the picture is unique to the plant. And in some plant, it may be very critical whereas in some other plants -- but also, the other issue is it something that you can determine before you do it or you have to do it after. I mean can you say it's not important before you do it. That's the Catch-22. I mean --

MR. KOLACZKOWSKI: Rich, I will say that -- and I can't speak for all licensees, but at least the pilots we worked with and what I'm hearing is that those people who want to go through this effort do plan on having an integrated PRA when it's all done. So that if they're using it for maintenance rule, whatever, they're going to get out what the potential effects would be from fire risk as well as internal risk all at the same time because it's all going to be the same model. That seems to be the intent, at least by some licensees anyways.

CHAIRMAN ROSEN: Okay, well --

MR. HENNEKE: You asked about the effort. This is Dennis Henneke, Duke Power again. You asked about the effort. It's about a factor of three or higher and we have good cable tracing. It's not just in the cable tracing. It's every aspect of it. So the numbers you've heard before about 7,000 hours. We hope to do it a little less, but 7,000 hours is probably a good number. The old number was -- we did it less than 2,000 hours in our previous numbers, so 7,000 is probably not a bad number.

MR. NAJAFI: Actually, I want to add something there too. We did also for the IPEEE, we did a survey at the end of it to look at the level of effort of 14 plants and the range was anywhere from 2 to 3 to about 10,000 man hours for just the fire IPEEE. So that range is a wide range. I mean people did very short little studies for 2000 and people did as much as 10,000.

CHAIRMAN ROSEN: I'm going to cut it off here and we'll reconvene at 10:30 and if we want to, we can pick this up.

(Whereupon, the proceedings in the foregoing matter went off the record at 10:06 a.m. and went back on the record at 10:27 a.m.)

CHAIRMAN ROSEN: We're back in session, and I'll turn the presentation back over to -- Dan Funk, is it?

MR. NOWLEN: Unless you wanted to follow up on the discussion before the break, Alan was through with his presentation.

CHAIRMAN ROSEN: We talked a little bit about that. I think Rich --

MR. NOWLEN: Okay. Then, Dan is next.

MR. FUNK: Okay. It looks like we're ready to move forward. I'm Dan Funk, and I'm going to be talking about the circuit analysis aspects of the procedure. As you can see, we've got three basic aspects or tasks related to circuit analysis, and I'll kind of take them one at a time as we go through this.

One other item that you'll notice is there's a Support Task B, which is the fire PRA database. And it's kind of a stepchild, if you will, in that it's truly not a circuit analysis aspect, but it turns out that a high percentage of the number crunching or the correlations that we try to develop are related to the circuits and the cables. So I think by default it wound up in the circuit analysis area, so you get me to talk about that one also.

You've seen this flow chart before, so I'm not going to belabor it too much. The one -- at this point, the one thing I would like to point out is notice the tasks re the first phase, if you will, of the circuit analysis, because fairly early in the process -- and what you'll see is just more of a design input to the PRA rather than an active aspect of the PRA. And I'll get into the specifics of that when I talk about that task.

The other aspects of circuit analysis, the Task 9 and Task 10 -- the more detailed aspects of the circuit analysis, occur quite a bit later. And, again, as you see from the flowchart, they occur after some of the screening has taken place, and you get into an iterative process.

And I will try to explain why that is and why it's important that they occur in that order. It was alluded to earlier. It all has to do with scope and trying to get the best bang for your buck. And, again, we'll get into the specifics of that when I talk about the tasks themselves.

One thing I wanted to do before I jump right into the tasks is just cover the circuits issues, if you will, from a more global perspective, or give a context setting if you will for the whole thing, because I think that's important.

Inevitably, the PRA or Appendix R or any aspects, when you get to the circuits there seems to be lots of issues, lots of confusion, lots of different perspectives, and it can be a pretty tough area from a lot of different angles. So I'm not going to solve the world today on that, but, again, from the world of PRA, I'd like to just try to give -- give a perspective, if you will, the big picture of where the circuits fits in, both where it was at and where it is today. And I'm sure you'll have questions in that area.

First of all, I think there has been substantial technical and process-related advancements related to the circuit analysis aspects of a PRA, and I'll give specific examples here in a moment. Probably from my perspective, being an electrical -- one of the greatest advances is, although simplistic, is just a collective awareness that circuit analysis is an integral and very important part of this whole process.

And it was mentioned earlier that -- that the fire PRA was somewhat of a stepchild to PRA in general. And if that would be true, I would consider circuit analysis to be the third cousin of the stepchild, in that we've always been an afterthought and never an integral part of the team before.

I've seen that change with this procedure, that there is a collective awareness within all of the different elements represented in this type of approach that circuits is an integral part of it now, and so we're finally a member of the team rather than just somebody that -- that they come to when they have a question.

Some specific examples of that -- in the past, as far as the spurious operations, I think the team has collectively agreed that they were dealt with previously in more of a cursory manner in original IPEEEs and PRAs, as to where now they're a frontline issue and they're incorporated in the process directly.

The procedures, the Task 3, 9, and 11, as you can see, they're an integral part of the process where, in the past, that just was not so. There would be specific cases come up that would require detailed analysis, but it was not a formal process from my perspective, and now it is.

And again, just being, if you will, an integral part of the team I think makes a huge difference in the final product, at least from the electrical perspective.

The final aspect of the integration, if you will, is the procedures, the circuit procedures are quite detailed if you look at them, and they try to add in -- get down to the nuts and bolts and the nitty-gritty, and I don't think that has existed in the past.

And so as part of that, I think we've taken quite a few aspects of the circuit analysis and have made them quantitative rather than qualitative. And, again, we can cover several examples, but it is -- again, in a general point of view, I think we can say we've fine-tuned it considerably from where we have been in the past. So those would be the process-related improvements.

When it comes to the knowledge base, it's not my intent to go back and cover all the EPRI and NRC-related fire tests that were done. Suffice it to say that we certainly have had a prompt jump in our understanding of fire-induced circuit failures.

As Dennis Henneke has pointed out, there are several areas that we have a lot more to learn. But I would rather be where we are today than where we were five years ago.

CHAIRMAN ROSEN: Do you want to give us just a brief synopsis of what more you might want to do? Because I thought those tests were pretty extensive and useful.

MR. FUNK: Oh, they definitely were. You know, again, we've gone from the world is flat to the world is round. But I can't tell you how big the diameter is.

So although we have learned a lot and the tests were quite detailed, there are still several aspects of the tests that were somewhat limited, both in data and how we conducted the test. For example, all the tests were conducted using one surrogate circuit -- basically, a motor-operated valve circuit with a seven-conductor cable essentially.

Sandia did do a little bit larger variety of tests, including the instrument circuits. But, in general, where the bulk of the data was was for that one circuit. Well, that circuit does not represent all circuits in the plant. And as we found out, the dependencies upon different cable types, whether it's a one-conductor, a 10-conductor, there are influence factors that we do not have a lot of data for that obviously in retrospect we wish we did.

So although there was considerable information gained, there is more -- more to be learned. Another example I would give is for armored cable. I believe we ran two armored cable tests, and we had one failure. So we're trying to make interpretations of data based on one data point. It's not enough to have a real high confidence level in that, and for that reason certain aspects of the test wind up, as Dennis has pointed out, being conservative.

And I'll talk to that a little bit more when I -- when I get to Task 10, which is the probabilistic aspect of the circuit failure. So I'll add a few more examples then, but it -- if that's sufficient for now, I'll keep moving forward.

CHAIRMAN ROSEN: Okay. Go ahead. We'll come back to it.

MR. FUNK: Okay. One other point that's probably worth making at this time is that the values that we are using for the probabilistic aspect of the circuit analysis did basically come out of the expert elicitation panel, which was participated -- both EPRI and NRC and several industry members to come up with those values. That process occurred very early in the circuit analysis effort, if you will, and certainly we know a lot more now than we did then.

But nonetheless, at this point, the fundamental probabilities that are in our guide were based on that expert elicitation panel. And, once again, I'll elaborate on that when I get to Task 10.

The three tasks -- circuit analysis tasks -- basically represent a phased approach to circuit analysis. And as we go through each task, the first being cable selection, the second a detailed failure modes analysis, and then the third being the probabilistic aspect of those failures. Each represents a refined level of detail, and with that refined level of detail goes more manhours and more effort.

And it was alluded to earlier the circuit aspect of this project can be a very dominant factor as far as your resources. It can be highly resource-intensive. And if you're not careful, it can dominate the whole process to the point that it risks successful completion of the project. And so we clearly learned early on that if this is going to be a doable practical guide that we have to carefully manage the circuit analysis task.

And what that boils down to is that we need to try to build in intelligence in where we spend those manhours for circuit analysis. Some components have a low impact on the final risk number for an area, while others have a very major impact. And, obviously, we would like to try to reserve the detailed circuit analysis for those particular components that are high contributors. And so it is that strategy that drives, if you will, the circuit analysis process.

As Steve mentioned, the routing of cables can be extremely intensive. And the example that I'll use is at one plant where the data they have available they may know where their cables are routed and have a good correlation between the cable number, the raceways that that cable goes through, and then the locations of those raceways in the plant. And all that is built into a database, so when we come along trying to get this information it's a matter of developing a simple query to get the output report. Pretty darn straightforward, not too labor-intensive.

Now, we've got another plant where they don't necessarily have that information in database form. It's still on paper. Well, they have a layout drawing that's got a bazillion raceways on it, and they do have a cable and raceway database that explains which raceways that cable is located in.

So, yes, they do have the same information, but the usability of that information in paperwork format to try to work with layout drawings and trace the cable's location, you can get the information. It just takes a tremendous amount of manhours to do that when you're talking about the amount of data we're talking about.

So as far as estimating what it takes to do one of these projects and the circuit impact, I can go to one plant and if they have that information already automated -- and many do -- I'm in good shape. I can estimate a couple hundred hours for conducting that task. I walk across the street to another plant where it's still on paper, there's a 6- to 7,000 manhour change in what it's going to take to get the same answer.

So, and both cases exist out there, and we found that during our pilot projects. So as far as trying to bound what it takes to do one of these projects and the doability of it, there's going to be a -- from my perspective, considerable variation, and a lot of it is going to be driven just on the simple practical aspects of how do you have your data, especially when it comes to the cable data.

A slightly different aspect of that is that even if you have good data, it's still a tremendous amount of information to try to manipulate. And it takes a fair amount of expertise to go in and try to do some of the detailed circuit analysis that we're asking -- asking the analysts to do in some cases.

And so common sense says we don't want to just go analyze 3,000 components, the cables for 3,000 components. We want to select the components that give us the biggest bang for the buck, and that's where this phased approach in summary comes in. And then, on the first pass, it's more of a bounding/capturing of all cables, associating those with the component, and then we proceed through the screening process. And for those components in those areas that proved to be risk-significant, well, then, come back to those and do a refined level of analysis.

So hopefully we're building in intelligence of how we're using our manhours as far as the circuit analysis, and that's how-- the whole concept that the circuit analysis is based on.

MEMBER DENNING: Excuse me.

MR. FUNK: Yes, sir.

MEMBER DENNING: When you say under this bullet "routing of all cables with minimal overall benefit," are you trying to say that -- I mean, obviously, you -- you have to route cables. I mean, you have to determine their routes or --

MR. FUNK: Correct.

MEMBER DENNING: Are you trying to say that ought to be done in a prioritized manner? Is that what --

MR. FUNK: That's exactly --

MEMBER DENNING: Are you trying to say that --

MR. FUNK: Yes, that's exactly right. In fact, that probably would have been the right word to stick in there, that, yes, you do need to know where all of your cables are. But when it comes to specific failure modes that may be of concern in an area for a high value component, that is going to receive a higher priority as far as chasing the cables, the specific cables that are going to cause me a concern.

But I'm only going to spend the manhours and the resources to analyze that at a systems level that component proves to be of concern. In other words, I'll conservatively assume it's going to fail, and then if that doesn't flag as a high-risk area I win the battle for that one, and I don't have to devote more manhours to it.

If it flags as being a problem on the first pass through the PRA model, then the guys come across the street to the electricals and say, "We need more." And that's -- and then we'll go to the next iteration, try to screen out as many cables as we can through a detailed analysis, send it back to them, and they run it through the mill again.

If it comes back for a third time saying we need more, then we go to Step 10 or Task 10, which would be the -- adding the probabilistic values to it, which each level, again, requires more information regarding the circuit design, more evaluation of the circuits, and the specifics of the configuration, which just equates to manhours and time.

Okay. With that, let me just jump into the tasks themselves. And similar to the way Alan covered it, I'll briefly describe the task and then the peer and public comments. With regard to cable selection, the Task 3 early on, it's conducted for all the fire PRA components. And important point is it's fundamentally a deterministic process.

We're not trying to associate probabilities with different failure modes, and, in fact, in many cases we're not even trying to understand the failure mode. We're just looking at a circuit. And if there's a cable associated with that circuit and it gets damaged, we are going to assume it causes the component not to be able to perform its function.

And so it can be a fairly straightforward process of correlating cables to the component. And, again, it is a first conservative pass. It is the most efficient way to approach it.

The one caveat to that that we've learned through practical experience is you can't -- although that's a nice concept there, you have to taint it with some practicality. And by that I mean if we associate -- just grab all the cables for all the PRA components and throw them into the PRA model, it tends to just overwhelm the model, and you're sorting failure modes and the different events out forever.

And so although it may be effective from the circuits point of view, it so overwhelms the model that the manhours I saved by this approach I paid back double on these guys. And they cost more than the circuit guys anyway.

(Laughter.)

So with that, what we want to do on this first pass is try to reach the balance point of conducting some what I call high-level circuit analysis. And by that I mean the electrical analysts, once they get into the routine of analyzing a plant, they get very familiar with the types of circuits that they're going to see, because typically all the motor-operated valves and the solenoid valves and the control circuits done by the same AE have a lot of commonality, a lot of similarity in the design.

So once they get a flavor for it, they can pretty quickly focus on the cables and the circuits of concern. And in doing that on this first pass through with that somewhat built up knowledge, they can do some prescreening. For example, if I have a motor-operated valve, and I needed to actually change state, essentially I'm going to have to identify most of the cables, because any of those cables, if damaged, could cause a fuse to blow, and then the operator would not be able to operate the valve.

However, if that valve is now only what we would call a spurious operation valve, in that it is already in the desired state, and the only thing that could cause me a problem is if a hot short actually caused that valve to pick up and change state in a misoperation, then that's a subset of the cables required for the complete operation of the valve.

And, again, the analysts can quickly screen out a fair number of cables in that regard. And so the procedure has been revised to include some of this high-level screening in the cable selection process. And, again, that's in the -- in the mind-set of efficiency in that it doesn't do any good if we just overwhelm the model from the get-go.

As far as cable selection, the final product -- again, I don't think of it being part of the PRA itself. It's more a design input in that it's just a listing of what fire areas or compartments or scenarios could a particular piece of equipment fail. It's just a design input. A lot of effort to get there and a lot of data to manipulate, but in the end that's all it is.

And notice at this stage, again, we haven't invoked any probabilistic aspects. It's just a correlation of data effort.

With regard to public and peer review comments, fundamentally the comments were practical in nature. And you can see my laundry list up here -- that we refine the guidance as to how to use the Appendix R circuit analysis.

And, again, that gets -- it's not so much any of the theory involved as much as my data is in this format. What's the best way for me to incorporate it into the database? A lot of practical aspects of how do you use the Appendix R circuit analysis information, because, unfortunately, it comes in all different sizes and shapes. It's not just a nice, clean database out there.

We expanded on the verification of assumptions related to the use of the Appendix R circuit analysis. Although there are certainly many similarities, there are subtle differences with regards to, for example, instrumentation. So we had to work out methods for handling the delta. Appendix R fundamentally was not that interested in instrument circuits related to equipment. Their perspective is make sure the equipment either worked or didn't work.

As to where -- obviously, for this project, as Alan discussed, we're trying to improve the HRA aspects, which means you've got to have instruments to do that. And so we've worked through some of those deltas, if you will, of how do we best use the Appendix R information for the purposes of this project.

It represents a wealth of knowledge, and we would be crazy not to use that information, because a lot of the correlations that they've had to come up with as far as their equipment, the cables, the locations, is the same information we're after. We've just got to make sure that we use it in the right context.

So, once again, we've expanded on some of the different practical aspects of what you look for in the Appendix R data to make it most usable for the PRA process.

Some of the areas that we had not covered that we included were guidance on bus ducts, which was, from my perspective, a real good catch if you will in that a bus duct is nothing more than a cable. And in some cases, they can cross fire boundaries. And once you start manipulating the data, you get in the mind-set of just all the data, and you get one step removed from the practical world. So in the early stages it is important to pick up in this case bus duct as another conductor.

The other aspect of the analysis that we had not provided guidance that we now do relates to the grounding of different types of systems. And not to get horribly detailed here, but you have several different ways, depending on the design scheme, the way systems are designed -- they can be grounded or ungrounded, which is what we dealt with. But, of course, there is the intermediate position of it can be a high resistance grounded system, and we had not addressed that and now we do.

Okay. That's Task 3. And once again, in summary, once you've conducted Task 3, you've established your correlations, and at that point we do the handoff to the PRA folks for them to run their first level of quantitative -- or I guess it's qualitative first and then quantitative screening.

Once they've done that, they'll come back and they'll have their first round of insights as to the risk significant areas. And at that point is where we would pick up with Task 9, which is the detailed circuit failure analysis. And this we view as a risk-focused deterministic analysis.

And as I mentioned earlier, we don't want to just go spend 5- to 10,000 manhours doing detailed circuit analysis as far as each conductor and each failure mode on each conductor for every component out there. We want to do it for the components that matter.

And so it is -- it is important to note that it is still a deterministic analysis, but it is risk-focused in that we're going to conduct this process on those components that are important to the overall PRA, or I should say the higher -- the higher contributors to risk. It's generally reserved for cases in which the quantitative screening indicates a clear need and advantage to do so.

The detailed failure modes analysis requires knowledge, another level of knowledge of the circuits functionality. You need to know the desired state of the component, the failure modes of the component, as well as the different aspects of the circuit design. Is it grounded? Is it ungrounded? What voltage level does it operate at? Are there backup power supplies? Again, you can see an additional knowledge of the circuits required to conduct this level of analysis.

And the one point that I wanted to make here is a lot of times we hear that we're looking at cables, and that is true. But it's important to note in this analysis we're not just looking at cables; it's actually a conductor-by-conductor analysis. So if I have a seven-conductor cable that's related to this component, I have to look at each single conductor, because each conductor, not each cable, can actually cause one or multiple different failure modes.

So it's a rigorous analysis any way you cut it to understand what the failure modes are. And once I have understood what those failure modes are at a conductor level, then I roll it up to the cable level. So it takes a fair amount of effort to get this information. But, once again, to try to get the level of knowledge that the PRA folks are after, that's what it takes. So you can see at this point why it's important to -- to try to reserve this level of analysis for the high-level hitters if you will.

And then, fundamentally, at this -- at this point, the objective is to screen out cables that cannot cause the failure mode of concern. So what we're looking to do is if I started off with my first pass on Task 3 of 10 cables, okay, I'm only worried about the valve going closed, and now I want to only identify the cables that could cause that particular failure mode.

With regard to public and peer review comments, I've got the laundry list up here, but we had to address -- and again, fundamentally, there was no great concerns over the process or procedures, and most of the comments related to practical aspects of the analysis. We better define the interface between 3 and 9 and to have -- and that has to do with, if you will, the high-level screening that I discussed earlier under Task 3.

We eliminated the control room assumptions. During the circuit analysis, the first pass we had, we went about it under the assumption, for example, of -- if a component was controlled automatically, but yet an operator could go over and manually make that action happen, we were going to do the circuit analysis assuming that he just did that because he's in the control room. We did not treat that as a "manual action."

But after revisiting that and maybe the -- all the workload that the operators would be under, we decided that that probably wasn't a great assumption to build in there, so we backed that out, and now you just do the analysis assuming no action. And we kind of turn it over to the human factors guy to determine whether it's appropriate to make the assumption that the operator would go manually start a pump and feed, for example, if it didn't start automatically because of circuit damage.

We enhanced the guidance to focus the analysis only on the failure mode of concern. Again, in the interest of efficiency, you could do the failure modes analysis in a complete fashion, and by that determine all of the possible failure states, including loss of indication, fail open/fail closed, fail open, and then fail closed. I mean, it can be quite intensive.

What we did is in practicality we found that, nah, the PRA guys just want to know that the valve is going to stay open or go closed, and so we just focus on the particular fail mode -- failure mode that they tell us is of concern for their analysis.

We augmented the guidance with in the appendices we have several examples of the circuit analysis for different types of circuits. And the devil is in the detail when it comes to the circuit stuff. And so we found that the more examples the better, so we -- there was recommendations for several examples, particularly related to designs of solenoid operated valves, and we added those in.

Lastly, we incorporated guidance for the human factors interface where manual recovery actions could be affected by circuit analysis. And the best example of that would be -- and it's fairly well-known -- would be a motor operated valve that is spuriously opened where the torque switch/limit switches are bypassed, so you've actually mechanically damaged the valve.

And later on in the human factors effort, where they're working on recovery actions, they just go out and assume an operator can manually open that valve. That may not be the case and the valve was mechanically bound due to the electrical damage. So we have tried to better solidify that interface in that we would identify those components that could receive possible permanent damage.

And that's it for Task 9. And again, to reiterate, those first two tasks are deterministic in nature, in that we're just correlating cable failures at a different level of rigor in each case, but yet still a fairly deterministic analysis. When we get to Task 10, which is where all the talk is about related to the circuit failure probabilities, this is where it comes in.

And to me, it's important to keep it all in perspective, in that, as I've gone through my processes, I am hoping not to have to do Task 10 for too many components. And so although the probabilistic aspect of the circuit analysis receives a lot of attention because it's the frontier part of this effort, hopefully as far as the circuit analysis aspects overall it's a limited portion of the analysis.

And fundamentally I'd like to get most of my answers using both the Task 3 and the Task 9 process. Task 10 comes in for those very difficult areas that we need additional information on. And if that's every area in the plant, then this becomes a very -- very resource-intensive effort to the point that, you know, its practicality would have to be questioned. But from our experience, that's not the case.

So with that said, once the PRA has got to the point that they do know their real difficult areas, the high-risk areas, they would come back to the electricals for this level of analysis. And it is probability-based. The procedure right now has two -- offers two methods.

We're recommending, as a first pass through, using the expert panel results, and those are the table numbers. If you looked at the procedures, there are several tables in there, and it's just a lookup process where, if I knew a few fundamentals regarding my circuit design, I go into that table and I grab a number. Those numbers are essentially the numbers out of the expert elicitation panel effort.

As Dennis pointed out, I think -- it is certainly my opinion, and I believe it's the general consensus of the team, that those numbers are fundamentally conservative. I think that's a true statement at this point.

The second method -- and I'll -- as we get into this a little further, I'll explain why I think that is, or where those conservatisms come into play. The second method offered is the computational basis. And, again, this is not a third -- three-decimal point computation that we're conducting here. It's an order of magnitude computation. I think we have to recognize the limits of the data we have, and the formula is really just a backwards extrapolation of the data.

I think it's more -- and this is my personal opinion. I think it's more representative of what the data showed than the expert panel numbers, and it does yield, in general, less conservative numbers overall. When the expert panel was brought together, the data had not been I think completely rolled up yet. And so there were some limitations of what information the expert panel had to work with.

And after the EPRI report was generated, I think there was a better understanding of the data, and it allowed, if you will, a degree of refinement in our predictions. And so again, in summary, the computational method I think backs out some of that conservatism, with a couple of exceptions. There are a few cases where the computational value would give you a more conservative number than the tables.

My third bullet there requires knowledge about the circuit design cable type construction. And, again, similar with the graded approach, when we get to this level you need to know pretty much everything there is to know about that circuit. And that just equates to time and effort to dig this information out of the plant databases, doing walkdowns, and other data collection efforts.

So it requires considerable information that equates to time and money to collect that information. And for that reason, it is generally reserved for only those cases that cannot be resolved for other means.

At this point, it's almost a horse-trading effort in that if -- if through the PRA process we've got an area that's of concern, and we have to assume that the cable is damaged by a fire in that area, it becomes: what is the best way to approach this problem?

Do I spend my resources doing additional fire analysis to see if the cable can be damaged, and what's the likelihood of damage? Or do I spend my money figuring out, okay, I'll just assume it gets damaged. But what are the consequences and the probability of that damage?

So, again, it requires some intelligent decision-making on the best approach, given the specifics of the case that you're trying to solve. And there is not a one answer fits all here, as we found out through our trial efforts.

Some of the key insights related to the circuit failure mode is our knowledge is greatly improved, but uncertainties are still high. Again, that equates to the comment Dennis had and that I elaborated on. The fire testing certainly improved our knowledge and was a prompt jump in how we understood the effects of fire-induced circuit failures. But there definitely is more to know, and the uncertainties -- for that reason, the uncertainties are high, especially for specific cases.

I mentioned before the armored cable would be one. Another one would be failures in conduit, which we just do not have a lot of good data points on that. For that reason, the expert panel numbers, and also our implementation tends to be somewhat cautious and conservative. Certainly, as data -- more data becomes available, like every effort in research, you just can't have enough data. This would be another case where we -- we think there's a strong case to be made for collecting additional data.

And, once again, like any good experiment, the first time you run it you learn everything you should have done the first time for doing it the second time. So I think with additional testing we can have a much more focused effort on the factors and the parameters that we know to be key that we do want to collect more information on, where we did not necessarily know that on the first round.

The other aspect related to the conservatism in the tables that I wanted to come back to has to do, once again, with the test circuit for the original testing. That circuit was designed to be quite -- quite biased, if you will, towards the hot short or spurious actuation failures, the understanding of that being that, hey, if I don't have any spurious operations for this circuit, I can bound all my other circuits out there.

Well, the reality is we did have spurious operations, and that's the deal. And so given that, it says -- it tells us that when we go in for, if you will, another round of testing, we would like to have more representative circuits rather than just a bounding case, so we can apply real numbers rather than the conservative numbers. And that's probably where the limits of our understanding exist today.

We have reasonably good data for certain very specific cases. But for many other cases, we're working off of extrapolated results. And for that reason, they tend to be conservative. So there certainly is areas where, through additional effort, both in testing and analysis of some existing data, I think we can -- we can further refine our understanding of the specific values for different cases.

A couple of other areas where I think there's great improvement to be had as far as pushing the state of the art if you will on using probabilistic methods for the circuit failures is the time factor. The testing did show that in many, many cases the spurious actuations occurred for extremely short periods of time, on the order of .1 to .3 seconds. And so is that important to the spurious operation itself?

Well, that's equipment-dependent. The example I give here is if it's a latching type of circuit, to where once I've had that spurious operation, if you will, the damage is done and it's all over. Well, then timing is not that important. But in many, many circuits, just the inherent nature of the design of plants where, for example, solenoid valves, upon loss of failure, will tend to fail in the desire of the safe state, the latching aspect is not important.

And, in many cases, I can show that if that valve returns to its failed state within 5, 10, 20 minutes, no long-term damage done. And that aspect has not been incorporated into the guidance at this point. We'd like to be there, but we're just not there yet. You know, we got to first base, and with that we've improved our knowledge, and we can better focus on implementing what we do know.

But as Dennis pointed out, there is room for improvement, or I'm not sure I would even classify it as improvement. There is room to further the state of the art, and we can see where those areas are at this point in time.

CHAIRMAN ROSEN: So now, in that particular case of a latching circuit --

MR. FUNK: Yes, sir.

CHAIRMAN ROSEN: -- or one without a latching circuit, if a licensee wanted to use this guidance and -- as part of a submission for regulatory relief in some risk-informed application, even though your guidance does not now incorporate that kind of guidance, if he wanted to go a step beyond and say there are a couple of cases which you are concerned about, but we've analyzed them and can show that while a hot short is possible, it wouldn't last for very long, and by the -- and the circuit will go back through a safe state. Is that precluded by the fact that it's not included in this?

MR. FUNK: No, not at all. In fact, I agree with you completely in that I think there is plenty of room in cases like that where you could show that there's no, if you will, harm done if a circuit returns to its desired state within, say, even a half an hour. And the original data in the EPRI report does contain a basic level analysis on timing, and nothing lasted more than 10 minutes.

And when you did a binomial distribution, you're basically at the 95 percent confidence level within just a few minutes. And so --

CHAIRMAN ROSEN: Are there good words in the NUREG that allows for kind of a hook for a licensee to make that case?

MR. KOLACZKOWSKI: Let me answer that. Alan Kolaczkowski. Yes. In the Task 2 procedure, in the component selection, there is a place where we indicate the fact that if you can up front determine that, based on the consideration of how long spurious events typically occur, you know, seconds to maybe even minutes, if from a system standpoint you can look at that component and say even if that component goes spurious for this amount of time, and then would go back to the safe state afterwards, there is an out for the system analyst to say, "I'm not going to put that component in the model," because I have justification why I can live with the interim spurious, if you will. But from an overall system standpoint, it's not going to do any -- any damage to the plant.

And so, yes, there is a place in the Task 2 procedure that has a hook for the analyst to use that as a justification.

CHAIRMAN ROSEN: Good. Thank you.

MR. NOWLEN: I'd like to add one last point, too, as well. Steve Nowlen. The risk which was issued by NRR that lists the moratorium on inspecting associated circuits also recognized this issue, in that I believe there is an upper bound of 20 minutes placed on the duration of the hot short. So it's a nominal treatment. But, again, this is a broadly recognized issue.

We purposely wrote the procedure such that we would not preclude people from bringing that into play. We simply say, "Given what we know today, I can't tell you the probability that a hot short will last two seconds versus 10 minutes." The data is just not quite up to that level yet.

CHAIRMAN ROSEN: Well, let's -- do you remember the data well enough to tell me how long the longest hot short lasted before --

MR. FUNK: Fourteen minutes.

MR. NOWLEN: Fourteen minutes sounds about right, yes. And there was only one that was --

MR. FUNK: There was only one. There was a strange one. All the rest of them were probably less than a minute. So they tended to be very dynamic, in that you'd wait, you'd wait, you'd wait. We'd sit around for 45 minutes and nothing would happen, and then it all happened in a matter of a few seconds.

And so to understand what really took place during the hot short, the cables tended to all fail within a very short period of time, or the conductors, and some would hot short, some would go to ground, so a lot happened in a very short period of time.

MR. HENNEKE: Yes. This is Dennis Henneke. That 14 minutes was a thermoplastic cable in a thermal --

MR. FUNK: Correct.

MR. HENNEKE: -- set. A cover around thermal set. A thermal set cable had not damaged; thermoplastic had. And that's why it lasted so long. But typically, you wouldn't --

MR. FUNK: No.

CHAIRMAN ROSEN: New plants have thermoplastic cable.

MR. FUNK: That's correct. As we pointed out, the one 14 minutes, when you look at the data, stands out as an outlier data point. It did happen, but it would not -- I would not call it representative of the typical case by any stretch of the imagination.

CHAIRMAN ROSEN: I don't want to focus too much on that, but I'm glad to hear that there's a way that -- that this guidance is not so prescriptive that it rules out some sort of --

MR. FUNK: No, absolutely not. And as they pointed out, it certainly -- the door is open to do that, where what I see the benefits to be gained is I think it could be dealt with more rigorously. We can further refine what we know about the timing issues. Can we deal with five minutes? Can we deal with one minute? And I think there's room to do that, and I think there's data to do that. But we have not taken it to that level at this point.

Okay. So the last -- second-to-the-last item here, it's a public review comment for the circuit failure mode likelihood analysis. And the first one is there were several questions regarding the interpretation of the EPRI test data, and that I have to agree with.

And it seems like it should be a very straightforward process of how do you count the beans if you will, but when you look at spurious operations there is a lot of different ways to look at it. Do you look at it from what we call the target cable? Do you look at it from the source cable? Is it equipment-dependent, where if you have a motor-operated valve you could have a spurious or a hot short, which would cause, yes, the spurious operation. But if functionally it didn't impair you, then you would clue that for consideration.

So there's a lot of different aspects of how you want to look at the data. And I think we're a lot smarter about how we do it now, but there, once again, is room for improvement there.

As I mentioned earlier, I do believe it's the team's consensus that the expert value -- expert panel values are, in general, conservative -- to reiterate that one last time. Additional independent review of the computational method was solicited based on the public and peer review comments.

Although the review was favorable, I think the team still acknowledges, as I call it, the inevitable limitations of a version 1 release that undoubtedly through time and effort it can be further refined. But that's where we're at right now. It's a great improvement over having nothing, but there's still room for improvement.

We modified some of the Task 10 examples to include only spurious operation failure. And, again, that was basically my perspective that the formula was backfit from the spurious operations testing, so I was not comfortable extrapolating that to try to analyze other failure modes. For example, can you use that formula to calculate spurious indications? Possibly. But at this point, without further data, I think that was too far of a stretch for the formula.

Lastly, I've got one slide devoted to the fire PRA database. And very simple conceptually, but when you get down to it, without a very, very robust, good database, this project is very unmanageable and very untenable.

So in your upfront planning, we've tried to put a lot of caveats in the procedure that you've got to -- got to pay very close attention to your database, because this is the tool that has to manipulate these thousands, if not millions, of data points to get the correlations that you're after.

It just simply is an impractical effort to try to be done by hand. And managing this amount of data, and maintaining data integrity through an iterative process, which this is, can be -- can be quite a challenge. So it's not to be underestimated as far as the practical aspects of conducting this analysis. There was no specific public comments on the database aspect.

And that's it.

CHAIRMAN ROSEN: Okay. Thank you. Any members of the committee have any further questions?

MEMBER POWERS: I would like to explore a little bit more on these expert panel -- you -- what I'd like to understand a little better -- apologize for the spinoff dealing with 50.46.

MR. FUNK: No problem.

MEMBER POWERS: It's -- well, it's -- I have a problem, when I could be in here doing fire stuff --

(Laughter.)

-- dealing with pipes. They don't burn.

(Laughter.)

How do you view the expert panels? Were they offering their opinion? Or were they trying to reflect the opinions that you would get if you could sample the larger community?

MR. FUNK: I think inevitably that given the limited amount of information that the expert panel was working with, inevitably you're going to have to say that it was partly their opinion, which would be their collective understanding of the phenomena we were trying to analyze.

As far as whether they were trying to represent a broader aspect of industry, I think, from my perspective, we had members on the -- that the makeup of the panel itself would be somewhat diverse, and that we had members of the panel that really didn't know a whole lot about, if you will, circuit analysis.

But they were very, very strongly suited in -- on the fire side or the fire science side, and that resulted in their comments coming from a completely different angle than, if you will, my perspective on it from a circuit side.

So I certainly couldn't speak for the panel whether each panel member was trying to think in the broadest of terms. But, again, working with a limited data set, I think they brought their -- their experience to bear from their perspective on the problem. So from that perspective, I would think it's more of an individual input to the process.

I don't know if anybody else -- Steve, you were on the panel. Do you have any other thoughts on that?

MR. NOWLEN: No. I'd say that was very true. You know, we did have pretty limited information available. The analysis of the data that we were working from was a preliminary analysis. The full data report didn't come out until after the expert panel report actually.

So to some extent, yes, we were expressing our opinions, hopefully informed. You know, there was a lot of background information available about cable testing in general, and -- but as Dan said, the panel was also very diverse. We had a number of people who had experience in equipment qualification and fire -- fire fundamentals, fire modeling, things of that nature, PRA folks.

So it was a fairly diverse panel, and I

think you have to expect that the results are somewhat diverse, but certainly there is a dose of opinion in all of them.

MEMBER POWERS: What I'm trying to understand better is the statement that you assemble all these people with a diverse background, expertise, credentials, and look at this, and yet you excuse their judgments and say, "Well, they're conservative."

MR. NOWLEN: Ah. One of the things --

MEMBER POWERS: I mean, it seems to me that if you're going to do that, you just as well have been the expert panel yourself.

MR. NOWLEN: Well, there was some --

MEMBER POWERS: I mean, what was the value of having these people do anything if you're going to just impugn it by saying, well, gee, that's conservative.

MR. NOWLEN: Well, we're not trying to impugn it. That's not the --

MEMBER POWERS: Well, you're doing something to it.

MR. NOWLEN: Yes. We're expressing our view from a more informed perspective today. I mean, keep in mind, I was a part of the panel, too, and I -- you know, Dan was a part of the --

MEMBER POWERS: And we're not holding that against the panel at all.

(Laugher.)

MR. NOWLEN: And we're not --

CHAIRMAN ROSEN: Your chance to torment him is next -- the next item on the agenda.

MR. NOWLEN: My primary tormentor. But at the time we were all working from a limited perspective, and it also has to do with the way we looked at the data. The way the spurious operation numbers were generated is we had two target conductors in a seven-conductor cable. And if either of those two conductors took a hit at any time for any length of time during the test, that counted as a spurious operation.

So, again, the issues that have been raised regarding, "Well, I don't care if I get a spurious hit on the closed conductor of a closed valve. I'm worried about getting hit on the open conductor of a closed valve that opens to the valve." And timing questions -- was it long enough to open a motor-operated valve? Is it a latching circuit?

All of these things taken together lead us to conclude that what the expert panel did was came up with conservative numbers based on the available information at the time. For some cases, it's probably pretty close to the right answer. But it's -- there are other cases where we believe the right answer is probably lower.

We don't have a real good basis for saying how much lower it should be. There is an alternative method that gives you some benefit. It's not huge. You know, fundamentally, there was a temptation I think on our part to second-guess the expert panel, and we explicitly chose not to go very far in that direction.

This is something that a consensus does need to build over time, and we really didn't want to usurp the expert panel results and other experts in the field. So, you know, we took it to a certain level. We certainly agree with Dennis that there is more work that could be done and should be done in this area, and I -- I believe Research -- in fact, I know Research has plans to do so.

And I believe Dennis has plans to look into it for his specific cases. So this is by no means over. We are going to continue to learn, and I think our method will have to evolve to reflect what we learn in the future.

MEMBER POWERS: Well, I found it

interesting -- and you can be very thankful that Professor Apostolakis is not here, because he would launch into a fairly lengthy tirade to say your expert panel really has to reflect not its own opinions but the opinions that you would get were you to have the capability to sample the entire pertinent community on this subject. And it doesn't sound like you tried to do that.

It does sound like you -- that you should go redo the panel, the expert panel. I mean, your explanation is coached, and all of the preliminary analysis is incomplete, etcetera, etcetera, etcetera.

MEMBER DENNING: How many uncertainties do those expert elicitations characterize, and how are they then used in the fire PRA and uncertainty analysis?

MR. NOWLEN: The expert panel results actually included uncertainty bounds on the estimates given. And so those are also reproduced, basically verbatim.

MR. NAJAFI: I would like to add a point here that -- recognize that this topical area in the previous fire PRAs was basically completely nonexistent. This is totally new. For years, we relied on existing deterministic analysis in

Appendix R. We took that analysis, and we said, "Whatever it says is accurate, it's right, its scope is right."

We recognized the importance of the issue, the need to put in -- for us move into a risk-informed environment. This is a critical piece and needs to have a risk perspective. So we have to take that piece and move it into a PRA and put a risk perspective into it.

For such a short time, we have made great strides in that direction. However, to expect that we're going to solve and have a tested, fully matured methodology for a -- let's call it probabilistic circuit analysis, in two, three years, competing --

CHAIRMAN ROSEN: No. I don't think that's what Dr. Powers was suggesting. What I think he was looking for, because of his interest and ours in the research of this agency, some definitive statement about the need for further work and perhaps redoing the expert panel in a more structured way, perhaps going on with the fire testing, as Mr. Funk suggested, something like that.

MR. NAJAFI: At the end of this presentation, towards the end of it when -- in J.S.'s presentation, we will put forth maybe a short list of those candidates. Obviously, all of those candidates have to be taken within the context of their benefits and their cost, meaning, do they tell us something new? Do they tell us anything more compared to other issues that we would like?

CHAIRMAN ROSEN: But, you see, Bijan, you've got to -- you can't have it both ways. You've got -- on one hand you're saying this is preliminary work, the other hand saying we don't want to do more research necessarily because you have to put it in the context of cost. I think there's some middle ground there, but -- but we are interested in what are the next steps. I clearly see this as not the end of the road at all, but rather the beginning of it.

MR. NAJAFI: Yes. I guess my point was that, for example, the competing factor that we have talked for almost a year is that -- advancing the area of the low-power shutdown. Is this better? Is it more important to look into the low-power shutdown for fire than to look for the fire HRA or look into further advancing the circuit analysis?

This is a decision that we -- I mean, in addition to the cost, we have to see the benefit of it. Which are the weaknesses that we really -- an improved understanding will benefit us as a whole? I mean, which one is higher priority? That's what I meant.

MR. NOWLEN: Okay. I'd like to add a final point, too -- is, again, to reiterate that NRC Research does have plans to pursue the circuit issue further through testing. And I believe that to redo the expert panel today would help perhaps, but I'd rather do it in a year or so when we know a little bit more, because we do have the risks and the Bin 2 issues that are identified in the risks.

Research plans to attack those issues within the next year or so, and that is going to bring a lot of new information to bear. And I would much rather put off any additional expert panel work until we have the benefit of that new information. And that planning is underway, even as we speak.

CHAIRMAN ROSEN: Well, we are interested in that planning and the basis upon which the decisions are made.

MR. NOWLEN: Yes. It's not really the topic of today's presentation, but --

CHAIRMAN ROSEN: Well, let me get you back to the topic of today's presentation.

MR. NOWLEN: Yes.

CHAIRMAN ROSEN: Steve, you're up on item

Roman five on our agenda, Fire Specific Tasks, Part 1. I'd like to get done with this, if we could, by 12:15.

MR. NOWLEN: Yes.

CHAIRMAN ROSEN: I obviously want this presentation behind.

MR. FUNK: I'd just like to, as a closing remark, you know, second everything Steve said, but also keep in perspective these -- the PRA numbers and the focus of the expert panel is related only to the probabilistic aspects of this. And keep in mind in the whole big picture of doing this PRA, deciding these probability numbers hopefully is only being done for a very, very limited number of the components and scenarios that you're trying to run. So for --

CHAIRMAN ROSEN: I understand that.

MR. FUNK: -- the vast majority of the cases where --

CHAIRMAN ROSEN: They also may be the risk-significant ones, so --

MR. FUNK: That would be very -- that would be very true.

It may be only one, but it's the important one.

(Laughter.)

That would be --

CHAIRMAN ROSEN: It may be only the things that control the result.

MR. FUNK: That would be a very good point. All yours.

MR. NOWLEN: Okay. We can probably pick up some time here. The topic of this part, we're going to go into the fire-specific pieces of the fire PRA. You've heard about the PRA pieces and the circuit pieces that go along with it. In particular, I'm going to cover a number of tasks -- 1, 4, 6, 7, 8, 13, and Support Task A. Bijan Najafi is going to pick up on Support Task 11.

This is the list -- plant partitioning. Support Task A is walkdowns. I'm going to just say a very few words about that. Plant partitioning, qualitative screening, fire ignition frequencies, the quantitative screening, scoping fire modeling, seismic/fire interactions. Bijan will pick up Task 11, which is the detailed fire modeling.

So just to remind you of the flowchart once again, up here it's the ones in purple. I'll be covering all of the purple boxes on this slide, plus Task 13, which is an appendage down here on the left. Bijan will cover Task 11.

CHAIRMAN ROSEN: Help me by keeping an eye on the clock as well --

MR. NOWLEN: Yes.

CHAIRMAN ROSEN: -- so we get done by quarter after 12:00.

MR. NOWLEN: I will do my best.

Walkdowns. Support Task A is about walkdowns. Again, this is sort of a side task. It's something that you have to do basically in order to support a PRA. They are integral to the PRA. Basically, we don't think you can do a PRA without doing this.

So you have various objectives, verifying your spatial features. Again, it's a very spatially-oriented phenomena. You're going to be counting fire sources, you're going to be looking for target locations, you're going to be looking for your fire protection features, etcetera.

So this really happens throughout the process. There is a support task that gives you guidance on how to do walkdowns, the way you should document them or some recommended forms, for example, for recording your results. And then they get picked up throughout the process, where each of the individual tasks will say, "As a part of this you may find a walkdown to be helpful." And this would be the sort of thing you'd want to do.

We did not get any public comments of particular note on this task. There were a handful of editorial comments. I think basically everyone is in agreement that this is just an integral part of any fire PRA.

So Task 1 and Task 4 are pretty closely tied. Task 1 is the plant partitioning. This is basically taking your plant and dividing it up into analysis compartments. This is an area where we basically consolidated best current practice. It's always been a task in fire PRA. It has evolved somewhat over time. We didn't feel here that there was a lot of new earth-shattering things to offer, simply consolidating the guidance that had been out there before.

In parallel with that, you get Tasks 2 and 3, which are tracing and mapping your equipment and cables to locations in the plant. Once you have that information combined with your plant partitioning, you are basically mapping all these equipment and cables into your specific fire locations, the compartments. You can make your first pass at screening.

And, again, this is basically a consolidation of typical practice. If you have a compartment that has no fire PRA equipment or cables, there is no trip initiators, and there's no short-term demand for a shutdown -- for example, you've lost a piece of equipment that your tech specs will require you to shut down -- then you can qualitatively screen that as a very low risk significant area.

Again, very typical of the practice that was undertaken in --

CHAIRMAN ROSEN: How do you handle the issue of that compartment having a substantial fire loading with a fire that could initiate and propagate to another compartment?

MR. NOWLEN: Yes. That is handled completely separately. The qualitative screening, Task 4, only considers the contribution of each compartment in and of itself. In Task 11, you pick up the question of intercompartment fires, and there you have to go back -- if you screen the compartment in Task 4, then you can conclude that I don't have to worry about a fire spreading from an adjacent compartment into this compartment, because there's nothing there.

But I do have to worry about a fire that initiates in that qualitatively screened compartment spreading to an adjoining compartment. So, yes, we pick that up later. It comes in Task 11. So, again, this is only the room in and of itself.

This is another area where we really didn't get any significant comments, a handful of editorial stuff. Again, I think it reflects the fact that these were just consolidation of existing practice.

Fire frequencies -- this is an area where we work pretty hard. We used basically common practice as it had been in the past, but it has been refined. We've gone primarily to component-based fire frequencies rather than saying the fire frequency for a cable room is X, the fire frequency for a switch gear room is X. It's now driven by component specifics. The fire frequency for an electrical panel of this type is X. The fire frequency for a large pump is X.

So there was some of that pre-existing in the IPEEE days, in particular with the fire PRA guide from EPRI, but we've really expanded on that. Most things are actually treated this way with a couple of exceptions. Cable fires you really can't do this way. Transient fires, that sort of thing.

There was quite extensive analysis of the event data. We went back and probably at least five passes through the event data. The IPEEEs typically use the full unscreened event set. They just took all the events, added them up, and calculated a frequency, and then they applied a severity factor to correct the frequency.

What we did is we tried to get away from that. And we did this screening that Dennis alluded to where we identified each event, whether it was potentially challenging, not challenging, or unknown, so that was a fairly significant step. I think in total we threw away about one-third of the events as non-challenging across the board.

It tended to be a little uneven. Some types of fires you generally kept them all; other types you would throw away a larger fraction -- for example, welding fires. A lot of welding fires just weren't significant. You know, the hot sparks, I'll have to look into that one. But transformer fires, oil fuel transformer fires tend to be spectacular events, and you keep them.

The other thing that we did here is we've utilized these fire severity profiles to reflect the events that we've kept in the database. This was an area -- the whole fire frequency area was subject to a lot of discussion. Dennis really helped us out quite a bit here. I mean, he really spent a lot of time going through the events. He peer reviewed our individual choices. We made a lot of changes based on his comments regarding the data. So there was a lot of time spent here.

In terms of the public comments, there were a lot of requests for clarification of the specifics, but really no major changes.

CHAIRMAN ROSEN: Well, can you give us a feeling for whether or not the fire frequencies are -- maybe this is not an answerable question. But can you say whether the fire frequencies have been increased or decreased in this approach, compared to what we used to use.

MR. NOWLEN: Yes. It's a complicated answer. The fire frequencies themselves have probably gone up a little bit. Well, in fact, they have gone up a little bit. But you have to combine that with the severity factor, because what you're really interested in is how many fires lead to a challenge, to the equipment that I'm interested in, under specific conditions.

So the fact that the fire frequencies went up a little bit should be balanced, to some extent, by the severity factor, which is retained in a somewhat new way. And we don't know what the balance is, because as Dennis points out, we haven't -- we haven't done this set as an integrated set of procedures. We've tested each of the individual procedures, but overall we haven't tested it.

One point that I would like to make is that when we looked at the data we looked at trends. We don't see in the recent data a strong trend downwards. It's relatively flat. Our fire frequencies are, in fact, based on post-1990 data, so we have eliminated a lot of the older data from the set. And that's kind of where we're at.

MR. NAJAFI: Could I add something?

MR. NOWLEN: Yes, sure. Bijan?

MR. NAJAFI: There are two factors that affected these frequencies, even without the severity to -- one to go up and one to come down. One, the effect of removing some of the non-challenging fire removed the frequency down.

The other thing that we did, we went through this change -- implementing a two-phase, two-stage Bayesian methodology to deal with some of the uncertainty we had in the data collection methodology, whether the data quality and the completeness -- to deal with that. And that tended to raise the number a little bit up.

We have one data point from an independent pilot plant that we compared the ignition frequency, just the ignition frequency, between what they came up with -- the IPEEE, the old method, which is this method, and the ball park is about the same.

The total plant, it ended up to be around .4 to .5 to .6 per reactor year for everything in the plant. So it's just -- it's about -- in some areas, it actually goes down. Some areas went up, but for the most part remains the same because of these two offsetting factors.

CHAIRMAN ROSEN: So, but that's an interesting number, the .5 --

MR. NAJAFI: But that's one point. That's one example.

CHAIRMAN ROSEN: That's one point for .5 -- .5 per reactor year says a plant is likely to have a fire of interest every other year.

MR. NAJAFI: A challenging, not severe, a challenging fire, a challenging fire that -- our definition of a challenging fire is a fire that if left alone could grow and become -- I mean, not those that self-extinguish, disappear, because the database has many events that they self-extinguish, they didn't even need anybody to react to it.

So it basically means every two years you will have in a plant a fire that -- it needs to be dealt with. Somebody needs to put it out; otherwise, it could potentially be a problem.

CHAIRMAN ROSEN: And those of us with plant backgrounds would probably say, "Well, I have one." And I'd say it may be a little high from my experience, but not very.

DR. HYSLOP: There's another consideration here. These are potentially challenging fires. So this fire might not have done the type of damage in a -- in one configuration, but we kept it because it could have in another.

MR. NAJAFI: Right. We --

CHAIRMAN ROSEN: It's not outside the bounds of reason, because I was just checking and trying to -- from an intuitive point of view.

MR. NOWLEN: Okay. I have to now correct something I just said. When it comes to which data we kept, the fire frequencies are based on the full data set, so going back to the beginning of time. It's the fire duration curves, the fire suppression time curves, that were based on the more current data. So I have to correct that. I was corrected.

MEMBER POWERS: Steve, we know that Europeans are -- have a fire frequency database. Did you make use of that, or have you compared your database to theirs?

MR. NOWLEN: We have recently completed for NRC -- we helped them develop the U.S. input to the OECD fire event database. Until that input is sent to OECD, we don't get to see what they have. You know, in other words, you have to give them data before they'll show them the rest.

So we'll get the database from OECD in short order, and we'll be able to take a look at it then. As far as this project, no, we didn't. The only thing we did do is we included consideration of known events internationally that had implications for us, but not in a real formal way. No.

MEMBER POWERS: Do you think that fire frequency data taken for western European plants has any applicability to American plants?

MR. NOWLEN: Carefully, yes. But there are significant differences. For example, the Europeans still are heavily into thermoplastic cables. The U.S. industry is virtually -- they don't use thermoplastic cables in any new application. And many of our plants have no thermoplastic.

So there are specific cases like that where I think we have to be very, very cautious about extrapolating the data. Another example is for the -- well, you said western European, so I can't bring in the differences to the eastern European.

I think there is things to learn, certainly. Whether we can use the data directly is yet to be seen.

MEMBER POWERS: It's been my impression that the value of international collaboration in the area of fire probably is strongest in the area of fire effects and less in fire frequency.

MR. NOWLEN: I think I would tend to agree. You know, we've looked at events from the international community, and we learned a lot, you know, comparing -- we did a report a few years ago where we compared fire PRA methods and how we would do an analysis to the events that we were seeing internationally.

And I think we learned quite a bit, but I think you're right. I mean, there are major issues with -- different countries have different reporting criteria. Whether the data is very complete -- I mean, the database that we're using is -- is huge.

I wouldn't go so far as to say that it's highly complete, but I think it's much more complete than what we're going to see from OECD because of the nature of, in particular, the NEIL reporting system where we get a lot of really tiny minor fires reported.

I don't think you're going to see that in the OECD database. So it's going to be a lot of apples and oranges stuff, and it's going to be very difficult to extrapolate directly to what a frequency should be for us.

MEMBER POWERS: It just strikes me that in my limited interactions on this subject, there's a whole lot of interest in getting prior frequency data and a lot less interest in getting fire effects database, yet I think that that is the one that's transferrable.

MR. NAJAFI: Well, actually, let me add a couple of things. I agree that it's easier to rely on the international because of the fire effect than it is on fire frequency, because they tend to either not collect or disseminate their records about small fires. We do. I mean, for -- it's been over 15 years EPRI has tried to obtain and exchange data fire events with western Europe.

The differences that -- we tried to create a comprehensive database that has many applications. We use the database for suppression, for fire effects, fire size, everything, not just the ignition frequency. That's why we like the comprehensive database.

But when you look at the database, even the OECD effort, it's the order of magnitude per reactor year, the size of the database, compared to this database. I mean, order of magnitude, a factor of 10 or 50 smaller events even per year reactor, just because they only keep records or share records of major events. And those are useful in effect, not on frequency.

One other point I want to add, I heard something twice today about the trends. In 2000, EPRI did a trending analysis of fire records, and I want to just point out one thing -- that depending on the type of the fire, generically you cannot say -- whether between '70s, '80s, and '90s -- there is a downward trend or upward trend. There are certain fires that there is an upward trend. There are certain types of fires that there is a downward trend.

For example, there is downward trend in hydrogen fire, specially attributed to the SBGTS, I mean, the standby gas treatment system. There are some upward trends. There seems to be upward trends in the transient fire in the turbine building, which is the indication that there may be people do a little bit more stuff in the turbine building than they used to do 20 years ago or 10 years ago.

There is -- so it is hard to say generically all fires have gone down. That's not true. Some have gone up slightly. Some have gone down slightly.

That's all I wanted to say.

CHAIRMAN ROSEN: Okay. Steve?

MR. NOWLEN: Okay. So the next step in the process is what we called 7A. 7 is split into two parts. This is the quantitative screening. And, in fact, if you read closely it's actually broken into four parts. But basically this is, again, very typical of past practice. You start with a compartment fire frequency and a room-loss CCDP.

If your quantitative screening criteria were actually simplified somewhat from our draft due to the public comments, basically I think we tried to get a little too smart for our own good when we came up with criteria for quantitative screening. And we concluded it was much ado about nothing; we simplified the criteria.

The final recommendations basically are that the screening CDF for a compartment should be no greater than $1E^{-7}$, which is about an order of magnitude less than in IPEEEs. There is also a check on all of your screen compartments. That should be less than 10 percent of your internal events CDF. So there's kind of a rollup screen check.

And we recognize and discuss in the report that, depending on what you're trying to do with your PRA, you may well want to come up with a much more stringent criteria, depending on your objectives. You may not really want to throw away anything. You may retain everything and simply say that I -- I've kept this, but I've only analyzed it so far.

So in some sense, the quantitative screening is almost an optional process here. If you want to keep things, if you want to use a more stringent criteria, then that's fine.

The next task is scoping fire modeling. This is where the concept of our fire severity profiles comes into play. Basically, the objective here is to eliminate the non-threatening fire sources -- that is, fire sources that cannot cause spread of the fire to secondary combustibles, and they can't cause any damage to anything of interest to me.

Again, this is largely a consolidation, although it's somewhat of an expansion on the methods that were used successfully in the IPEEEs to screen out fire sources. The expansion is is that we established this explicit tie to the fire severity profiles. And you can see an example -- this is just arbitrary scale here, but the probability that any fire involving a particular source would reach a peak heat release rate of a given value.

We basically threw these up as a distribution. The distribution, in our mind, helps reflect the fact that we have kept fires that were very small fires. And the distribution includes fires that are very small.

In terms of the screening, we recommend that you use the 98th percentile value. Basically, as you get too far out on the tail, 99, 99.5, you know, you're beginning to get into some statistical unreality. You know, some of these sources just really can't get to a 10 megawatt fire, but statistically there is some probability that they could.

So to reflect that we recommend use of the 98th percentile, and these curves were developed basically based on an expert panel type approach.

MEMBER POWERS: There must be some reason you chose 98. I mean, 95 I would have understood; 99 I could have understood. But 98, I mean, it's a peculiar number.

MR. NOWLEN: Well, it came -- it came about based on the way we drew the curves. We felt that the 98th percentile values were representative of some of the fires that we really do expect to see, low likelihood fires but we do expect to see these on occasion. And so that's kind of how we drew the curve.

We tended to establish what we thought was a 75th percentile value, and the 98th percentile value, and we drew a curve accordingly. We weren't quite so interested in the two percent fire, because we know that's not going to be a threat to anyone, or, you know, the lower intensity fires. So our focus was more on those upper-end fires. And when we came down to it we said, "Yes. The 98th percentile fire, that's the right one to use for this particular task."

MEMBER POWERS: There was a fraction with 99 and another fraction with 97.5.

MR. NOWLEN: Well, it was more -- no, actually, it wasn't. By the time we got past drawing these curves, we all very much agreed that the 98th percentile value was the right one. The debate came earlier in drawing the curves. Well, is 500 kilowatts the 90th percentile, or is that the 99th percentile, or is that the 95th percentile? That's where the debate really came in.

Once we settled on that, then it -- it was pretty obvious which the right answer here was. And we all agreed pretty quickly.

Just to follow up a little bit on this, you'll notice I've drawn a portion of this in red. Yes, it does show up red there. This is related to our severity factor approach. Basically, our approach ties you directly into this same profile, and you would explore the heat release rate on a specific example scenario and determine where is the minimum size fire that begins to get me into trouble. It spreads or it causes damage.

You would then establish your severity factor based on the fraction of fires that are larger than that minimum value in the distribution. So, again, we've tried to tie our fire frequency work to the severity curves.

We tie the severity curves to both the screening fire modeling, the scoping fire modeling, and then back to the detailed fire modeling when we deal with our severity factors. So one of the things here is to try and integrate.

And, again, we didn't get really any major public comments here, some editorial and clarification stuff.

MEMBER POWERS: Did you decide on the minimum intensity?

MR. NOWLEN: Through fire modeling, you look at the specific configuration of your plants. For example, you have a fire source located in this position, the nearest combustible material or target, depending on which is closest -- often it's the same thing. The nearest combustible may be, say, three feet above the top of the panel. Let's say I'm dealing with an electrical panel.

What I can do is I can go into a simple -- fire modeling tools, for example, the FTT tools will provide this answer. And you estimate, well, how big does a fire have to be before it can cause damage or spread to that target? That becomes your minimum. Anything larger than that obviously would also spread.

MEMBER POWERS: Clearly there is a stochastic comment -- complement to that. So in saying your minimum, you've taken some confidence bound.

MR. NOWLEN: In a sense, yes. I mean, to the extent that the fire modeling tools, for example, are uncertain. Surely there's uncertainty there. We've tried to -- you know, the severity profiles we think reflect that aleatory uncertainty associated with how fires behave. I mean, that's really what the curve --

MEMBER POWERS: Well, I don' think it's aleatory.

MR. NOWLEN: No. It's inherent in the nature of fires. It's not something that's a state of knowledge issue. I mean, we know that fires behave differently and will reach different peak intensities. I can set up an experiment and burn the same electrical panel twice. I'll get three heat release rate answers.

You know, that's -- that's the nature of fire, so I think that's more of an aleatory rather than epistemic where I'm worried about state of knowledge. I simply don't know. I think that --

MEMBER POWERS: It's a good thing that Apostolakis is not here.

(Laughter.)

MR. NOWLEN: I probably wouldn't have gone there if he had been here.

MEMBER POWERS: You wouldn't want to go there.

MR. NOWLEN: But anyway, I think, you know, to some extent there is uncertainty. This severity profile reflects uncertainty in the behavior of fires. There is another part that comes in through the model, and that's -- I'm going to leave that for the afternoon, I believe, the V&V effort.

Okay. So back here, 7B, the second part of quantitative screening, is now to bring in the insights of your screening of fire ignition sources. You've gotten rid of certain ignition sources, you refine your compartment fire frequency, and you can now refine your screening result.

There is actually three steps in here, in fact, under 7B where you can also begin to look ahead to what's going to happen in later tasks. You can begin to incorporate detailed fire modeling insights. You can incorporate detailed HRA and recovery. You can bring in circuits insights.

The idea is that we wanted the process to be flexible enough to allow the analyst to look forward. This is not intended to be a rigid "you must flow through here this way." There are all kinds of feedback loops that we could have drawn on that figure to make it totally illegible. We didn't do that. Well, these secondary steps on quantitative screening reflect some of those feedback loops.

And, again, there were just no major public comments, a few editorial things.

The last part here -- I didn't follow my promise to catch up -- seismic fire interactions. Again, this is a consolidation of current practice. The approach that's recommended remains a qualitative assessment that is separate from fire risk quantification. We do not attempt to quantify the risk contribution of seismic fire interactions.

That's consistent with -- basically, our approach is consistent with the recommendations of the original fire risk scoping study where this issue was brought out. There were some additions and clarifications based on lessons that we learned from the IPEEE process. But, again, there is not a lot new here. We did not attempt to go the quantification route.

MEMBER POWERS: What kind of a database do you have on fires initiated by seismic events?

MR. NOWLEN: There have been a number of studies done of seismically-induced fires. EPRI did a study a few years ago. There have been studies in the general -- the more general community of fire protection. There have been studies of major events -- the San Francisco earthquake, the Kobe earthquake. You know, there have been various studies.

The nuclear industry -- our experience base is basically zero. So we have difficulty here trying to come up with frequencies. It's that same issue. Where do we get a population? Where do we get a life? You know, where do we get the operating experience associated with general industry and fires that have occurred in that arena?

We do gain insights on the types of fires that occur. For example, gas line fires are far and away the most common post-seismic fire. You break a gas line; you get a fire.

So we gain some qualitative insights, which have been factored into the guidance. But, again, getting -- getting quantitative is still a challenge that we didn't attempt to overcome.

CHAIRMAN ROSEN: Well, don't you have a minimum? I mean, you know how many earthquakes have occurred of a various magnitude. That's measured at plants. And you know how many fires there have been, which is probably zero.

MR. NOWLEN: Zero.

CHAIRMAN ROSEN: So, but that creates a minimum. You know, it can't be higher than that, right?

MR. NOWLEN: Yes. And we believe that number is very low, which is another reason we're comfortable with the qualitative approach rather than trying to quantify this. I think the ultimate conclusion of the fire risk scoping study was that this -- this is better addressed qualitatively. If you find a potential vulnerability, fix it and be done with it rather than attempting to spend significant amounts of resources trying to quantify it.

And I think that's where we are today. We still feel that's the correct answer.

CHAIRMAN ROSEN: I guess I just don't know how to do a qualitative assessment separate from the fire risk quantification. I mean --

MEMBER POWERS: You're going to do a qualitative assessment at the conclusion of this briefing. You're very good at it, as a matter of fact.

(Laughter.)

MR. NOWLEN: Well, again, the idea is that you want to identify and address potential vulnerabilities. That's qualitative. We're not doing anything quantitative in trying to estimate the frequency that I might actually see an earthquake leading to a fire that might give me adverse consequences that would complicate my response to the earthquake in the first place. You know, dah, dah, dah.

We don't try and get quantitative. We do -- it's based on walkdowns, for example, looking for gas lines, looking for unsecured gas models, looking at anchorages of electrical panels that could tip and create a fire in a critical area. You know, it's that sort of a walkdown-based, non-quantitative approach. If you find something, fix it and be done with it. Don't try and quantify the risk of it.

MEMBER POWERS: And you're fixing against the earthquakes of the safe shutdown magnitude or --

MR. NOWLEN: And with -- I don't believe we got very specific about what level earthquake you should consider. I would presume that's appropriate.

MEMBER POWERS: I mean, I can always hypothesize an earthquake, but that -- that will knock your plant down.

MR. NOWLEN: Agreed. I think you have to -- yes, you have to exercise some judgment there obviously. I mean, it's kind of similar to circuits if you --

MEMBER POWERS: When is the last time I exercised judgment?

(Laughter.)

MR. NOWLEN: Gosh, not in my memory.

(Laughter.)

CHAIRMAN ROSEN: Well, Steve, I guess you're getting close to being finished.

MR. NOWLEN: Yes, that's my last slide I believe.

CHAIRMAN ROSEN: All right. And it's noon, and we could start another presentation or we could go to lunch. Hearing no objection, I would say let's go to lunch and pick up with Bijan right after lunch, which will be -- we have an hour on the schedule for lunch. But I'll exercise the chairman's prerogative and shorten that to 45 minutes, if I may, to try to make up some of the time. We're now behind one whole presentation.

So can you all be back here around 12:45? Thank you very much.

(Whereupon, at 11:57 a.m., the proceedings in the foregoing matter recessed for lunch until 12:40 p.m.)

CHAIRMAN ROSEN: We're back. Bijan, why

don't you take off with the next presentation?

VI. FIRE SPECIFIC TASKS, PART 2

MR. NAJAFI: Okay. Basically this morning presentation, we covered the technical tasks related to the PRA/HRA and basically the circuit analysis and some of the ignition frequency and screening tasks.

What I will be talking about next is the task that basically determines the extent of the fire growth and damage that is caused in its time. And what we refer to a detailed fire model, this is basically the asterisks that he was talking about, a PRA with the asterisks on the side.

So this asterisk basically to give you an idea is now about 30 percent of the entire document. Of a 700-page, probably about 200 pages of it is this asterisk with the associated appendices.

Basically we have broken down these tasks into three distinct parts because of the unique nature of how you deal with each one. One is the fires that involve single compartments, fires that start from one that cause harm within the same compartment. One is the fire that grows beyond a fire barrier. And then the other one is the main control.

They are unique issues related to the control room regarding habitability, evacuation, and ability to model basically fire growth in a different scale. It makes it unique and different challenges that we have separated into a different set of basically set of subprocedure or procedure instruction set.

Generally the procedures for this particular task follow three different fundamental steps. The first step says that you need to select, identify a fire scenario and characterize it.

What I mean by that is when you go into a room, there are numerous potential hazard sources. And depending on where it is in the room, there could be numerous potential targets of interest.

The question is, how do you pick the right combination? How do you define the scenarios, which fire starts, because theoretically you can have a very large number of fires starting from every corner of the room depending on the room. Especially if you're in a turbine building, fire can start in three floors in three different areas.

So it is a trick or an art how you pick the right set of scenarios in a risk context because your idea here is not necessarily what it was in the IPEEE, the vulnerability assessment, which you had the basically way out to say, "As long as I pick the worst ones, I'm okay."

Here you want to have an adequate picture of risk. And what's that adequate picture? You have to pick the right scenarios and you have to pick the right number of them.

You can't just pick two and say, "Okay. I covered the top 2 if you lift 50 percent of the risk out." So you have to pick the right ones and the right numbers.

So then you have to characterize it. Characterize to us means that what is the location, the size, the timing, the energy of the initial fire? The fire that it starts, what is the initial fire's -- you have to define in its severity, in its size, in its type. Is it an electrical fire or is it an oil fire?

And then the second piece that this procedure goes through, it says, how do you determine the growth spread and basically timing of the fire because basically it's a fire growth. There are count detectional methods and many things to analyze that.

And, then, finally is basically fire detection and suppression. That element comes into the picture in a when do the detection activities, whether it's automatic, manual, when to come into the picture, and how they mitigate the growth of the fire and its progression.

So this is how the procedures are structured. There are three different subprocedures, one for each one of the methodologies for different scenarios, and then each procedure goes through these as steps.

For the fire severity and fire basically, this is the big difference that it is between the current method and what it was before. Before we had in the methods a fixed fire size, and then we set a severity.

What is that before we said, we pick the heat release rate of a fire to be 100-kilowatt or 200-kilowatt. We did recognize at the time that when we say 200-kilowatt, not every fire that is started in our fire size is going to translate to be a 200-kilowatt fire, a subset of that.

So we created something we call severity in order to basically make the gap between the fire that we define and the fire that we monitor because it's two different things. The 100-kilowatt is what we put in our computational fire modeling code, but the fire that it starts is not necessarily 100-kilowatt. So to bridge that gap, we have created a single severity factor. So it was a heat release rate times a severity factor.

This one has some advantages. It's simplification. And if you pick the right vulnerability assessment, you can capture your dominant or important things. But it has some weaknesses.

For example, if you have a scenario-specific configuration that a smaller fire than what you picked can cause the damage and grow, you may miss it in that kind of scenario. If you said that 100-kilowatt with a severity factor of .1 in a configuration that even a 50-kilowatt fire can propagate to a cable trade that causes a cable fire that gives you a problem, that was not captured in the previous method.

So basically we made a change, which is basically one of the larger improvements or differences in this procedure, to create distribution, as Steve showed you before, create a distribution, for heat release rate. And we created a definition of heat release rate, which allows you to become more specific to this scenario and configuration of the ruin. That initial phase of fire proportion.

MEMBER WALLIS: How is this tied to

reality? I mean, you talk about a 300-kilowatt trash can fire? It's got some kind of severity factor. But there are all kinds of trash can fires presumably. How does your model relate to the reality?

MR. NAJAFI: In different parts of our -- different types of fire, we have made it to relate to reality by different means. For example, what you used as a trash can, what we do is based --

MEMBER WALLIS: What's in the trash can presumably.

MR. NAJAFI: Well, because the other examples are electrical fire. When we say 100-kilowatt fire in electrical panel, how does that correlate to reality? We do that based on experiments, fire tests.

We do look at fire tests and fire experiments. And we measure heat release rate. And based on that, we say this is electrical cabinet fire. We think it's going to be anywhere between a 100 to 200 to 500-kilowatt fire because of what we measured in experiments, fire experiments.

MEMBER WALLIS: So you take a lot of trash cans with lots of different things in them and ignite them.

MR. NAJAFI: The trash can is a different set of experiments. We have a database collected from Livermore Lab tests that were done way back. There's a table here, which was, by the way, in the old method, too, but it's about, I venture to say, 20 to 330 different fuel packages. And it says that for this fuel package, this is the total BTU that they measured and this is the kilowatt that they measured.

Now it tells the user, "Go see. Do you find something close to any of these?" So that part of it is a little bit of extrapolation. The user has to go and look at these fuel packages and say, "What I have here," which another extrapolation still needs to be done after that, meaning that, as I said, a user has to characterize now --

MEMBER WALLIS: You also have to do some research to find some experiment that looks something like what he has actually got.

MR. NAJAFI: But we already have documented it for him. He doesn't have to go to another book. But, remember, also the other part of that is to determine what kind of fuel package he should postulate for his room first. I mean, does he have to say that "In this room, I have a ten-gallon trash can full of paper"? Do I have an oil can of this much?

There are processes in this document that say how do you determine because you don't walk into a plant and necessarily always see the transient there. You don't see "I am modeling this because I saw it." You don't see it. You have to model things that you potentially don't see.

So how do you go about determining what do you model? The processes say, "Look at your practice. Look at what kind of corrective preventive maintenance do you do." If you have a pump in the room that you have to change the oil in, then you have to bring oil to change.

And when you bring it, look at your practice to see where do you stage it. Do you stage it at the door with the door open? Then you have to model it there.

So part of when I say you defined the scenario is that where do you put the fire? I mean, the transient is that you have to know both what is the worst place in the --

MEMBER WALLIS: He spills some of the oil. Then he wipes it up and puts it in the trash can.

MR. NAJAFI: Exactly. So you have to look at those and postulate it. Then these factors are these sort of hints or helpful aids have been described in this report that says these are the factors they have to consider.

MEMBER WALLIS: It just seems to be much more iffy than some of the thermal hydraulic analysis, where you have a pipe and a vessel, you know the pressure and the temperature. And even then, it's difficult to figure out what happens. But at least you know more. When you have a trash can with heaven knows what in it, it's much more vague what you are dealing with.

MEMBER POWERS: See what an easy field you work in?

MEMBER WALLIS: Yes, I know. That's why my mind is boggled by the idea of trying to --

CHAIRMAN ROSEN: Well, once we do this, I'm going to do PRA on top of it.

MR. NAJAFI: I mean, I have always compared when people --

MEMBER POWERS: That's just a deliberate obfuscation, is all you're doing there.

MR. NAJAFI: No. What I have compared this to, for example, in many of these fire issues that you raise, compare it when we used to real robust Level Ii assessments. And now we have these fire phenomena that in most cases so far have been deterministic.

We are trying to do the sort of creative probablistic framework for it similar to thermal hydraulic analysis, Level II analysis, map march. We still remember days that we used to do marching. Don't do that any more.

Basically these are the kinds of things that we are dealing with, that there are some uncertainties. Some of the things we compensate for, for example, in a transient analysis are through this severity calculation. We say, "What is the worst fire that could give us the problem?" Then we adjust the severity factor. Do you see what I am saying?

So you keep building up the fire to a minimum size that is going to give you a problem. You capture those kinds of things by variable heat release rate, variable heat, fire size.

So, I mean, this issue up here, if I don't know exactly what size of fire, like if they bring a ten-gallon oil to change or a 55-gallon oil to change the diesel fuel lubricant when you have to analyze basically to find basically what size of fire do you need to give you trouble and then from that back calculate some severity factor based on our distribution of heat release rate for that size of fire. But, I mean, there are some levels of uncertainty in the year.

The next step once you have characterized the fire, you know what type of fire you are putting where and what size. Then it's basically you need to assess the fire growth. You need to determine the extent and the fire. So those are the key things.

There are two ways. Traditionally there are computational fire models. There are plenty of those that allow you to do that. Examples are CFAST, MAGIC, FDS, and hundreds of others.

This document does not necessarily recommend or suggest any -- it's not a document on fire modeling tools. So it doesn't say this model is better than this and use this model. It says that these are the things that you need to calculate. These are the things that you need to find. Go find the right code. And that's the job of another document to say what is the right code.

The second part of it is that there are certain fire progression propagation scenarios in a nuclear power plant that are not addressed adequately by these computational fire models.

Actually, there is a document that we did maybe two or three years ago. For example, you can calculate mean temperatures. They're within their capability.

MEMBER WALLIS: I noticed in another document, the V&V thing, that some coats do better than others on certain fires.

MR. NAJAFI: You see, there are two different issues here. One, do they have the capability to do it; two, how good they do it. If you look at the capability, that is what I am talking about.

MEMBER WALLIS: The capability is a claim that they can do it.

MR. NAJAFI: Yes.

MEMBER WALLIS: That's nothing that says they've done it well.

MR. NAJAFI: Yes.

MEMBER WALLIS: That's quite different.

MR. NAJAFI: Yes.

MEMBER WALLIS: I'm capable of all kinds of stuff on that basis.

MR. NAJAFI: These codes are not even capable. I mean, most, if not all, of these computational fire models that we work within the nuclear industry, they do not --

MEMBER WALLIS: I mean, you ask them to do it. They just say, "I can't do it."

MR. NAJAFI: Yes. I give you a couple of examples of it in the next page.

MEMBER WALLIS: No. I understand better, I think.

MR. NAJAFI: So, I mean, for those things, actually, you would be surprised to see almost half of them not even within the capability of these codes. And I will give you a couple of examples of it in the following pages. These are a good example.

These first example is a high-energy arcing. These is basically a switchgear fire or event that basically is a two-phased event. The first phase is an energy release. It's fast expansion of whatever it is, and it has the potential to cause secondary fires.

Would any of these codes model them? No. They don't even claim to model them. So we have to come up because it's important to a switchgear room, fire in a nuclear power plant. And in many cases, in BWRs, for example, typically many of them, their safeguard switchgear happen to be in their turbine building. A lot of other stuff is there. So you could potentially be a risk-significant scenario coming out of a switchgear event.

MEMBER WALLIS: Is yours own of influence spherical?

MR. NAJAFI: Pardon me?

MEMBER WALLIS: Is yours own of influence sphere?

MR. NAJAFI: Yes.

MR. NOWLEN: Well, in part. No, that is not quite true. There is a sphere, but there is also an influence that asymmetrically --

MEMBER WALLIS: Because these are --

MR. NOWLEN: No, but there is an initial blast that --

MEMBER WALLIS: There is a blast.

MR. NOWLEN: Essentially an explosion. It's an electrical arc over. That creates a spherical damage zone, but then you also get the heat effect very shortly afterwards that goes upwards.

MEMBER SIEBER: It's a plume.

MR. NOWLEN: So it's not a simple sphere. There's a sphere combined with a plume effect overhead.

MR. NAJAFI: Yes, yes. He is right. Actually the effect above is more than sideways.

CHAIRMAN ROSEN: Well, then you have the hot gas layer cooling. So certainly you have --

MR. NAJAFI: We treat that totally different.

MR. NOWLEN: Yes. See, the problem with this particular one is the early energy release. Once we get that initial release and things have gone and now we have a fire, we're back to the world of fire modeling. That they can handle. So we --

MEMBER WALLIS: A big match that just gets things going.

MR. NOWLEN: That's right. And it tends to get things going a little bit more energetically than your typical fire. So, again, the idea here was to create a rule set that would deal with that very early stage explosive event and then turn it over to the fire model to take it from there.

MR. NAJAFI: And, then, basically the rule set that we developed is based on events. So we went and reviewed about a dozen of these kinds of events that have occurred. We based our model on the worst one of them. And maybe lessons learned from a few of maybe a set of three that really caused severe external damage, significant external damage.

So it went beyond that initial phase. Then, as Steve said, it turns into traditional fire modeling with potential added fires. Now you may have two fires burning. Now you may have cable trays that are above a tack of two trays. Now you have two fires in here and a fire out of the switchgear itself.

So now you have to account for them. And there is some guideline, some instruction in there that says how do you model that kind of scenario.

The second example that is totally new -- and this is something basically -- I mean, the need came out of the IPEEE exercise. In part, if you look at the lessons learned from IPEEE, control room was almost like in 40 percent of the assessments, control room was the number one scenario.

In many of those, the fires are coming from evacuations. And a lot of them are created by fire inside of the main control board because it takes the functional out.

A lot of them are not the smoke generated. It's the functionality having the need to shut down from outside because there was no model to assess the fire propagation within the main control board. And either you assume that fire goes throughout the main control board and basically fails the complete control and you have to evacuate and use the alternate shutdown or you assume arbitrarily a perchant or a suction.

So we had to develop a method because the computer computational models don't do that. You cannot model a fire inside an electrical unit. You can't do that. They are compartment fires with established boundaries.

Therefore, we developed some probablistic model, that it uses some of the principles of fire plume equations and things like that to determine basically how the fire propagates within a control panel and, in effect, causes loss of safety functions, that it's basically short of assuming one corner, fire starting from one corner, it goes to the other corner with probability of one.

So that basically it has the potential to bring the control room fire risk to a lot more realistic number than it was with the IPEEEs. The other example is the cable fires. These models, even though you can probably put in there, some of these models give you really sort of unexpected result the minute you start modeling cable fires.

The issue there is that not only how the fire propagates across the length of a cable tray, whether it's horizontal, vertical, whatever. In plants, there are plenty of these stacks, how the fire goes up the stack. And that's important in cable tunnels, cable spreading through critical areas of the plant. You can just --

MEMBER WALLIS: Are these cable trays different? I mean, do you have different cables in different trays? They are arranged in different ways? It's a different problem for each cable tray.

MR. NAJAFI: It is a different problem, but, remember, right now we're looking at these as so haphazard but as a target. The issue is how big the fire gets. If I have a cable, one section of the tray burning, I may have a 500-kilowatt fire. That 500-kilowatt fire, if it goes up, I can have a 2, 3, 4-megawatt fire if I start burning four or five trays at the same time.

CHAIRMAN ROSEN: If they're all filled.

MR. NAJAFI: If they're all filled, exactly. You're right, if they're all filled. So the issue is that there are a lot of variables in there. Cable material, of course, is one. Cable fill is one. The orientation is one. Whether they're energized or deenergized, cable is one. I mean, all of these factors can affect how fast it goes, how far it goes.

I mean, these are not the ones that CFAST or MAGIC or FDS, for that matter, deal with, I mean, how fast the fire grows and how far it grows. So we have developed some model that basically uses either first principle in the case of the single cable tray and some experiment base on the case of the cable tray stack. It was a fire tested. It was done in Sandia. We use as a basis to determine basic timing of the fire growth, I mean, how the fire goes into a cable tray.

There are a number of other ones that basically a good example I would go quickly through them. Fire propagation to adjacent cabinet, that's very important in a control room, relay room, where all your relays are. You may have no cable. You may have nothing. All you have is cabinet next to each other and what you want to know, how the fire goes from one panel to another one, like a computer room in a plant.

I mean, those things you can't use in a computational model. We have developed a rule base for that that is based on experiments.

MEMBER WALLIS: What does "Consolidation" on this slide mean?

MR. NAJAFI: "Consolidation" means that the method already existed. It's not something new. This is what it was, even in the EPRI's fire PRA guide before. And this next one is the passive fire protection features, electrical raceway fire barrier systems. If you have a fire outside, what's the temperature inside?

Some codes do that. Traditionally the CFAST that we use, they're not used for that kind of thing. Then hydrogen fire is new, meaning in a turbine building, there has been hydrogen fire. We have defined and created a rule based on events domestically and internationally that defines a set of what is the likelihood of a hydrogen fire getting this much damage, that much damage. It is very simplistic, but it is something that was a gap and we needed to provide some guidance there.

The turbine generator fie is the same thing. It was in there basically to create a set of rules that says what is the likelihood of having a fire that involves both -- the turbine generator issue is that you can have three different types of fire types: electrical, hydrogen, oil. And you can have it all combined. You can have two out of three. You can have three out of three.

So how do you characterize? How do you say, what is the likelihood I could have three out of three? We have put some set of instruction again based on review of fire events domestically/internationally.

And then the last one is a smoke damage. This is somewhat the consolidation of the research done by Sandia and provides some guidance how to deal with the effect of the smoke damage on sensitive electronic and the switchgear-type.

MEMBER WALLIS: Does this deal with smoke propagation to remote areas?

MR. NAJAFI: This is not that. This is basically smoke damage, establishes criteria for what is the effect of the smoke on a piece of equipment.

MEMBER WALLIS: Okay. But it doesn't tell you how to calculate whether the smoke that starts here goes here?

MR. NAJAFI: No, not this one. This model doesn't say how the smoke goes from A to B. It says that if you have a smoke -- and Steve can explain it a lot better than I can -- what's the effect of that smoke on that piece of equipment.

MR. NOWLEN: Yes. Again, the focus is on damaging equipment. And the insights we have gotten from the research in FAST is that you need high concentrations of thick, dense smoke in order to cause most things to damage.

And so what the guidance has done is it

has told them what sorts of things are vulnerable to damage due to smoke. High-voltage equipment, for example, is vulnerable to smoke arcing. And then it gives them basically an empirical rule set for saying, "How far away from the fire should I go before I assume that the smoke has been diluted enough that it's not going to cause" --

CHAIRMAN ROSEN: That was the issue I was talking about. You've got some sort of empirical rule set.

MR. NOWLEN: Yes.

CHAIRMAN ROSEN: We have seen in operating experience where smoke fires have propagated through cabinets the remote thick cabinets you would not think would be involved in providing you basically as an analyst with an intractable problem in terms of doing analysis.

MR. NOWLEN: Yes. And we have, for example, given guidance to look for bus ducts that connect one panel to another. And if you're postulating a fire in one, you have to assume that the smoke is going to pass right through the bus stop to the other one. And you're likely to lose it, regardless of what the separation might be.

CHAIRMAN ROSEN: Regardless of what the

dilution would be --

MR. NOWLEN: Right.

CHAIRMAN ROSEN: -- because there wouldn't be any in that case.

MR. NOWLEN: Exactly. And that's exactly the nature of the guidance, but what it doesn't do is say, you know, "Would I have to worry about my operator coming down into an adjacent room to perform a function?" That's not what this particular rule set is for. That's a separate question. This is --

MR. NAJAFI: And that question, again going back to the issue of capability versus act, that is within the capability of many of these codes, that it can assess the propagation of a smoke from one room and a smoke density going from here. That is actually one of the mainstays of most of these codes. So we didn't need to develop anything. The computational models deal with that.

The next step is basically once you have determined what is the mechanism through which the fire propagates, then you have to superimpose on this basically your detection and suppression activities and determine which in this progression line the fire will be controlled and basically damage would be prevented.

So what we do is basically the outcome of this is a non-suppression probability, but the approach, these are the things that we credit. I mean, the prompt detection and suppression by the plant personnel and fire watch, there's a model for it. There's automatic detection and suppression, which looks into the reliability, availability, and the effectiveness of the suppression, looks at the three factors.

The reliability still remains to be generic based on review of the data, that it was done in the FIVE and fire PRA guide time frame. Actually, that is one of the examples that somebody talking about why we don't look outside the nuclear, that reliability data comes, part of it, from outside of the nuclear industry because that we felt at that time was easy to get and it was applicable data. Suppression is suppression. I mean reliability.

The availability is plant-specific. There is guidance here that specifically says how to determine the availability of the system, recognizing that many of these systems come into operation, go out of service. I mean, they could be in and out of service regularly for a number of reasons.

And the effectiveness is basically

scenario-specific because it's very important to acknowledge that, even if you have designed and installed and maintained a suppression system, detection system according to the code does not mean that it will be effective to do what it is intended to do, to prevent damage in all scenarios, because these are means of fire control. These are not means of damage prevention.

So you have to make sure that it does prevent the damage to the scenario of the concern. That you have to look at. When there is manual detection but there is guidance to credit how the operator or somebody can detect.

And there is the fire brigade model. At this point, the brigade model is it was and still is currently based on data. It is true that the data when it comes to the brigade response, it is not the best that we could have. The data still has weaknesses in it. But it basically has enough information in it that we can generate some statistical curves.

CHAIRMAN ROSEN: It's not plant-specific?

MR. NAJAFI: It's not plant-specific. In fact, one of the areas that you will see at the end when we say, "Okay. These are potential good things to do" is that in fire-fighting for the most part, we do not capture as much as we should unique attributes of the fire brigade program.

I mean, you can't capture why plant A, they have a better brigade than plant B. I mean, if you use that approach --

CHAIRMAN ROSEN: You say you cannot capture?

MR. NAJAFI: This method, given the same scenario, given the same time, if the only difference is their brigade is better trained, you really do not capture it with this method. Is it better to have a method that captures a unique aspect? Like, for example, they have a fire department. These guys have a five-man brigade.

If the timing, yes. If you can say these guys can get in there in 10 minutes, that guy takes 15 minutes, you can capture that. But the things like if these guys have a fire department, these guys don't, these guys are better trained, these guys don't, some of these things you cannot capture.

We did attempt. I mean, our rule of engagement, for lack of a better word, was that we're going to document the state-of-the-art. If we find basically areas of research that it's going to take us a little bit of time, maybe a matter of days, we will try to make that improvement. If it's going to take us a lot of time, like fire HRA, let's not do it.

This one we did think about. We did try to come up with something new. But I guess it took a little bit longer than we were trying when --

MEMBER POWERS: Let me ask you a question about your database that you used for the brigade performance. It's really about how old it is because it seems to me that OSHA has imposed some new rules in how you fight fires. I'm wondering if that database reflects those rules.

MR. NAJAFI: For this, as Steve mentioned before, when it comes to the suppression, we limited the data from going way back because this data source goes back to 67. And for the suppression, we do not go that far. I can't remember how far we go for suppression.

MR. NOWLEN: Yes, post-Appendix R.

MR. NAJAFI: So we go back to 81.

MEMBER POWERS: Now the rules, the OSHA rules, are now a year and a half old. Is that correct?

MR. NOWLEN: Something like that, yes.

MEMBER POWERS: Relatively recent vintage.

And those rules affect particularly fighting fires in confined spaces, which is what you're always worried about.

MR. NOWLEN: Well, there have also been some enhancements to some of the NFPA industrial fire brigade rules as well that parallel that. You know, we have new two in, two out rules. You're not supposed to go in and fight fire until you have two people that can go in and two people that stay at the door.

And no, we don't have much experience with that yet. So I would have to say our data probably doesn't reflect that.

MR. NAJAFI: In fact, I know it doesn't because this goes up to 2000.

MR. NOWLEN: That's for --

MEMBER POWERS: And so if we encountered here an area where you cannot claim to be conservative; in fact, exactly the opposite, you're nonconservative --

MR. NOWLEN: Well, but we have the balancing issue of fire control versus full suppression. And I have stated before this Committee previously that I tend to agree that the issue of controlling a fire is what is really of interest to me in risk space. But our data doesn't give us the answer about when they achieve fire control with a few exceptions, not nearly enough to build the model on.

So, you know, you have some counterbalancing effects here. I don't know where it is going to shake out in the end. I would tend to agree to some extent with Dennis. We are probably still being a little conservative.

MEMBER POWERS: I guess I don't understand because part of the two in, two out rule is going to delay your response.

MR. NOWLEN: Yes, but the methodology addresses response time. The curves are timed from arrival, the initiation to completion of suppression efforts. So the methodology says you have to assess the time it takes for you to get a team on site actively ready to fight the fire. Then you apply the curve, which actually is another conservatism because in some cases, the data that we get doesn't really distinguish between when the fire really started and the brigade arrived and then they put it out. They just say, "At this time we had a fire reported, and at this time, it was out."

So in those cases, we took that as the suppression time when, in reality, there was probably a split in between when they knew they had a fire, the fire brigade arrived on scene. We should really be using that time from when they arrived on scene to when they got it out.

So there's a number of issues here with the fire brigade model that our judgment would be in balance. We're still being a bit conservative. We would really like to work this one more. Dennis has a comment.

MR. HENNEKE: Yes. Although the code has changed, the two in, two out rule, for example, has been used for some time. So the fact that the code changes doesn't change the way we do business. So I would say the data reflects that already for most cases.

MEMBER POWERS: Well, I can hardly speak for every facility, but of the six or so that I have visited and asked this specific question, none of them had implemented the two in, two out rule at the time I visited.

MR. NOWLEN: I know in my experience, I have seen some who have. So it's --

MEMBER POWERS: I'm sure there have.

MR. NOWLEN: Like other aspects of the fire brigade, it's uneven across industry. There is definitely a variation. You know, everyone meets the rules. I mean, I don't think that's in question at all. Everyone complies with the regulations. But a number of people go well beyond that.

And the point we're making here is right now our methodology does not allow us to make very many distinctions between good and better. And that we see as a limitation yet.

MR. NAJAFI: And I would also want to emphasize that when I say it does not allow, it does not allow for determining between the effectiveness of the brigade when it gets there. I mean, we can account for the timing if they're slow getting to the point.

We have a time to arrival in the model that accounts for that. But once you're there, I mean, how effective you are in fighting the fire, if you do the same fire in two different plants or five different plants, in our method, you get the same number.

I mean, right now we don't qualify, let's say, the brigade of one plant versus the other. That's the part. The arrival time, it is made plant-specific.

DR. HYSLOP: But, on the other hand,

effectiveness of some sense is already captured. The data itself is what we use. Those cases where the brigades have been effective are considered. Those cases where the brigades have been effective are also considered. So to that extent, we try to capture it.

MR. NAJAFI: And the public comments that we got, basically there were very few in terms of editorial clarification comment, including consistency with the SDP NEI-04-02. And we went through that and made corrections. There were some about the references that we basically made corrections accordingly.

One of the probably more interesting or important ones that we got was about the V&V at the model and the fact that there is another project going on for the V&V of the computational fire model. And we have to make a case about the other pseudo fire model that we have created and what kind of validation do we have for those, if any.

So basically, I mean, even though some of these models are based on data, we did not systematically go through validating the models that we either developed ourselves or even the computational model in this document. This document purely is just basically saying how you do the fire modeling, pick the right model. It's somewhere else. For those there are gaps, it suggests alternatives.

And that's it. If you guys have any question?

CHAIRMAN ROSEN: Okay. Hearing none, we'll move right on with Alan talking about PRA and HRA.

MEMBER POWERS: Did I understand there is to be a document that is going to go through and review all of these available codes, computational codes?

MR. NAJAFI: Next.

MEMBER POWERS: That will be entertaining to see what --

CHAIRMAN ROSEN: Yes. After Alan, you'll get to revel in it.

VII. PRA/HRA TASKS, PART 2

MR. KOLACZKOWSKI: Okay. I'm back in. And that's because while PRA and HRA has some initial tasks to perform in building the modeling and helping select the components, et cetera, as you have seen, there is a lot that goes on in terms of qualitative screening, quantitative screening. You're doing some scoping fire modeling. You're doing some preliminary cable circuit work, et cetera.

And basically what you are doing is you are trying to screen out things that are going to be unimportant. You are iterating on the model, et cetera. But finally you get to the point when you finally said, "I've done the best I can do everywhere. I am going to do my final best estimate fire risk calculation."

And so now you come back into PRA space, where you have done whatever you are going to do to the model and you have decided these are the targets that are affected, these are the probabilities, et cetera and so forth. And now you have just got to put it all back together and determine my fire risk in terms of CDF, LERF, et cetera.

And so the last few tasks in the process are kind of back in PRA space, if you will, and, of course, documentation. So I'm really talking about the last boxes in the process, where you are finally, again, taking all of your best inputs and then you just turn the crank at the end. So, therefore, it's not --

MEMBER WALLIS: All these boxes. Is there some assessment of how well you can do the job in each box?

MR. KOLACZKOWSKI: Some assessment as to

how well?

MEMBER WALLIS: I see all of these boxes. It's all very nice. And I say, "Well, when they're doing tasks," or whatever, "how well can they do it?" I don't know what the answer to that is.

MR. KOLACZKOWSKI: Dr. Wallis, I did --

MEMBER WALLIS: Circuit failure load unlikelihood analysis. Is that something we are going to do another day or something? How well can you do task 10?

CHAIRMAN ROSEN: Well, I think we heard all we are going to hear about that from earlier today. Do you want to take a stab at that?

MEMBER DENNING: The answer is --

MR. NAJAFI: If you're talking about the level of confidence that we have in the state-of-the-art, that is one question. How well do we think the state-of-the-art is in each box? Where are we now? Are we here? Are we here or is the question, how easy it is for a potential user out there to get --

MEMBER WALLIS: I think there is a whole level. One is how easy it is because a lot of this is site-specific.

MR. NAJAFI: Yes. I'm just saying that

there are two questions. There are two questions. Which is the question we will try to answer is how easy it is to use, which one is the hard one, which one is the easy one or where are we in the state, where is our --

MEMBER WALLIS: Well, in terms of being an athlete trying to run the Olympics, are you a little kid learning to walk or are you somewhere further along than that? Do you use the high school level, the high school sports level or something or where are you?

MR. NAJAFI: I have said before that I think if I had to compare this with the general state, I'm not answering this per box but the overall. We may be about five years or so behind internal event, I mean, technology wise.

They're a little ahead of us. And we have -- I mean, in the past five years, we have made a big jump. We have made a huge jump and addressed some of the very important boxes, boxes number 3, 9, and 1.

We have gone from a zero to maybe a 50-75 percent. We're not to 80-90 percent of where we can be, but as a whole, there has been a significant jump. And we are basically, I would say -- I mean, people can disagree how close we are to an internal event technology. Are we close to it? Are we very far from it?

CHAIRMAN ROSEN: Bijan, you recognized the internal event technology for many, many years as evolving --

MR. NAJAFI: --

CHAIRMAN ROSEN: And asked that question all along. I think, practitioners would say, "Well, we're doing a pretty good job. I'd say we're at 50 percent of what we do perhaps." But that 50 percent hasn't changed, and there are great improvements made over the years.

So what happens is you get a bigger and bigger appetite. You realize more and more things, and you realize the scope of what you are trying to do is bigger than you thought earlier. So your estimate probably is a little high.

MR. NAJAFI: Well, that's why I try to put a reference point and compare it with internal event. If there estimate is 50 percent and definitely subjective, if everybody agrees, then you can use the fact that I'm saying that we're maybe a few years behind that, where maybe if that 50 percent is acceptable, then maybe we're at 40 percent. But I don't know enough to make that judgment that for an internal event, we are at 50.

CHAIRMAN ROSEN: No. I never said internal event is at 50 percent now, but it used to be.

MEMBER DENNING: I'd like to jump into this because I think there is a really important element of this that really affects the advisory committee. And that is I think we have to ask ourselves, what are we really trying to do here? What can you really do in fire PRA? What are we really doing in internal events PRA? And 15 years ago, our objectives were much less than they are today in a risk-informed regulatory environment.

And I think your question, Graham, you look at uncertainties and ask yourself, "Well, how big are the uncertainties?" and you'd like to know not just our own judgment of what those uncertainties are but in some real sense.

And then what are we really going to do with our fire PRA results? Are we going to use it just to get insights or are we going to use it somehow to trade off regulatory relaxations and stuff like that? The demands on our abilities become much higher if that is what we are going to do.

And there is another piece of this. And

that is, what realistically can you do? You know, we can keep working and working this problem, the HRA problem, forever. And there are elements that are just irreducible as far as uncertainty is concerned.

And I think that the true answer here in the fire PRA is that there is more that really can be done. There still is more. There are limitations as to how far you can go, but, you know, you guys kind of identified some areas where it still is productive to do some more things. But five years from now, that may not be true. We may have really reached the limits.

On internal events, I don't know. I think that as far as far as the general technology were there on HRAs, they're more as part of that. I don't really know where the boundary is where we start just kidding ourselves as to whether an improved HRA model is any better.

CHAIRMAN ROSEN: I would like to jump in on your jump in, if I could. I think we have to assume that the fire technology will be used, just like the internal events technology is for a regulatory purpose.

So that we're not doing it just to get insights. We're doing it to get insights on the way to doing much more with it.

MEMBER DENNING: I absolutely agree with you. And I think that what we have to do is and I don't think we have done effectively yet is when we look at those insights, we are going to recognize the sources of uncertainties, the magnitudes of the uncertainties, and not step beyond those when we make regulatory relaxations.

CHAIRMAN ROSEN: I agree, especially because now one of the classic insights we have had in the last decade or so is that fire is very important to the overall risk. And so clearly the approach you outlined is definitely called for.

MR. KOLACZKOWSKI: I'll try to get to the uncertainty next. The only thing I want to say about this particular task, the quantification, I mean, it's pretty much just like we do in --

MEMBER WALLIS: I want to get back to the question here. Since no plant has yet completed for a PRA, we don't really know. It is conceivable that they could come up with some numbers with uncertainties, which is so enormous that you begin to wonder what you can use that number for. We don't know yet until someone has done it.

MEMBER DENNING: You meant with this

improved technology.

MEMBER WALLIS: Yes.

MR. NOWLEN: I think you're going to find that there clearly are going to be changes. Some things that were downplayed before may show up as more. Important things that we played up before will go down.

So it's going to be very much a mixed bag. We don't know what that mixture is yet. We don't know what the absolute answer is. You're correct.

But in the broader sense, does that mean that we can't use the tool or is it that the tool is too immature yet for risk-informed regulation? I would advocate that that is not the case, that the tool has matured substantially, that it is ready for some prime time action. It is ready to start looking at risk-informed regulation, it is ready to support 805.

I think the difficulty you are going to get into is when you start trying to shave it a little too thin. There are going to be areas where you just can't go that thin; circuits, for example. We can get a good estimate of what the important circuits are, what their important failure modes are, and an estimate of what their risk contribution is.

How thin can we slice it? Well, not that thin quite yet. You know, HRA, when we start getting into some of the HRA issues, we just can't cut it too darn thin.

But, again, I don't think you want to take from that the impression that the tools aren't ready for prime time. I think they are ready for us to start using.

CHAIRMAN ROSEN: A little bit in a way, we are caught in a Catch-22 here. If the tools are not ready for prime time, then people won't adopt them and they won't be improved. If they are ready for prime time, then there may be some early adopters who will use them and find out ways to improve them.

And that is some of what our experience is in internal events as well.

MR. NAJAFI: That's exactly what I was going to add. I mean, probably considering where we are now because we have gone through one iteration of this process, methods were developed, were used by the entire industry over a five to ten-year period, and we were going through phase II maturation.

So in my opinion, this is the time for us, even if the need or to go to Phase III, there has got to be a widespread experience base again. I mean, you can't do that in a vacuum and like Catch-22, you say. Until people start using this -- I don't mean one plant, two plants, I mean people start using it because you can't really do effective -- because, as Dr. Wallis said, really, we may have some ideas about the insights or the CDF or the results. But another thing that we may not know until that experience is gained is that once this is used is the uncertainty bounds are going to be large enough to make decision-making impractical.

We need to learn that. We need to learn what is driving that uncertainty bound so that we focus the research and effort on that area and not on the wrong area.

I mean, yes, it is Catch-22, but I want us to recognize that this is Phase II, this is not Phase I. We have gone through an industry-wide learning processes over a decade. And this is the second phase. This is our lessons learned number two.

So now we're ready to go into application. I mean, Level I did not get fully matured until the risks became involved, Appendix J came in, all of these application methodologies fed back into the core technology and made it even more mature.

We need to move into that phase and start getting those lessons learned feeding back into where do we make the improvements.

MR. KOLACZKOWSKI: I won't say anything about quantification. It's a turn-the-crank task. It's just basically run the model and get the results. So there's nothing new here. We know how to do that, internal events PRA. It's not surprising we didn't get many comments, public comments, on that particular task.

Uncertainty and sensitivity. It addresses, this particular task addresses, both modeling and data uncertainties. It attempts to provide a comprehensive list of uncertainty sources. However, it does not specifically address these are the uncertainties, these are the bounds you should use, et cetera and so forth. In fact, there are many uncertainties, which, in fact, we're not going to rigorously quantify at all. We try to recognize that and list what some of those are in the procedure.

You heard examples of the fact that, you know, we're going to use a 98 percentile HRR point on the curve. We're not going to attempt to really put an uncertainty bound on the HRR number.

We're going to say we have used the 98 percentile period. It now becomes a deterministic number as if it were known with certainty in the quantification. And so we have to recognize and at least acknowledge we use the 98 percentile, but we're not really putting a bounds on that HRR number and somehow propagating it through a Monte Carlo-type calculation or a Latin hyper tube calculation.

CHAIRMAN ROSEN: In the sense that this is a document used by the licensees and the staff to make decisions, it turns out to be a road map, which is fine. It shows you how to go from A to B. But it doesn't tell you what the speed limit is.

MR. KOLACZKOWSKI: But, see, we have the same issues in internal events still. I mean, we will worry about the fact that a suppression pool is heating up in a certain scenario. And the PRA analyst has to decide, is the temperature so hot that I am going to lose the MPSH or I am going to fail the bearings on the pump and the pump is going to fail?

At some point, the analyst makes the call it is going to fail at this temperature or higher and at this temperature below, it's not. And the analyst may or may not really try to develop an uncertainty about that model.

Now, I may do a sensitivity analysis, which we also address in our procedure, where we will say something like, "Well, what if you would assume that the pump had failed at a lower temperature or at a higher temperature? Would it drastically increase or decrease the CDF?" And we talk about those kind of sensitivity analyses.

MEMBER WALLIS: There are uncertainties in the temperature itself.

MR. KOLACZKOWSKI: Agreed, agreed. That's all I'm saying --

MEMBER WALLIS: In the thermal hydraulics and not --

MEMBER POWERS: Our philosophy you term the parametric. An uncertain parametric quantity into a model uncertainty I find just stunning. Why would anybody want to do that?

You have your 98 percentile. That's a parent parameter. You could have put an uncertainty boundary on that. Instead, you turned it into an intractable model uncertainty. I just don't think I would do that.

MR. NOWLEN: Well, I'm not sure because -- well, let me take a shot at it. You know, the 98 percentile value that he is referring to is used in one step of screening. And you have to pick a conservative heat release rate in order to screen individual ignition sources in or out of the analysis. A recommendation was to pick 98.

MEMBER WALLIS: What do you mean by 98? Do you test several hundred waste processes and find out that there is only a certain number that are above 300 kilowatts or something? Is that what you do, how you get a 98?

MR. NOWLEN: In a sense, yes. We have drawn heat release rate distributions for the peak heat release rate from a given fire ignition source like a transient trash can.

MEMBER WALLIS: And you find ways to get the 98th percentile?

MR. NOWLEN: Right. We give them the 98th percentile based on our curve. We say, "Here is the distribution. And this is the 98th percentile value." Our recommendation was that before you throw away a trash can fire as a potential contributor in this room, consider that 98th percentile value and whether or not it's sufficiently large to create a problem.

MEMBER WALLIS: Isn't that a long way from the mean wastebasket, which might be --

MR. NOWLEN: Much more slower, yes. Much slower or usually an order of magnitude difference.

MEMBER WALLIS: Which is what the PRA guy used.

MR. NOWLEN: Well, again, for screening, for the purpose of deciding whether you're going to "Yes. Well, we are going to screen this trash can. Do I need to retain a scenario involving a trash can for this room?"

MEMBER WALLIS: Does that mean in the PRA, you go back to the mean value?

MR. NOWLEN: No. When you go back to the PRA, you deal with the distribution. You say, "Okay" --

MEMBER WALLIS: Oh, you deal with the distribution?

MR. NOWLEN: Yes. You look at the whole --

MEMBER WALLIS: The distribution through the --

MR. NOWLEN: But there are different ways of dealing with it because, again, you have to find out "Okay. I know now that the 98th percentile fire is big enough." Well, then you step down, and you have to find, "Well, how small does it get before it is no longer of concern?"

MEMBER WALLIS: It depends on the severity factor.

MR. NOWLEN: Precisely. That is where the severity factor comes in. And then what you have to do is you have to deal with the fires between. Basically once you have found your minimum fire, you have to deal with all the fires that are larger than the minimum.

And there are different ways of doing that. I mean, if you want to go through a full-blown statistical propagate the distribution through --

MEMBER WALLIS: I'm not sure I'd like --

MR. NOWLEN: No. Well, our recommendation is that you simply discretize the distribution above your minimum. And you do three or four different fires depending on how many --

MEMBER WALLIS: It's a huge amount of work.

MR. NOWLEN: It can be. It can be. But, again, by this time, you're way down into task 11. You've eliminated all of your non-threatening fire scenarios. You're dealing only with those things that are the dominant contributors to fire risk.

CHAIRMAN ROSEN: How many is that?

MR. NOWLEN: And it's worth the effort.

CHAIRMAN ROSEN: Is that a dozen scenarios in the plan or 50 scenarios or 1,000?

MR. NOWLEN: Probably not even a dozen. I mean, it's --

MR. NAJAFI: And remember that on top of that, if you start to deal with distributions and deeds, now you have the other piece of the model that it has spatial affected. So the complexity of that and complexity of the distribution on a fire size can make the model almost unquantifiable very quickly because you have all of these permutations because some of these permutations because of the fire effect you could have, all of a sudden, 50 components fighting at the same time.

So there's a combination of sequences or cut sets, let's say, that can be created. And now you're adding another layer of I want to do Monte Carlo on the distribution of the fire size. The problem becomes intractable very quickly.

That's why we chose this discretized method to say that we find the lowest fire that could be of concern to propagation or damage. And then we model basically, account for the area under the curve for that fire enlarger and we don't consider or worry about the area under the curve for that fire and smaller. We're not going to do anything. And then that's how it makes it manageable, as opposed to just throwing the distribution into our equation and saying, "Deal with the distribution."

MR. NOWLEN: So going back to the point we started from, the idea of the 98th percentile, what we're talking about is that we are, in fact, screening away certain fire sources as non-threatening. Okay? But once we have kept the source, then we do deal with the uncertainty associated with that fire. And it becomes a part of the quantification.

So, again, I think the analog to certain things that are done in internal events you have to make decisions as to what you are going to retain and what you are going to throw away. And sometimes they face similar challenges that you've got to pick a number, you've got to pick a temperature at which this pump is going to fail and go with it and decide whether you're going to include it or not. I mean, there is an analog here.

MR. KOLACZKOWSKI: So I guess what I am trying to say is that while there are uncertainties that we suggest that we actually put distributions on and propagate through the analysis, there are yet other uncertainties, a lot of them being modeling type.

When we finally just decide on a model,

hopefully it's somewhat conservative but hopefully not overly conservative to address the uncertainty in the modeling issue. But then we basically say that is the model we're going with, and then we move on. That's no different than what we do in internal events PRA as well.

Again, the major public comments here were just each task used to have a section on uncertainty in each procedure. Instead, based on public comments, in part, we decided to assemble all of that and put it under the uncertainty task. So now it reads together in one section, rather than having to go through each and every task to kind of collectively add up where all of the uncertainty sources are. So now it's all under task 15.

I also want to mention we do address technical quality issues in this particular chapter, although they are separated. We talk about uncertainties, but then we also talk about technical quality issues, like ensuring completeness and accuracy and peer review a little bit. And that kind of thing is also addressed in there.

That's probably about it as far as uncertainty goes.

MEMBER WALLIS: It looked as if all of the peer reviewers were from industry. Was that the case?

MR. NAJAFI: That is correct.

MEMBER WALLIS: Did you have anybody from academia or from outside sort of whoever the fire research people are, the insurance companies, and so on?

MR. NOWLEN: No, no, not really. We assembled it from primarily the group of participating utilities with EPRI those who had funded the projects through EPRI. Basically we gave them a seat at the table, and they -- well, what role do we get to play? And we settled on the peer review role. We said, "Well, we'll form a peer review team from you."

There were a couple of exceptions in some key areas. We did solicit some additional peer review from specific consultant types. In the electrical area, that was true, in the HRA area and as well in some of the statistical.

For example, Ali Mohsleh gave us a lot of advice and review of some of our statistical methods associated with fire frequency and things of that nature.

So there were specific cases where we solicited additional input.

MR. NAJAFI: He did review our uncertainty stuff, Ali Mohsleh.

MR. KOLACZKOWSKI: Yes, Ali Mohsleh did. Yes, that's true. He provided us comment on that.

MR. NOWLEN: And we drew in Dennis Bley on some of the HRA work. We had Kiang Zee and Andy Ratchfort on some of the circuit works. They're both well-known consultants in the field. So selectively we pulled in additional capability.

CHAIRMAN ROSEN: All right. Well, I think we are at the stage now where we are going to ask you to wrap up as quickly as you can, J. S.

DR. HYSLOP: Okay. I'll do that.

IX. CONCLUDING PRESENTATION/REMARKS

DR. HYSLOP: One more handout, but it's only two pages. Okay. I'm going to go over some insights quickly. These are insights based on the authors' judgments. As I say, we didn't get integrated risk insights to these projects. So, again, this is somewhat subject to judgment.

Basically, the overall range of CDF, as Bijan has said, was around 10^{-7}, 10^{-4} for IPEEEs. We expect that overall range to be maintained. We don't expect these procedures to adjust that overall range. Basically you're going to have a playoff.

Some particular method issues are going to increase the CDF, and some are going to decrease it. So we expect the range to be fairly --

CHAIRMAN ROSEN: We're not allowed to bore in on this because this is just your judgment.

DR. HYSLOP: That's all it is, yes.

CHAIRMAN ROSEN: It's intuition.

DR. HYSLOP: Yes.

CHAIRMAN ROSEN: Of course, you recognize that a plant that is already borderline from a fire perspective, if they do this and determine that they have additional vulnerabilities could go over the end.

DR. HYSLOP: Could go over. My argument is based on there is going to be some to make it bigger and some to make it smaller. But, of course, it's our judgment. And there could be some changes, sure.

MR. NAJAFI: Yes, but there is a second bullet that doesn't specifically say that plant-specific information could change, could change. Actually, it is likely to change because we have made changes more in the specific technical areas. If that affects a specific plant more; for example, those that they have not as good a plant separation of electrical cable, they could potentially see a higher number. Those that they have better separation, they may see better numbers than they did with the previous method.

The conclusion that J. S. is saying, industry-wide conclusion, we don't see, all of a sudden, everybody going to 10^{-3}. I hope not. We don't see, all of a sudden, everybody going to 10^{-8}. We generally think that the pattern of the industry experience would be maintained, but specific plants may see significant changes.

MEMBER WALLIS: I thought we're often told when we see a big fire risk that, well, it's big. But it's conservative, very conservative. So if you're reducing conservatism by being more realistic, you would expect CDFs to go down in general.

MR. NOWLEN: Yes. That's the balancing --

MEMBER WALLIS: Are you saying you expect them to stay about the same?

MR. NOWLEN: Again, that's the balancing act. In some areas, the IPEEEs were very conservative. In other areas, they basically didn't treat a phenomenon like spurious operations.

MEMBER WALLIS: So we should not think of these CDF values we're given as being conservative? We think of them as being realistic?

MR. NOWLEN: Not necessarily. I mean, again, there is also an element of what approach did the plant take for their IPEEE? Did they just do the minimum to meet the need and they weren't too concerned about a conservative answer or did they really fine-tune it and try and get as good an answer as -- so there is a lot of variability there, too.

Again, we have reduced conservatism. So yes, that's going to bring the CDFs down in some cases. But we were also addressing things that were addressed before. So that could counterbalance it.

MEMBER DENNING: With regards to Graham's comment, I think that the answer is that we don't consider them -- you know, we have heard this, that they are conservative, but, really, what we should be understanding is that the uncertainties are very large.

MEMBER WALLIS: Yes.

MR. NOWLEN: Yes. That's true as well. The uncertainties in the IPEEEs are very large.

CHAIRMAN ROSEN: And I think we should also have in the back of our mind that all of the factors may occur at one plant in a negative way, and we could get a surprise at plant or plants.

MR. NOWLEN: This is very plant-specific.

MEMBER WALLIS: CDFs are already high. And if they are off by a factor of ten, they might be really scary.

CHAIRMAN ROSEN: That's the worry.

MR. NOWLEN: Well, you have to have the confluence of someone who thought they were conservative and really weren't. And then they got all of this other stuff. You know, again, our judgment is that industry-wide, we really just don't see that happening. I don't think we are turning people in to 10^{-3} plants.

CHAIRMAN ROSEN: When you add multiple spurious actuations and high-energy arcing faults in the control room to a plant that is on the borderline already of our tolerance of risk, then --

MR. NOWLEN: But are they on the borderline because they were conservative the first time around? That's the key question. If they came in with a very high risk number and it's all based, for example, on Phase I FIVE screening, I can guarantee you it's a conservative result. I mean, it depends a lot on how deeply they dug to get that conservative number.

Now, if they went and sharpened a pencil and still came out a 10^{-4} plant, then yes, but I don't think that is what happened in IPEEEs. And ones you came in with the higher numbers were ones you stick pretty closely to five, which tended to be fairly conservative. The ones who came in with the lower numbers are the ones who sharpened their pencil.

DR. HYSLOP: And my next bullet about the multiple spurious high-energy arcing faults, of course, that could increase for some plants, but the main control board model may decrease the control room risk for some particular configurations also. That is, those main control boards relate to visions where the assumption was, well, the just damages it all. So there could be some balance there.

All in all, we feel that a continued use of this methodology is needed to validate our insights, provide us more feedback. As has been stated before, cable tracing to support fire PRA is still a major resource requirement.

There is the iterative screening nature of fire PRA, where we look at fire models and fire damage in both scoping and detailed models. And, you know, you would hope someone doing circuit analysis would certainly take benefit of that, eliminate the number of important components. But, all in all, it's still a pretty important task, time-consuming.

So my final slide, we feel this is the best available method to estimate fire risk and obtain insights. As Steve said, we feel it's ready for prime time. That doesn't mean that things won't continue to evolve. As we get insights, as we get reports back from further uses, we will certainly incorporate those, certainly think about them anyhow.

We feel that there are improvements which will benefit the state-of-the-art. There has been a lot of discussion about spurious actuations. And we have said that there is a testing program associated with the BEN II and the risk that research is going to address. That is certainly a prime time to gather some data to validate this computational model that Dan has talked about, the model that goes further than the testing did. It looks at multiple cable conductors, not just the ones in the test. So we could benefit there.

Post-fire HRA. As I have said, we developed a screening approach and not a detailed approach. And we have had some discussions on how we might benefit there.

Low-power shutdown operations, that's an area that was one in the future for us. Certainly there are some differences between a low-power shutdown analysis and a full-power analysis that we would have to look at.

Lastly, there has been some talk about the fire brigade and the notion that we're using duration curves. And those duration curves only allow for some plant specificity prior to arrival of the brigade. We feel that a plant-specific assessment of fire-fighting that would take into account the individual aspects of a fire brigade on a plant-specific basis would be beneficial.

So those are the improvements that we feel would benefit the state-of-the-art. We certainly don't feel like we need to do these to move forward, certainly not all of them. You know, so anyhow I just wanted to leave you with that.

CHAIRMAN ROSEN: With respect to that third one, low-power shutdown operations, --

DR. HYSLOP: Yes?

CHAIRMAN ROSEN: -- it would seem to me you need a new fire initiation database or another cut at that database --

DR. HYSLOP: Sure.

CHAIRMAN ROSEN: -- because there are going to be a lot more initiators. And the frequency will be different, won't they?

DR. HYSLOP: Yes. Definitely you might have more activity. So you might have more transient fires, for example. So that would be a new fire frequency look would certainly be appropriate.

MR. NOWLEN: Yes. We've actually taken a look at the database. Our judgment is that it's a new slice at the same data, basically. In a lot of cases, we will take out the low-power shutdown events as non-plausible for power operations.

In a sense, we have to turn that around and do just the opposite, say, "Well, what of these events are not relevant to the shutdown condition? And how will we deal with features like a lot of electrical equipment gets deenergized?" So it can't be a source. It's got no electrical energy. So there's definitely a different kind of the same set of data that's going to be --

CHAIRMAN ROSEN: On the other hand, you have a need to maintain decay heat, decay cooling.

MR. NOWLEN: Yes. Different systems come online.

CHAIRMAN ROSEN: Different systems. Some systems don't need it at all, like safety injection.

MR. NOWLEN: Exactly.

CHAIRMAN ROSEN: But you have got to be very, very careful about decay heat systems.

MR. NOWLEN: Absolutely.

CHAIRMAN ROSEN: And, in particular, in PWRs, in some of those operating modes, where they have very little margin, like at mid loop or at other reduced inventory conditions, having a fire at that time could be very significant.

MR. NOWLEN: Absolutely. The other one is we talked a lot about transients. You know, the transients go through the roof during outages. You're bringing in all kinds of equipment, storage materials, crates of new equipment. Things get staged all over the plant.

CHAIRMAN ROSEN: Your controls may not be as good because the staff is markedly changed and a lot of new people on the site in the building.

MR. NOWLEN: We take systems out for service. We take fire protection systems out for service. I mean, there is a number of issues that are going to be specific to the safe shutdown.

Our general conclusion is the framework of the PRA will work for the shutdown condition, but there is a number of quite different considerations and inputs that need to be developed.

CHAIRMAN ROSEN: I would think that, from my point of view, that would be one of the first things I would look at on that list because in the level of risk, even without a fire of substantial uncertain operations.

MR. NAJAFI: In 2003, we jointly took up a feasibility study for low-power shutdown to basically assess, size up the problem, to see what we need to do. And we completed that December of 2003, that feasibility study, jointly, that basically in that study, we determined what are the kinds of approaches that are available? How do we need to go about doing this? What are the issues? What is the unknown?

The only thing I would like to point out is that it is important that there are considerable variations and methodologies in low-power shutdown for internal events. And what we come up with, it should build upon those methods that vary from a qualitative to a fully quantitative method.

So that's another consideration we have to take into account. I mean, would our method work with a qualitative as well as a quantitative method or not? So that's another concern.

CHAIRMAN ROSEN: Okay. Are there any other comments?

MEMBER DENNING: Just a couple of comments. First of all, I think we ought to say that this part of the presentation, how well it has been done, how well it is coordinated, we are very impressed by the presentations that were made and how well you all worked together in doing that. So I thought it was an excellent presentation.

And I thought also just the amount of cooperation between EPRI and NRC is clearly something we want to encourage. I think this is a great example of that. And I don't know what we can do that encourages EPRI to continue to.

I think that it's not over yet. I mean, I think there is more value beginning here and that we would like to cooperate, not only NRC but EPRI, to continue on this work.

CHAIRMAN ROSEN: Well, Rich, we have been asked to write a letter endorsing this NUREG. And I think in the letter, we can address some of those points.

MEMBER DENNING: I think we should.

CHAIRMAN ROSEN: Let me ask my other colleagues or if you're not, let you continue --

MEMBER DENNING: I'm done.

CHAIRMAN ROSEN: -- if they have any overall comments to help me with drafting a letter.

MEMBER SIEBER: Well, I agree with Rich,

and I think the presentations were good. I think there has been a lot of progress. And as far as I'm concerned, it's essential that there be some progress to lend some validity to the overall PRA structure for plants.

As I see it, fire risk is about a third of the total risk of the plant. And shutdown risk is in there also. And that's another area that needs to be worked on.

So, as far as I am concerned, I think that we are making progress in risk-informed regulation when we do work like this. And, particularly, I agree with Rich that cooperation amongst the agency and contractors, EPRI, and utilities is an important and perhaps the only way to come up with a realistic approach to things.

You know, the operating companies have the data. They have the experience. There are other talents other places, like in the agency and the contractors that the agency uses. And no single entity can do this job by itself. And so if you don't follow through on this kind of an approach, you won't be successful in my opinion.

So, again, I give my congratulations toward this effort. I think you have made a lot of progress. I think it's been a pretty efficient progress but a long time coming. You know, we have been dealing with this for many years.

When I look in the mirror and look at my white hair, I'm hopeful to see the end of it to where you can say I now have a product, but I may not live that long.

So you are all younger than I am, but keep in mind that there are some of us who are older who are anxiously awaiting a final result. And so I hope this foretells a good final result. So I offer my congratulations for the effort that has been put forth, and I think it is a good effort that uses good expertise and good judgment all the way along the line.

So I don't know if that helps you with your letter, but that is the kind of letter I would write.

CHAIRMAN ROSEN: It certainly helps. Thank you.

Bill?

MEMBER SHACK: Well, I was only around for about a fifth of the presentations, but the presentations I saw were very impressive. I'm really looking forward to some of the first products. I want to see a PRA done with an uncertainty analysis and begin to look at some of the insights from that and some of the uncertainties associated with that.

It seems to me very exciting, but you're just starting to really get to this. And it will be very interesting to see the progress.

CHAIRMAN ROSEN: Okay. Wallis?

MEMBER WALLIS: Well, I missed a fair amount. You have a framework here which looks good. And I think you did a good job presenting it. I think I've already said that I'm amazed at all of the stuff you're trying to model.

If you really model what the combustibles are and how different things they might be and, you know, what the probability of finding them at various times is when they are changing oil and whether the stuff ignites and whether it gets suppressed and how the fire grows and how severe it is and whether or not it damages cables and when it does it and whether the fire brigade responds in the right time and with the right methods and all of that.

This is a most enormous task. And although you've got this impressive framework, I am going to have to see it. I am going to have to see it work with a lot of plants which are different. And there are a lot of plant-specific things.

It seems to me to be much more difficult than thermal hydraulic analysis. And we had decades to try to work that out with all kinds of huge experiments and so on. So if you can do it, it's going to be very impressive.

The framework for doing it, an intellectual framework, it's boxes and how it's all tied together and the cooperation and all of that. It's good. I still don't know if you can really do it.

CHAIRMAN ROSEN: Okay.

MEMBER SIEBER: I might make one other comment. You know, when we were talking about changing oil and something and working in the plant, particularly during an outage, the impression that I got from the discussion was that it was sort of a helter-skelter kind of thing.

In plants that I worked in, the operating companies are much more careful about fire and fire protection. You know how much combustible material you are taking in. You don't take any in that you're going to bring back out.

In other words, you keep the combustible loading down. You used approved containers to carry oils in it. You used approved containers to carry oily rags. You don't leave them there. You know, you get them out of that fire area.

And there are people who watch that, whose job it is to make sure that you aren't changing the combustible loading in the plant, that you're introducing new ignitions forces or if you are, there's a burn permit or something like that, grinding permit so that if there's a fire watch, you can do something about it.

I wouldn't want casual readers of the transcript or casual listeners to come away with the impression that it's like changing the oil in your car in your garage. It is not like that. That's not the way the operating companies operate.

MR. NOWLEN: I'll even offer that if we left that impression, it was certainly unintentional. What we're dealing with with the transience is that, despite all of our controls, occasionally things do go wrong. We do occasionally get something left somewhere it shouldn't have been. That's what we have to deal with.

My experience has been very parallel to you. I have seen plants, and they're sparkling clean, well-thought-out. It was not our intent to give that impression. But the data shows things do occasionally go wrong, and that's what we're trying to deal with.

MEMBER SIEBER: Twenty or 30 years ago, you would find things like that. And 20 or 30 years ago, you would go into almost any area and be able to point out discrepancies in the plant, places where people were careless, but the industry has improved a lot since those days I think.

MR. NOWLEN: Absolutely.

MEMBER SIEBER: And I haven't been in every plant, but I have been in a lot of them. And I think in general fire protection and safety culture have improved tremendously over the years to a point today where they are really pretty good.

CHAIRMAN ROSEN: Well, I'm glad for that clarification. I may have contributed to some of that. If I did so, it was unintentional. I do think, though, that there are more shots on goal. There are more chances to have a fire protection problem, even though the current practice I think is, if not uniform, to a broad extent very good.

MEMBER SIEBER: Yes.

CHAIRMAN ROSEN: But we still have to be concerned that there are more transient combustibles in the plant and more people, be it as it may, that they are better controlled than they used to be.

Well, I have the same set of senses that my colleagues have. I think it's an excellent piece of work. I think it's a long time coming, but we're glad to see it in its current form. It's something you can hand to somebody or a group of people and say, "Let's give this a try. Here are some resources. Let's group up and go for it in our plant." So that's a good thing.

I do have a concern, though. I expressed it earlier about these documents being a good road map for getting from A to B, maybe to A to C through B, but there are no speed limits. You can't go something like you can only go 70 miles an hour between A and B, but between B and C, you can go 80 miles an hour, something like that.

So in the process between the regulator and the applicant or the person who uses these documents, they're going to have to work how good is good enough out at each and every step. And that's a little worrisome, troublesome. I think it is probably in the development.

At some point this will be I presume endorsed by a reg guide or something like that. And maybe we can see more of a "Don't do this, but if you get to this point, that's too much" from the staff.

MR. NOWLEN: Well, there's also an element of that that was part of the ground rules of a cooperative EPRI-NRC effort; that is, that there was a certain place we weren't allowed to go, you know, deciding, for example, what is good enough to meet a particular regulatory requirement.

NRC and EPRI cannot sit together and make that decision in this sort of a process. It's just off bounds. So that may be some of your comment that there were areas where because of the nature of the MOU and the limits that are put on what sort of work can be done, you know, I think it was asked earlier, "Are you allowed to analyze data versus collect?" Well, we ran into similar issues.

So perhaps some of the speed limits are things that need to be decided in a different context, a regulatory context --

CHAIRMAN ROSEN: Well, I think that's right.

MR. NOWLEN: -- that wasn't our context.

CHAIRMAN ROSEN: So maybe my comment should be taken by the staff if they think it's correct that at some point that's the next piece of this. One of the --

MR. LANE: I'll make a comment on this.

CHAIRMAN ROSEN: Please introduce yourself for the record.

MR. LANE: This is Paul Lane at NRR Plant Systems Branch.

We are developing the reg guide to go along with 805, and we will be briefing the Subcommittee in the May 17th meeting. We are looking at this effort. We have put some words into our reg guide to discuss that. You guys will be able to review that.

Also, we have had a chance to comment on it. We are looking at the limitations. And then we were going to have to really study on how to actually put it into the reg guide on how to use it, look at the limitations and do that, but we are moving forward to keep on track. And it will end up being in probably the next revision of the reg guide.

So we have initial words now on -- it's not a full endorsement now. It's just that this is items that are coming. And this is sort of our expectation on the use at this time now.

CHAIRMAN ROSEN: Okay. I won't miss that Subcommittee.

MR. LANE: Okay.

CHAIRMAN ROSEN: All right. I think we're ready to go on. Thank you all, gentlemen. We're all ready to go on and talk about verification and validation of models. This is Mark Salley? Can you help us with that? Notice we're only 25 minutes behind. Quite remarkable.

VERIFICATION AND VALIDATION OF SELECTED FIRE MODELS FOR NUCLEAR POWER PLANT APPLICATIONS

I. INTRODUCTORY REMARKS

MR. SALLEY: I guess we had a double feature for you today, and you have been through the first one. We'll get into the second one. Again I have Gary with me from EPRI. And I'd like to start off with Gary.

MR. VINE: Well, I think you had a good session this morning. I really appreciate the comments that Dr. Denning made about our process and Steve's willingness to consider some input from your members on commenting on our cooperation between EPRI and RES. I think that is very important for you to address if you are willing to do that because there are, of course, new members of the Commission, new senior leadership in NRC who may not be familiar with the way we work together.

I think it's obvious from the discussion here, especially the last discussion, the last 15 minutes, that both RES and EPRI take very seriously this boundary condition that we avoid getting into regulatory discussions.

We know that our ability to continue to cooperate depends on us taking very seriously when we should part company and what we can do and we can't do together.

And so we do take that seriously. We hope you respect that we do it that way and would continue to support our efforts in this and other areas under those conditions.

MR. SALLEY: Dana hit me with 47 questions this morning in the first 5 minutes. I would kind of like to pick up on one of them here that fits in appropriately. His question was, do we reach to the outside fire protection community to see how we are doing things and what it looks like?

In the second topic, which is going to be the fire modeling V&V, which I came over to Research in September, that was the first thing I did was I talked to the folks I missed, Kevin McGraten, Anthony Hammonds, and I said, you know, "Who has done one of these V&Vs before? And can I take a look at it so I can have an idea what the NRC's product looks like?"

So we tried that reach-out to them. And what we found out was no one had done one yet. The only thing that we could find was a Society of Fire Protection Engineers had done one on a simple DETACT code, which is basically when heat detectors or sprinkler heads go off, a very simple small code.

That puts us in a unique position here in that our V&V, probably one of the first ones that will be formally done, and other people will be looking at it, rather than we had one of another industry, the hospital industry, who is doing the risk-informed, performance-based, or the people who build skyscrapers or shopping malls or petrochemical, we didn't have any of that. So we are reaching out.

And just one other point on reaching out, when Naime and I had done NUREG 1805, which you all should have gotten, it's amazing, Naime and I were both amazed that the people who were looking at our work, some of the comments that we were receiving were from the U.K., South Africa, Korea, the Netherlands.

It was amazing the people who go into our Web page, the NRC. Those are the ones we got comments from. So who else looked at it I don't know, but it was interesting to be seeing people from South Africa looking at our fire dynamics methods and sending us comments.

The second project, like I said, is something new. It's the V&V for fire modeling. A follow-up for one of the questions I talked to in NIST, NIST says, "Well, how are the people who are doing this transition to a risk-informed, performance-based fire protection in other industries, how are they doing this V&V for their fire model? What are they doing?"

The simple answer I got back was, "Well, what the fire model gives you is what they take and what they go with. And that's as far as the V&V. Other than the little bit that the developer will do, that seems to suffice the general fire protection community as far as the fire marshal types and that. So that rigor isn't there yet. So we're trying to put the rigor to it.

Again, it's a very technically challenging --

MEMBER WALLIS: Any model's okay without verification at all?

MR. SALLEY: Excuse me?

MEMBER WALLIS: Any model's okay without verification?

MR. SALLEY: The verification that they

use is what the developer puts to it. And basically that is how it is being used commercially today for fire models. That was the response that I got outside of nuclear. So that was the answer that I got.

Like I said, to be truthful, I wanted a cookbook. I wanted to see how somebody else did it so that we didn't have to invent the process, that we could look at it and do what they did well and maybe do a few things different. We couldn't find that.

Again, this project is very technically challenging. It's a good partnership on a technical project like this that we are again working with EPRI. We're pooling our resources. We're trying to be efficient on this.

This project is still in process. It should be ready for draft release, hopefully this month. We're doing the final pieces on it to get out for draft where it will be out for a 60-day public comment period. Again, we're going to come to you later.

So the purpose of today's presentation is to give you an introduction to it. It's a big project. If you thought the requal. was thick, you ain't seen nothing yet. It's a big project. And we wanted to give you an introduction to show you how it's setting up and what it's looking like so when you do get it, you will have a feel for it.

Again, the best thing I think to do here is we'll introduce the folks who are going to present it, a couple of new faces for you. We have Kendra Hill and Jason Dreisbach from the Office of Regulatory Research. We also have Francisco Joglar from SAIC EPRI.

With that, I will turn it over to them to start.

MEMBER POWERS: You mentioned international interests. I noticed that you also --

MR. SALLEY: Yes.

MEMBER POWERS: -- had international database that you used. You got stuff from the French and the Germans and so on.

MR. SALLEY: Yes.

MEMBER POWERS: Right?

MR. SALLEY: Yes, we did.

MEMBER POWERS: And your report is very well-edited except that when it comes to French, you misspell things. I would suggest that you have someone who checks the French and doesn't put like (foreign phrase) and spells the French names properly and so on because it's part of showing that you appreciate and understand them and don't garble their names and so on.

MR. SALLEY: Yes. Sorry.

CHAIRMAN ROSEN: Well, I figured out who Kendra was, but I didn't quite figure out who --

II. PRESENTATION

MR. DREISBACH: I'm Jason Dreisbach.

CHAIRMAN ROSEN: Jason. Okay.

MR. JOGLAR: Francisco Joglar, SAIC.

MS. HILL: My name is Kendra Hill, as he said. I'm from the Office of Research. And I will just share a very brief background on why a need for this model verification and validation was identified. And I will also share an introduction to what the project entails.

There has been a significant increase in the use of fire models and other fire phenomenon estimation tools in the nuclear industry and other industries as well.

The use of these types of tools in the nuclear industry has become especially important in the risk-informed, performance-based environment that has been evolving in recent years. And with the increased use of these tools in the nuclear industry came a need for these tools to be verified and validated for their performance in applications specific to nuclear power plant needs.

Verifying and validating these models also helps us to gain a quantitative understanding of the predictive capability of the models in typical nuclear power plant scenarios, which is important in a number of regulatory applications.

For example, in the significance determination process, there may be the use of -- it may involve the use of deterministic models in phases II and III. The deviation and exemptional question licensees may also use deterministic models.

MEMBER WALLIS: What do you mean by "verified and validated"?

MS. HILL: I think "verified and validated" in the sense that we use it in this project means that we have taken them through the process that we will describe later on in the presentation.

MEMBER WALLIS: Well, what I saw in your report was that you compared the methods with some data.

MS. HILL: Right.

MEMBER WALLIS: And sometimes there were errors of 1,000 percent and so on.

MS. HILL: That's correct.

MEMBER WALLIS: So you're not really verifying and validating. You're doing research. You're saying, "How do these models compare with certain kinds of data that we have?" That's quite different from saying that there's a criterion for validating.

It makes it valid now for use for certain purposes. It's quite different from just looking at how well it does with some rather sort of stylized sort of fire situations and not in the lab. Then is 1,000 percent acceptable for verification, 1,000 percent error?

MR. JOGLAR: Well, part of the verification and validation is it was for us to check that these computer programs were doing whatever was stated in their documentation that they would do.

MEMBER WALLIS: It actually spit out numbers and said, "This is the temperature." Do you mean that they actually will end up saying, "Here is the temperature" and we will end up with an output?

MR. JOGLAR: That's part of it. I mean, checking whatever is documented and whatever mathematics are in that model, it --

MEMBER WALLIS: You actually check the math as well?

MR. JOGLAR: The standard that was selected to do these V&V calls for that. So it's part of the project. At some point we start having these numbers that you're referring --

MEMBER WALLIS: Validation sometimes means that you simply check that the code does what the math says it should do. It says nothing about how well it does it.

MR. JOGLAR: That's part of it. That's part of it.

MEMBER DENNING: Let's get back to the definitions of verification and validation.

MEMBER WALLIS: Right.

MEMBER DENNING: And I guess let's hear what --

MEMBER WALLIS: Yes. Let's hear what --

MEMBER DENNING: -- you guys want to say, but my view is what Graham said.

MEMBER WALLIS: No, I don't think it has anything to do with --

MEMBER DENNING: No. I mean, exactly what is verification and what is validation?

MR. SALLEY: I think if we wait a little bit in the presentation and hold that to the end if we don't suffice you --

MEMBER WALLIS: You will tell us?

MR. SALLEY: Yes, we will.

MEMBER WALLIS: Up front?

MR. SALLEY: Well, our setup is a little different, but yes, we will get to that. And there is a unique standard, an ASTM standard that we use for this process. And I think when they get through that, it should answer your question. If it doesn't, then we'll pick it back up if that's okay.

MEMBER DENNING: Well, let me just say that what I believe verification and validation mean and what the difference is, I think that verification is the process of checking to make sure that the equations that are supposed to be in there have been incorporated in the code correctly and that validation is comparison against either experiments or against a model that you have a great deal of confidence in. That's what I believe our standard definitions are.

MR. JOGLAR: And the framework we use for this process, which is an ASTM standard, is defined that way.

CHAIRMAN ROSEN: Okay. So we don't have to wait until the end. Very good.

MS. HILL: There was also a requirement in NSD 805 that fire models shall be verified and validated. So to meet the needs that were identified, the NRC and EPRI collaborated to develop this verification and validation study, which henceforth I will just refer to as the V&V.

We collaborated to develop this V&V study for five state-of-the-art fire modeling tools, as requested by NRR, with some inputs from industry as well.

MEMBER WALLIS: So let's go back to the criterion for EPRI verification is, then, no errors?

MS. HILL: No.

MEMBER WALLIS: Is it? No errors?

MR. JOGLAR: I'm sorry? I don't think I understood.

MEMBER WALLIS: Check for the criterion, verification is adequate is that there are no errors. The equations have been properly coded with no errors. Is that the criterion for adequate verification? And what is the criterion for adequate verification?

CHAIRMAN ROSEN: Well, start with the easy ones. Start with verification.

MR. JOGLAR: The verification, I think that is correct. We are talking --

MEMBER WALLIS: Like no typos in a report. Is that what it is?

MR. JOGLAR: Well, more in the programming of these equations than in the actual report of it. In the validation, I think that's -- you can correct me if I am wrong, but that is an area that in this MOU coverage, we just --

MEMBER WALLIS: It's much more subjective, is it?

MR. JOGLAR: I can't understand the question.

MR. NAJAFI: Could you repeat the question? I'm sorry. I apologize.

MEMBER WALLIS: Well, I just want to know what we are talking about. Validation, whether the thing is valid or not, is a subjective judgment. Is that what it is or are there criteria for validation?

MR. SALLEY: Well, I guess a slide that we kind of missed here putting this together was the ASTM 1355 standard, which we are going to talk about. It had a set criteria for things like how robust the model was, did it have --

MEMBER WALLIS: It did have some set criteria?

MR. SALLEY: It had a very specific criterion on how we walk through each of the models. And I wish we would have captured a slide in here. If anybody has a --

MEMBER WALLIS: That is what you are going to do when you actually validate these models?

MR. SALLEY: Yes. We set them through the standard as far as robustness, sensitivity, those types of --

MEMBER WALLIS: Okay. Thank you.

MS. HILL: We collaborated to develop this V&V study for five state-of-the-art fire modeling tools, as requested by NRR. The tools that were chosen for inclusion in the scope of the project include two first order spreadsheet tools, one of which is developed in-house. And the other was FIVE-Rev1, which was developed by EPRI.

We also included two zone modeling tools: CFAST, developed by NIST; and MAGIC, which is developed by France's EdF. As I said, if the V&V study follows the guidelines set out in the ASTM E1355, standard guide for evaluating the predictive capability of deterministic fire models and as the name indicates, this standard has guidelines that are specific to evaluating fire modeling tools.

And, just to give a quick summary on what the standard suggests, the standard calls for defining the model in scenarios for which the evaluation would be conducted, assessing the appropriateness of the theoretical basis and the assumptions used in the model, assessing the mathematical and the numerical robustness of the model, and validating the model by quantifying the model uncertainty and the accuracy of the model results.

Using this standard, the V&V report is written in seven volumes. Volume I contains a general overview of the project and a high-level summary of the project results. Volumes II through VI contain the V&V of each of the individual models that were included in the scope and the chapters in each of the volumes follow the guidelines from the standard. There's a chapter that addresses each one of the guidelines from the standard. Volume VII contains a detailed description of the experiments that were used for comparison to model results.

Currently the schedule calls for a draft for public comment to be released by the end of this month followed by a 60-day public comment period, as Mark mentioned in his introduction. And a final report is expected to be issued by December of this year.

Now I will turn it over to Jason Dreisbach, who will give some details about the approach that we took.

MR. DREISBACH: Okay. My --

MEMBER WALLIS: I'm sorry. These experiments, were they designed to model what happens in a nuclear power plant or were they designed more for other purposes, like, say, factory mutual or somebody to try to model fires in general?

MR. JOGLAR: The selected experiments, to the extent possible, were designed to model nuclear power plant fire scenarios to the extent possible.

MEMBER WALLIS: So the rooms and the amount of combustibles and everything look something like what is in a nuclear power plant?

MEMBER DENNING: If you go to the next viewgraph, I think that addresses it?

MEMBER WALLIS: It will be there? It will be there?

MR. DREISBACH: Yes, the next viewgraph. But before we get to there, I just want to get a more general idea of what is actually entailed in the V&V. Again, I'm Jason Dreisbach from the Office of Nuclear Regulatory Research.

As we mentioned before, we are comparing experimental data with model runs that we have done for all those five miles that we outlined previously.

When we compare the data, we examine specifically 13 different parameters that are listed here from hot gas layer temperature to a plume temperature, oxygen, and smoke concentrations down through the different heat fluxes.

MEMBER WALLIS: How about the source of energy, though, and if you have a trash can fire you talked about earlier? Then the source of energy is a somewhat whimsical thing, isn't it? How big the flame is and how fast the vapor or whatever it is burns is a very undefined, uncertain thing. Did you have to put that as an input into all of these models?

MR. DREISBACH: Absolutely.

MR. JOGLAR: It is an input. It is an input. And, therefore --

MEMBER WALLIS: How do you do the experiment, then? Did the experiment actually produce a 300-kilowatt fire?

MR. JOGLAR: It can be designed to do that, yes.

MR. DREISBACH: Yes.

MEMBER WALLIS: It's designed? But that is not the way the trash can is designed.

MR. JOGLAR: That is correct. That is correct. The experiments are designed for a heat restrike, which we use as an input.

MEMBER WALLIS: So to check that it actually happened?

MR. JOGLAR: Yes.

MR. DREISBACH: Yes.

MR. JOGLAR: It's also measured.

MEMBER WALLIS: Oh, it's also measured? Okay.

MR. DREISBACH: Yes, yes.

MEMBER WALLIS: So it's one of these --

MR. DREISBACH: In the experiment, it is measured. And we have data. And we compare it to make sure that one of the things we check also -- it's not one of the parameters that we use to compare because the models generally aren't designed to predict the energy release. It's an input, as I said before.

So it's not one of the ones that we compare as far as accuracy is concerned, but it is an input that we check when we run the model.

CHAIRMAN ROSEN: So if you've got a 290-kilowatt release rate, instead of a 300 from the experimental setup, you can adjust your results?

MR. DREISBACH: Exactly, exactly. That's a way to verify that our inputs are appropriate and reasonable once we do the model runs and we compare it to the experiments.

MR. JOGLAR: And, as illustrated in this list, although we don't compare heat release rates itself, we do consider factors that affect it, like the oxygen in the room.

MR. DREISBACH: Right. So not directing comparing the heat release rate is fine because the heat release rate is going to affect all of these other parameters in some way or another. Most of these other parameters are going to be affected.

So if we have heat release rate completely wrong, that is going to be potentially affected in our comparisons.

MEMBER WALLIS: There's never enough combustible that you worry about things like flashover, where suddenly there is a much bigger fire?

MR. DREISBACH: In the experiments that we are examining, most of them did not get to that point. There were maybe one or two, I think, but I'm not sure that we --

MR. JOGLAR: There was one that I don't think it experienced flashover, but the conditions were similar because the fire was relatively large for the size of the ---

MEMBER WALLIS: You can have a fire that is paralyzed, there's a lot of combustible gas, and them, boom, it goes off. That's not a heat input at 300 kilowatts. That's two stages of fire.

MR. JOGLAR: Yes.

MR. DREISBACH: Right.

MEMBER WALLIS: Did you get to that sort of sophistication? Are you putting in a very controlled type of fire?

MR. JOGLAR: For the most part, it's a controlled type of fire.

MR. DREISBACH: Yes.

MEMBER SIEBER: I take it that it is basically not oxygen-starved?

MR. DREISBACH: Exactly, exactly.

MEMBER SIEBER: Otherwise, you get all of these strange phenomena. And if you're oxygen-starved and have this transient going on with mixing and --

MEMBER WALLIS: It has to mix a bit well before it burns again and so on.

MR. DREISBACH: One of the things that --

MEMBER SIEBER: Right. You can model that.

MR. DREISBACH: One of the things that is a published limitation of a lot of these models is it has a difficult time in the oxygen-starved environment.

MEMBER SIEBER: Yes.

MR. DREISBACH: So we were sort of precluding those kinds of situations.

MR. JOGLAR: But there are experiments that we consider that were run with closed doors. And the fire did die because of lack of oxygen. And those comparisons, to the extent possible, are there because at some point, the experiment was stopped at some oxygen level.

MEMBER WALLIS: Along comes the fire department and opens the door.

MR. JOGLAR: And so at some oxygen level, the fire was stopped. And up to that point, we have comparisons.

MEMBER SIEBER: Yes. One of the fortunate things is if you have an oxygen-starved fire, you get a conservative result from your experiment. You know, if the actual fire is oxygen-starved but your test is not, the result is --

MEMBER WALLIS: Maybe the other way around.

MR. DREISBACH: We mentioned a little bit about this previously, but the experiments that we actually used are representative for the most part of nuclear power plant scenarios. And we also included some that were included by the model developers for their own validations.

In some cases, for example, the multi-compartment comparisons, we use something that wasn't necessarily a power plant scenario but something that was used by the developers for their own validation. We included that.

Also, we had to take into account the resources because obviously there are a lot of different experiments out there that we could have used to compare our model runs with, but we chose 26. And that was sort of when you take into account the fact that we are doing 5 models and we're comparing 13 parameters over 26 different experiments, that is a lot of accounting to account for. So we kind of had to take account of our resources in that sense.

So the 26 different experiments for comparison, the 4 different categories we had were: control, switchgear room scenarios; pump room scenarios; turbine-building scenarios; and, as I mentioned before, multi-compartment scenarios.

Also, we have evaluated and included a discussion of the results of a modeling study done on the HDR experiments that the Germans did in their containment buildings. I think they were done in the mid '80s. And some folks did some modeling of that. And we had a discussion of that. We didn't try and simulate any of those experiments because somebody had already done them. And we just included some of the discussion there.

Moving on, this is the way we quantified our accuracy. And this comes out of a -- this is a suggested method in the ASCME 1355 standard. It is essentially a normalization error fraction kind of thing where we have an absolute delta and we normalize it by the ambient quantities.

Based on this quantification of accuracies, we report results. And I'm going to turn it over to Francisco to talk about those: the results, preliminary results.

MR. JOGLAR: Again this is Francisco Joglar from SAIC.

Basically, for the 26 experiments, we run these codes, where applicable, and compare it with the 13 parameters that were listed before. These comparisons are going to be presented in the report in the form of graphs. And that is what the first bullet is. We are going to basically give these graphical comparisons.

From this graph, we calculate an accuracy using the equation that was presented before. So you have a sense of how many of these accuracies we have. And to start understanding where they are, we have to group them. And we are going to group them in histograms.

And these histograms are classified by fire scenario and by attribute. When I say by "fire scenario," it is that we have identified a library of typical nuclear power plant fire scenarios. And we try to map those typical scenarios to the characteristics of these experiments we have selected. So that we can group these accuracies depending if they're applicable to pump rooms or to turbine buildings, et cetera.

MEMBER WALLIS: See, now, your accuracy is just based on peak values. And the actual cost of the fire could be quite different. And, yet, the peak values could be the same. It seems to me that if the peak value is only, say, achieved for ten seconds, it's unlikely to burn a cable but that if the peak value is achieved for an hour, it's going to be very different.

So I would be worried about comparing

Table Mountain with Matahorn and saying it's the same thing because the peak is the same.

MR. JOGLAR: That is correct. That's why we are trying to put all of the information in the graphic representations of the experiments and --

MEMBER WALLIS: That will tell you some more.

MR. JOGLAR: Yes. The first, our first, part of this is basically to go to the peak values and get the accuracies to see where we are, but, recognizing that, we are trying to add all of the information that we have regarding these comparisons. In these graphs, you see all of the experimental data that we have and all the simulations.

And hopefully in our conclusions, we can address the issues of wherever a peak value is going to be representative of a comparison considering that time, too.

MR. NAJAFI: This is, in part, the nature of the way that we had to do this exercise, meaning that we had to look at attributes that are important to our scenarios.

As a result of that, we presented these results in three different forms. We start with these graphical representations. These give you more information, but at the same time, we generated several hundred curves.

So then we started saying, "How can we funnel this information?" How can we best create very staged or phased potential uses of this kind of information?" That's why we created a graphical that gives you a lot more curves but more information into a histogram that gives you a little bit less condensed information. You lose some of that information in the process, but you can use it to see ranges and then all the way to the bottom, a table that you may take 200 curves to generate 2 tables. So it loses something and gains some. All of these layers are there for potential different uses.

MEMBER WALLIS: Some of your graphs are mislabeled. You get the layer height and degrees Centigrade and all of that. You fix those things up.

CHAIRMAN ROSEN: I understand this, the next chart, I think. It's the one after that that I'm still having trouble with. What is the access, the wire access, on this curve?

MR. DREISBACH: The frequency accuracy difference.

CHAIRMAN ROSEN: The what?

MR. DREISBACH: The frequency that you

get, an accuracy of 15 percent over a range of experiments.

CHAIRMAN ROSEN: Okay. So it's not labeled. So it's --

MR. DREISBACH: It's a distribution. It's a distribution of accuracy.

MR. JOGLAR: So basically all of our accuracies we group in this bin. We basically see where they fall. If they fall between 10 and 15 percent --

MR. NAJAFI: The sum is one.

CHAIRMAN ROSEN: All right. So in the 15 percent, which is the big one --

MEMBER WALLIS: It's like the probability of getting a certain accuracy.

MR. DREISBACH: Exactly, exactly.

CHAIRMAN ROSEN: Thirty percent is going to be 15 percent off.

MR. DREISBACH: Right. So this is like one of four different scenarios is the controlled switchgear room scenario. We have maybe 15 different experiments that we compare these models to. So we have got potentially at least 15, but maybe we have got more than one data point for each experiment. Maybe there are multiple thermal couples that we're using to compare the data for.

So now we have got -- I don't know -- 60 different data points for a hot gas layer temperature. So we have boiled it down, like Bijan said, into sort of a distribution of accuracy so that we get an idea. For the range of experiments that we compared against, we get this distribution of accuracies.

MEMBER WALLIS: So it's way under-predicted in this case? And it's never above 55 percent of the real value? Is that right?

MR. NAJAFI: Positive values means the code -- correct me if I am wrong -- overpredicts the test. So basically we're on the conservative side.

CHAIRMAN ROSEN: We see no negative values there.

MR. DREISBACH: That's correct.

MR. JOGLAR: In these examples, if --

MR. DREISBACH: For this example, right.

MR. JOGLAR: The reason for the heat environment, -- I think you were mentioning accuracies of 1,000 percent -- is because if we present just the range, we lose the information of where most of these accuracies are. We wanted to know that and present it.

MR. DREISBACH: Right. So, again, we have maybe 200 graphs where we have the experimental data and the model runs. Maybe we're down to 50 or so. And now we boil that all down to four tables. And that's the next step. So you lose a little bit of information, but you gain a little bit of information like --

MEMBER DENNING: Before you go on, I wanted to make a comment on the definition of accuracy to make sure that we recognize what it really is here. And that is that in a denominator, you have the range of the experiment. So if you went from zero degrees Centigrade to 100 degrees Centigrade, that's the base in the bottom. And so, then, in that case --

MEMBER WALLIS: So if you measure, you predicted 300, you would be 2?

MR. DREISBACH: Yes.

MEMBER WALLIS: You would be 2, 200 percent?

MR. DREISBACH: Two hundred percent it would be, yes, 200 percent.

MEMBER DENNING: Or is it three?

MR. DREISBACH: Three hundred percent.

MEMBER WALLIS: No. It's two, isn't it, because it's the difference between --

MEMBER DENNING: Yes, you're right.

MR. DREISBACH: And, then, the final thing is the tabular results.

MR. JOGLAR: Which basically the columns are our five tools. And the rows are our 13 attributes. And what is presented in each cell is the range, what's the lowest and the highest accuracy that we calculated.

CHAIRMAN ROSEN: Why is FDS not populated?

MR. DREISBACH: We haven't finished boiling down all the data from those runs. It's a much more complex code to run. It takes a lot longer to run those codes on the order of days overnight sometimes.

So boiling the information down from that code took longer. So we haven't put those data out yet.

CHAIRMAN ROSEN: But it's your intent to --

MR. DREISBACH: Absolutely, that's --

MEMBER DENNING: It's interesting because it is the most basic of the codes. Are you seeing results that are better than the others or is there no clear --

MR. DREISBACH: I think, just as any other thing, it would be depending on the individual scenario and on the parameter that you're looking at. Sometimes maybe it's better. Sometimes it's not as good.

Sometimes it's just the same. You're not getting any benefit. And that's something that's been proven out in some of the other validation that has gone on between the different types of codes. So there's this feel that in some cases, it's not going to make a difference whether or not you use a zone model, versus a field model, in the simpler cases because the accuracies are essentially the same.

MR. JOGLAR: If I may make a comment, one of the purposes of us trying to classify this information in this way is to try to identify patterns and try to at least identify which codes into which attributes are conservative or not.

First, we are still finalizing these numbers, but so far there have proven to be no apparent patterns that we can identify at this point.

MEMBER WALLIS: Now, minus is not the same as plus here when you cannot get down to less than -100 percent, presumably, because, you know, that would mean nothing happened at all. In other words, when --

MEMBER DENNING: It could go either way.

MEMBER WALLIS: It's going down, instead of going up. So you get these huge errors on the positive side, but -93 percent is really humongous, that's 7, instead of 100 or something. That's an enormous error in terms of fractional error, -93 percent when you are measuring 7 when the real value --

MR. JOGLAR: It's like being -- I don't know if you --

MEMBER WALLIS: No. You're predicting 7 when the real value is 100.

MR. NAJAFI: No, no.

MEMBER WALLIS: What is it?

MR. NAJAFI: You are predicting 100 when the real value is 200.

MEMBER WALLIS: Right.

MR. NAJAFI: You are predicting 100.

MEMBER WALLIS: So that is off by -- that minimizes it. If you are going the other way, then it really blows off. If you're going the other way, it blows off.

MR. NAJAFI: So it's under-predicting by a factor of two.

MEMBER WALLIS: Right.

CHAIRMAN ROSEN: So if you are worried

about damage to receptors, you have to look at these minus --

MEMBER WALLIS: So it could be -300.

MR. NAJAFI: It's non-conservative.

MEMBER WALLIS: It could be -300.

MEMBER DENNING: Well, no. Wait a minute. Let's go back. Tell me again. Let's take a heat flux. And it varies. You know, do you start with a zero heat flux or do you start with some assumed -- do you wait until the heat flux is established?

MR. JOGLAR: We start with ambient conditions.

MEMBER DENNING: And the heat flux is zero to start with?

MR. JOGLAR: Heat flux is zero. Oxygen concentration would be 21 percent error. So if we want to look at this heat flux example where we had the -- where was that, the '93 percent there? So that it's possible that we had a maximum 150 experimentally, right?

MR. DREISBACH: Let's call it like let's use real units and say it may be two kilowatts, two kilowatts in --

MEMBER DENNING: Okay. So it could have been the maximum heat flux.

MR. DREISBACH: Right.

MEMBER DENNING: Okay. So in the denominator, you've got two, then, right, because it's two minus zero?

MEMBER WALLIS: Yes, if you measure it in the --

MEMBER DENNING: Yes. Okay. And so, then, in the numerator, you must have, let's see, the difference between the peaks?

MR. JOGLAR: Yes. You will have what we predicted. Let's say we predicted 10 or .1.

MEMBER DENNING: Well, since we know that the measured was two, then let's put in X there and let's figure out what X. So X minus two over two is equal to -.93, correct?

MR. DREISBACH: Yes.

MR. JOGLAR: Yes, that is correct.

MEMBER DENNING: Okay.

CHAIRMAN ROSEN: Now the solution.

MEMBER DENNING: Now the solution.

MR. DREISBACH: It's probably I would imagine something on the order of a half a kilowatt is what you're predicting in the model versus an actual value of about two kilowatts. That will give you maybe on the order of 80 percent negative. So what we see --

MEMBER DENNING: I think the X is .14 unless I made a mistake there.

MR. JOGLAR: .2, .5.

MR. DREISBACH: Yes.

MEMBER DENNING: Okay.

MR. DREISBACH: It's on the order of .2. So we're under-predicting severely --

MEMBER DENNING: Severely. Yes, right.

MR. DREISBACH: -- the heat flux at these points.

MEMBER DENNING: Right.

MR. DREISBACH: That's what we see many times.

CHAIRMAN ROSEN: Okay?

MEMBER DENNING: Okay. We understand.

CHAIRMAN ROSEN: Okay. We understand that.

MEMBER DENNING: Okay. Now, there's another point, though, here, which is not terribly surprising for people who have familiarity with at least what goes to show up there, and that is that they are not very accurate.

And here is the message now. Now, what does that mean to, like, the methodology that we had before? How do you treat that? Do you just have to deal with that conservatively or how do we take these results, which say these are ballpark kinds of things, at best? How do we deal with it?

MR. NAJAFI: Okay. Let me add a couple of things. Why don't we go to the next slide? We will come back to this again. What I want to hear is that the results that we presented here, it's more a progress report. This has been a very important and technically challenging project. We have seen numbers that we did expect. We have seen numbers that are somewhat surprising to us. So it's a combination.

I would like to emphasize the importance of the project because a successful transition to a risk-informed and performance program really requires or needs reliable codes that can predict the fire effects, whether it's in a performance and it's alone or as part of a risk-informed approach in support of the fire PRA method that we mentioned.

However, this has been a challenge, I mean, because this is something that, as Mark explained, has not been done in the outside community and, in my opinion, for a good reason. And that reason is because outside community uses these codes primarily in the design stage. We are using it. And, therefore, we are trying to use it in a post-design stage. Therefore, they are not so much reliant on a quantitative measure.

And in most of the validation, if you look in the past, they basically stopped at this thing because they look at these and you're off by 50 percent, you put a safety factor. You are done.

But if you try to implement the same kind of predictive capability without an existing design, you need more quantitative information. You may need it because your design margin may tolerate or may not. So we need to know more. So that's why we went to this extra step. And going that extra step has presented these challenges. We need more time to digest these results.

The second point to emphasize that makes basically the external review of this work very critical -- I shouldn't use the word "critical," maybe essential -- in fact, I would even venture to say that I see the external review of this, what has been done here, even more essential than the work we presented this morning because the community outside, whether it is the fire science community, fire modeling community, is a very large community with a large degree of experience in use and development of these codes.

So we need to get these out. We need these results. Let it be digested by ourselves and a thorough review by the outside bigger fire protection community before we start making basically the kinds of judgments, conclusions that you are suggesting.

At this point, how does this affect what we do in there? I would not want to do that kind of judgment until we have gone through that process. And these results have matured to a point that I can say yes, this is what I believe. And once we get there, then this is my personal opinion, that we need to figure out those, where do we go with this at that time. But we're not there yet.

Mark, do you want to add something?

MR. SALLEY: You're good.

CHAIRMAN ROSEN: All right. Well, I think we're done with this portion of our agenda.

MEMBER DENNING: I have another question on verification, if I may ask, --

CHAIRMAN ROSEN: Yes.

MEMBER DENNING: -- although I don't think it is nearly as important as --

CHAIRMAN ROSEN: Go right ahead. We have --

MEMBER DENNING: That is, it wasn't clear to me. What have you actually done or planned to do as far as verification of these models? You know, we discussed with verification before. I've seen what you are doing for validation.

Do you really intend to do anything for verification or are you going to say these are models that are widely used in the industry and we believe that they have incorporated the things properly? What have you done?

MR. JOGLAR: The standard calls for some steps to be done, and we are doing them. They include a review of the legal basis, a sensitivity analysis, and check for numerical robustness, which in a simple terms means run and check with that pretty fine case you have that same number if you run it again. Those steps are done.

MEMBER DENNING: Now, you're not going to go into the coding and check to make sure that they have coded it properly. You're going to assume that that has been coded properly. You are just looking at the basic documents that describe the methodology or are you actually going into the code and checking to see if they have coded it properly?

MR. JOGLAR: Not as a research team but,

for example, in MAGIC, which I have been working closely, I have seen documents from EdF saying that they have done some kind of software quality testing. And to the extent we can, we have included those details in the report.

MEMBER DENNING: Right.

MR. DREISBACH: We are taking the developer at its word. Most of the developers make the effort to do that kind of thing where they verify they run it against software testers and they do some sort of sensitivity and they check to make sure the phenomenology is integrated appropriately.

So we sort of take the developer at their word in that step, but we document it as well in our document in reference to what the developer documentation says.

MR. JOGLAR: There are two tools: the hand calculations that we, the NRC and EPRI, have basically access to the programming, and those we can basically check line by line that it is correct. The others, basically the team doesn't have access to the actual source code.

MR. NAJAFI: And let me add something, too, because there is a reason that we did not, in my opinion, think that were necessary. Most of these codes, CFAST, MAGIC, and FDS, have been previously validated and verified, V&Ved, even though by the developers. Part of the validation that they do is the exercise you are talking about.

The reason we do this again because not only the quantitative nature of it, we're trying to introduce or superimpose in the V&V they did the attributes important and essential to a nuclear power plant.

So the kind of thing you are talking about, we expect it is addressed by their internal V&V. We are only concerned about how the predictive capability of these are in uniqueness as a concern to the nuclear power plant, let's say temperature in the upper plume of a cable fire. That's all we're concerned about because they didn't do that.

MEMBER DENNING: I didn't mean compliant. I thought you should. I thought you've taken exactly the right approach.

MEMBER WALLIS: Now, is this a consistency? When you have got a range here, you've got CFAST and MAGIC, if I look at it and compare them, it may look as if MAGIC is on the whole doing slightly better on most things, but maybe that's illusion because you're comparing a lot of different experiments. And it may be that MAGIC does well on some of the experiments and CFAST does well on some of the others or do they consistently do better? I mean, they err consistently in the same direction, even --

MR. JOGLAR: Those are the kinds of patterns we would like to identify if they exist. I may also want to clarify that when you look at columns in CFAST and MAGIC, that range is built on the same accuracies, meaning the same calculation for the same experiments. So that should be consistent. We are not in that table comparing two ranges that have different --

MEMBER WALLIS: Where CFAST is off by +262, MAGIC may be off by -53 because you're just giving me a range.

MR. JOGLAR: But those are the same accuracies for each of them, not numerically, but --

MEMBER WALLIS: It's just a range, though.

MR. JOGLAR: The range is the lowest and highest accuracy from that group of accuracies, which that group is the same for both.

MEMBER WALLIS: It's the same group, but --

MR. JOGLAR: Yes.

MEMBER WALLIS: -- the individual ones are not necessarily the maximum and minimum.

MEMBER DENNING: They're not necessarily correlated as to --

MEMBER WALLIS: Right.

MR. NAJAFI: And also note that this is one table of maybe six or seven that we chose to show you here.

MEMBER WALLIS: Yes.

MR. NAJAFI: So the other may be the other way around. At this point, we're not recommending you start making those kinds of conclusions yet. So hold off --

MEMBER WALLIS: Sorry. This is an EPRI? Whose work is this? This is EPRI work. So EPRI's code is FIVE, is it?

MR. NAJAFI: Yes.

MEMBER WALLIS: Is EPRI making any effort to improve FIVE so that it is better than that? If you know some of the causes of error, you --

MR. NAJAFI: I want to just emphasize the first two codes, the FDT and FIVE, are basically principal equations out of the SFB handbook. I'm not sure how you can improve it unless you ask Dr. Quintiri to revise the equations.

MEMBER DENNING: EPRI was fully aware that what we call FIVE here is a just very simple approximation, --

MEMBER WALLIS: Right.

MEMBER DENNING: -- hand calculation-types of things.

MEMBER WALLIS: I think we may have seen it a couple of years ago or something. I forget now. I think we did see something.

MR. NAJAFI: Because I guess the point I am making, the first two columns, there's not a hell of a lot of room in improvement because the theory is well-established somewhere else. This is just a library. The first two is just a library.

CHAIRMAN ROSEN: We're running over a little bit. So unless someone feels that they have one more burning comment, I'll --

MEMBER WALLIS: Take a break?

CHAIRMAN ROSEN: Well, we're actually done, I think, for the day. You can take --

MEMBER WALLIS: You're worried about being done for the day at 3:00 o'clock?

CHAIRMAN ROSEN: Do you want to continue? If not, we're off the record now. Have at it.

(Whereupon, at 3:02 p.m., the foregoing matter was adjourned.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards Subcommittee on Fire Protection Meeting

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Eric Mollen

Eric Mollen
Official Reporter
Neal R. Gross & Co., Inc.

AGENDA

Part 1
Final NUREG/CR-6850, EPRI 1008239
''EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities"

8:30 a.m. Introductory Remarks - Mark Salley, RES; Gary Vine, EPRI

8:45 a.m. Programmatic Overview and Technical Introduction - J.S. Hyslop, RES; Bijan Najafi, EPRI-SAIC

9:15 a.m. PRA/HRA Tasks, Part 1 - Alan Kolaczkowski, RES-SAIC

9:35 a.m. Electrical Analysis Tasks - Daniel Funk, EPRI-Edan Engineering

10:15 a.m. Break

10:30 a.m Fire Specific Tasks, Part 1 - Steve Nowlen, RES-SNL

11:10 a.m. Fire Specific Tasks, Part 2 (i.e. Detailed Modeling) - Bijan Najafi, EPRI-SAIC

11:50 a.m. PRA/HRA Tasks, Part 2 - Alan Kolaczkowski, RES-SAIC

12:10 p.m. Lunch

1:10 p.m. Peer Review - Dennis Henneke, Duke Power

1:25 p.m. Concluding Presentation/Remarks - J.S. Hyslop, RES

1:40 p.m. End

Part 2
Draft NUREG 1824, EPRI 1011999
"Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications"

1:45 p.m. Introductory Remarks - Mark Salley, RES; Gary Vine, EPRI

1:55 p.m. Presentation - Jason Dreisbach, RES, Kendra Hill, RES, Francisco Joglar, EPRI-SAIC

2:55 p.m. Adjourn

Sandia National Laboratories

EPRI/NRC-RES FIRE PRA METHODOLOGY:
Overview

J.S. Hyslop, NRC/RES
Bijan Najafi (for R. P. Kassawara, EPRI)

ACRS Fire Protection Subcommittee
May 4, 2005
Rockville, MD

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

BACKGROUND

- MOU between NRC-RES and EPRI on fire risk
- One of several elements on MOU
- Primary objective of this program: develop, field test, and document state-of-art
- Prior briefings of ACRS, including focused briefing in April 04
- Purpose: Brief ACRS on final NUREG/CR-6850, EPRI 1008239 "*EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities*" which addresses public comments

ROLES OF PARTICIPANTS

- NRC-RES and EPRI develop and test methods
- Three volunteer pilot plants support testing
- Other participating licensees provide peer-review of methods

- EPRI and NRC-RES reach consensus on documented methodology

EXPECTED USE OF METHODOLOGY

- Support for new rule 10CFR50.48c implementation
- Analyses under the current fire protection regulations (i.e. exemptions/deviations or other plant changes such as risk-informed technical specifications)
- Basis for staff review guidance that RES will develop for NFPA 805 related changes
- ANS fire risk standard
- Analysis and reviews of fire protection inspection findings (phase 3 SDP)

ADVANCEMENT TO STATE OF ART

- Improvements made in areas important to fire risk (resource constraints considered)
- Means to advance
  - Consolidate existing research
  - Analyze more extensive data
  - Modify existing methods
  - Develop new approaches

ACRS Fire Protection Subcommittee, May 4, 2005, Washington, D.C. 20555 | Slide 5 | A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

RELATIONSHIP TO FIRE MODEL V&V

- Fire modeling tools provide input to fire PRA
- Fire model verification and validation (V&V) is required for NFPA 805 applications
- In limited cases, fire models (empirical correlations) utilized
  - Address cases where computational fire models inadequate
  - Fill important gaps in fire PRA
- PRA Methodology document not a reference for fire models
  - Any necessary V&V left to analyst

ACRS Fire Protection Subcommittee, May 4, 2005, Washington, D.C. 20555 | Slide 6 | A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

PUBLIC COMMENTS

- Comments provided during public comment period by industry and consultants
  - Duke Power, Florida Power and Light, EPM, RDS
- Comments provided by NRR
- No public comment required NRC-RES and EPRI to significantly adjust our approach
  - Few comments on state-of-the-art limitation
  - Remaining comments were minor and clarifications

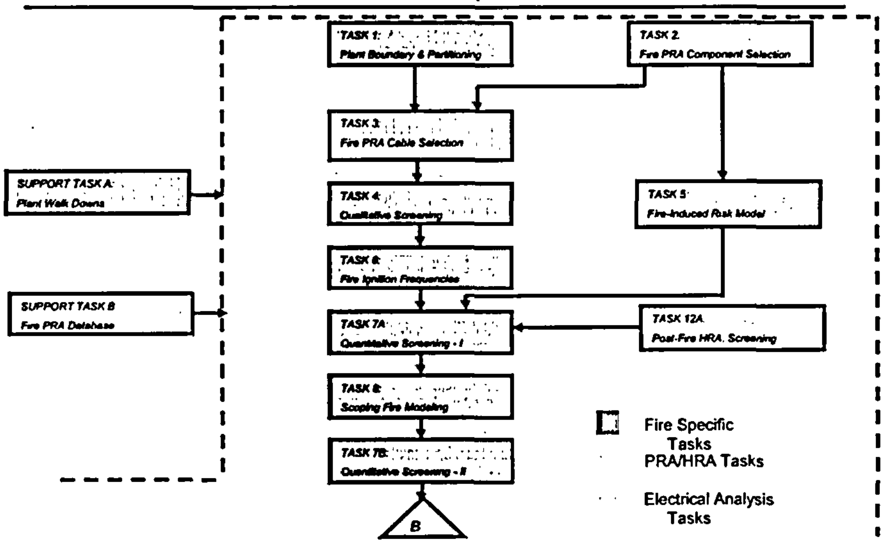
MILESTONES

• Draft report for public comment	Oct 2004
• ACRS	May/Jun 2005
• Public Fire PRA Methodology Workshop	Jun 14-16, 2005
• Publication	Aug 2005
• BWR pilot	2006
• Revision of methodology (if needed)	Dec 2006

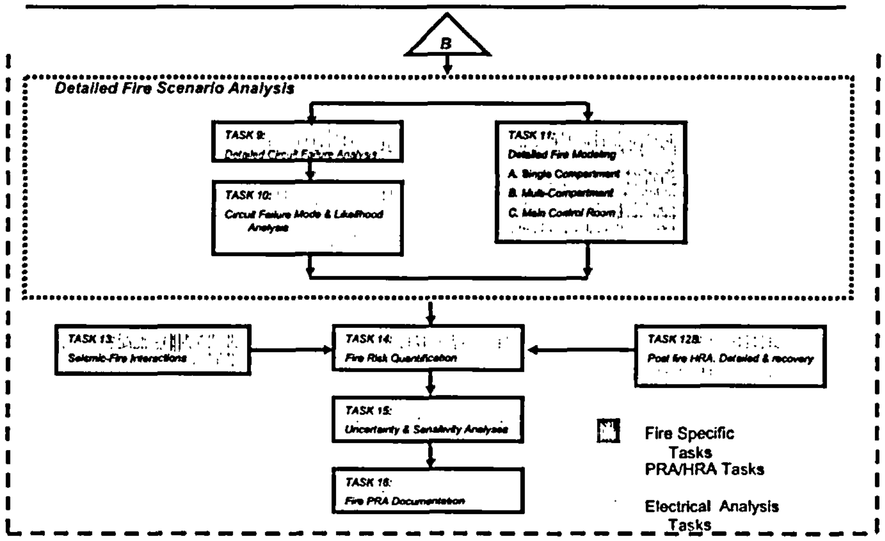
PROJECT TEAM

- Covers all technical disciplines critical to Fire PRA
  - Technical Lead: B. Najafi, S. Nowlen
  - General PRA & plant systems analysis: A. Kolaczkowski, R. Anoba
  - Circuit Analysis and Appendix R: D. Funk, F. Wyant
  - Human Reliability Analysis: J. Forrester, W. Hannaman, A. Kolaczkowski
  - Fire analysis: F. Joglar, M. Kazarians
  - Consultants: A. Mosleh, D. Bley
- Collectively, over 250 years of relevant experience
- Principal authors of documented Fire PRA methods in the US for the past 2 decades
- Experience with use of previous methods; their strengths and weaknesses
- The Methodology reflects the consensus of this team, EPRI and RES

FIRE PRA PROCESS FLOW CHART



FIRE PRA PROCESS FLOW CHART



ACRS Fire Protection Subcommittee, May 4, 2005, Washington, D.C. 20555

Slide 11

A Collaboration of U S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Sandia National Laboratories

EPRI/NRC-RES FIRE PRA METHODOLOGY:

PRA/HRA Part 1: Tasks 2, 5, and 12

Alan Kolaczkowski, SAIC

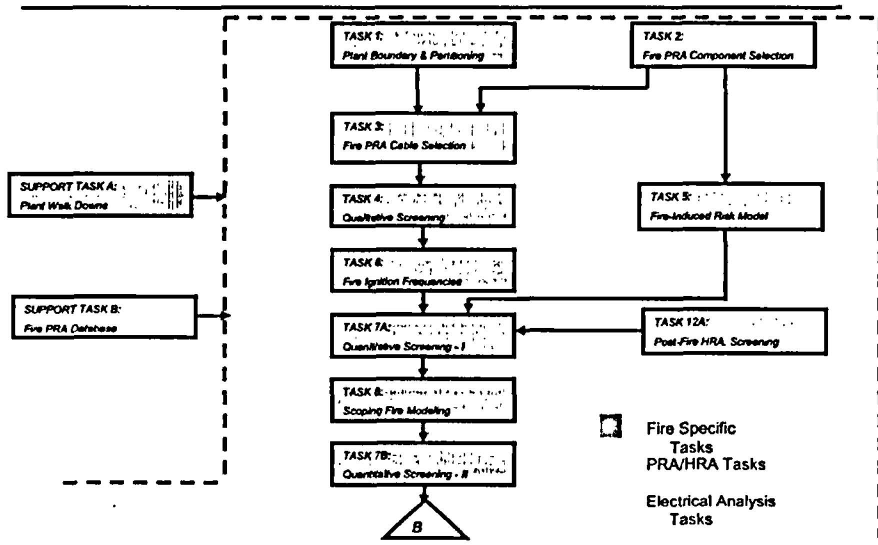
ACRS Fire Protection Subcommittee
May 4, 2005
Rockville, MD

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

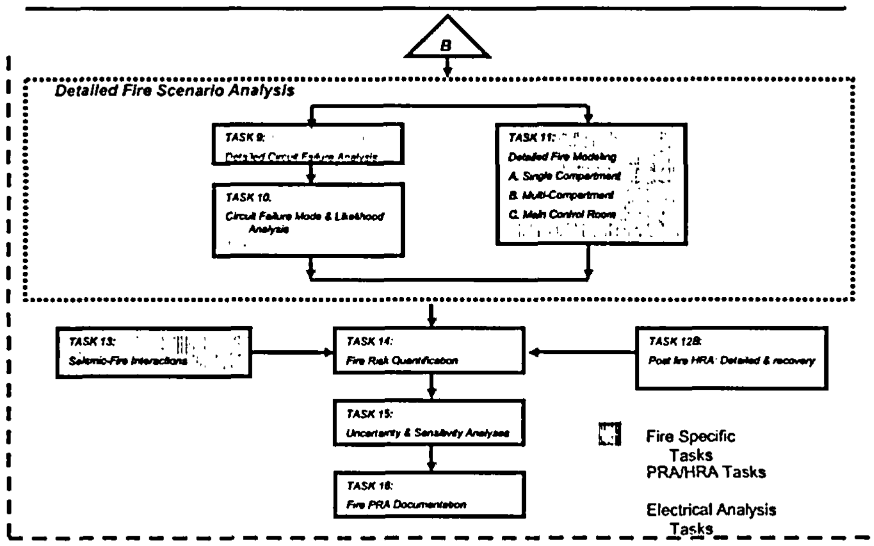
Topics/Tasks Covered Here:

- Task 2: Fire PRA Component Selection
- Task 5: Fire-Induced Risk Model
- Task 12: Post Fire Human Reliability Analysis (HRA)
  - Screening (Task 12A)
  - Detailed (Task 12B)

FIRE PRA PROCESS FLOW CHART



FIRE PRA PROCESS FLOW CHART



Task 2: Fire PRA Components Selection

- Sets much of the Fire PRA scope
  - What will be credited in the Fire PRA safe shutdown model
- Some aspects reflect consolidation of past practice
  - Builds from equipment credited in Internal Events PRA
- Key areas of advancement over IPEEE:
  - Incorporate pre-existing Post-Fire Safe Shutdown Analysis insights from deterministic analysis (e.g., from Appendix R)
  - Include multiple spurious actuation events (not previously addressed)
  - Identify key instrumentation supporting post-fire operator actions

Task 2: Fire PRA Components Selection (cont.)

- Public comments and internal writing team discussion led to some additions and clarifications
  - Added search for "new" scenarios and associated components
  - Added more on unique manual actions including supporting instrumentation needed as well as accounting for equipment effects as a result of actions
  - Clarified guidance on search for and identification of initiating events, "high consequence events," and multiple spurious events
  - Other minor clarifications and editorial comments – nearly all included

Task 5: Fire-Induced Risk Model

- Addresses the process of constructing the Fire PRA safe shutdown model
  - Core damage (CCDP, CDF)
  - Large early release (CLERP, LERF)
  - Considers future use of the model (ICDP, ILERP)
  - Assumes use of quality Internal Events PRA (or current IPEEE)
- Advances:
  - Modeling of unique operator actions per Fire Procedures
    - Discussed briefly in prior EPRI guides, but often neglected in IPEEEs
  - Modeling of key instrument failures (per equipment selection)
  - Incorporation of multiple spurious operation

Task 5: Fire-Induced Risk Model (cont)

- A few changes made as a result of public comments and internal writing team discussion
  - Clarified modeling level of detail (at first can be broad as long as conservative, but as model evolves, failure modes need to be more specific and include timing considerations)
  - Clarified the failing of equipment in the model for ICDP/ILERP calculations (comments expressed confusion)
  - Carry-over of changes from Task 2
  - Other minor clarifications and editorial comments – nearly all included

Task 12: Post Fire HRA

- Task covers:
  - Identification of Human Failure Events (HFEs) including existing HFEs in Internal Events PRA and new HFEs unique to fires
  - Four sets of screening human error probabilities (HEPs) ranging from 10x Internal Events PRA HEPs to 1.0 – Task 12A
  - Plant- and scenario-specific performance shaping factors (PSFs) to be considered for estimating best estimate HEPs for significant fire scenarios – Task 12B
- Main advances:
  - Screening level HEPs
  - Identification and discussion of PSFs for detailed analysis
- Procedure does not provide detailed quantification guidance
  - Details need to be method-specific

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Task 12: Post Fire HRA (cont)

- Some changes were made as a result of public comments
  - Removed discussion of fire-specific pre-initiator HFEs
    - Those impacting fire protection systems, barriers, general fire protection program elements
    - Possible confusion/overlap with use of experience/data covered in other Tasks
    - Does not preclude plant-specific HRA of fire-specific pre-initiator HFEs
  - Added "general" guidance on use of existing HRA methods, BUT no specific quantification guidance as requested by one comment

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EPRI/NRC-RES FIRE PRA METHODOLOGY:

Electrical Analysis Tasks 3, 9, 10 and Support Task B

Daniel Funk

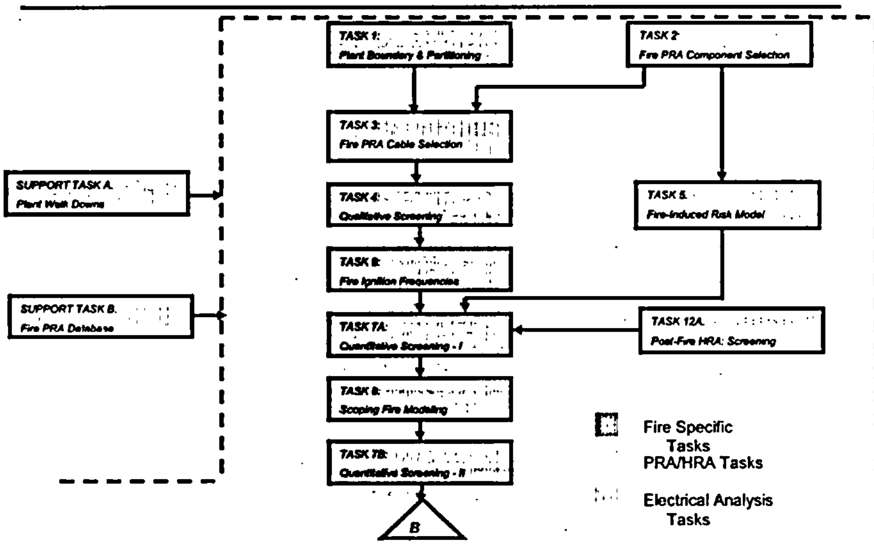
ACRS Fire Protection Subcommittee
May 4, 2005
Rockville, MD

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Electrical Analysis Scope

- Task 3: Fire PRA Cable Selection
- Task 9: Detailed Circuit Failure Analysis
- Task 10: Circuit Failure Mode Likelihood Analysis
- Support Task B: Fire PRA Database (Chapter 18)

FIRE PRA PROCESS FLOW CHART



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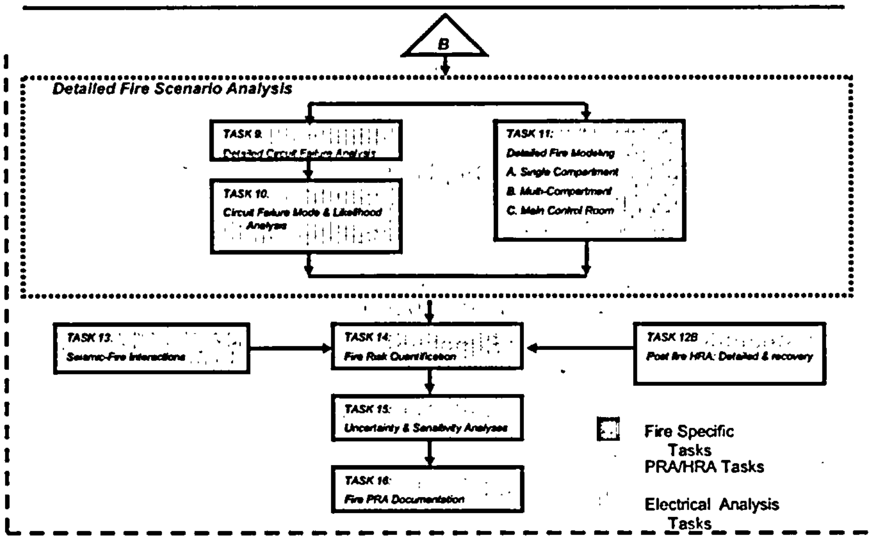
FIRE PRA PROCESS FLOW CHART



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Circuits Overview:
Improvements & Refinements

- Substantial Technical and Process-Related Advances
- Collective Awareness of Circuit Failure Implications Greatly Improved
- Circuit Analysis is Now an Integral and Formal Part of the Fire PRA Process
  - Generally Dealt with in a Cursory Manor by Original IPEEE
  - Rigorous and Formal Process for Correlating Cables-to-Equipment-to-Affected Locations
    - Definitive Data and Criteria has Replaced Estimations and Judgment
    - General Approach is Now Quantitative in Lieu of Qualitative

Circuits Overview:
Improvements & Refinements

- Knowledge Base Improvements
  - EPRI/NRC Fire Tests: Prompt Jump in Understanding of Fire-Induced Circuit Failures
  - Analysis Methods Based on Expert Panel Values Supplemented by Minor Supplemental Analysis

Phased Approach to Electrical Analysis

- Each Electrical Analysis Task Represents a Refined Level of Detail
- Level-of-Effort for the Electrical Work is a Key Driver for Project Scope, Schedule, and Resources
  - High Programmatic Risk if Not Carefully Controlled
  - Routing of all Cables can be a Large Resource Sink with Minimal Overall Benefit
  - Potential Implications Confirmed at ALL Participating Plants
- Detailed Analysis Driven by Quantitative Screening Results – Intelligence-Based Circuit Analysis
  - Iterative Process
  - Conservative First Pass with Realism Incorporated Where it Matters

Task 3: Cable Selection

- Conducted for all Fire PRA Components
- Deterministic Process
- Associate Cables to Components Irrespective of Failure Mode
  - Some High-Level Circuit Analysis Incorporated to Prevent Overwhelming the PRA Model With Inconsequential Cable Failures
  - Final Product is a Listing of Components that Could be Impacted by a Fire for a Given Location (Fire Area, Fire Compartment, Fire Scenario)

Task 3: Cable Selection

- Public and Peer Review Comments Primarily Associated with Practical Aspects of Conducting Cable Selection
  - Refined Guidance for Using Appendix R Circuit Analysis
  - Enhanced Guidance for Selective Circuit Analysis as Part of Task 3
    - Screen Up Front Circuits Readily Identifiable as **NOT** having the Potential to Affect Desired Functionality
    - Experience at Participating Plants Confirmed PRA Model is Easily Overwhelmed without Some Level of Up-Front Screening
  - Expanded on Verification of Assumptions as Related to Use of Appendix R Circuit Analyses
  - Guidance for Bus Ducts (Not Previously Addressed)
  - Guidance for Treatment of Resistance Grounded Systems (Not Previously Addressed)

Task 9: Detailed Circuit Failure Analysis

- "Risk-Focused" Deterministic Analysis
- Generally Reserved for Cases in Which Quantitative Screening Indicates a Clear Need and Advantage for Further Analysis
- Detailed Failure Modes Analysis
  - Requires Knowledge About Desired Functionality and Component Failure Modes
  - Conductor-by-Conductor Evaluation
- Objective is to Screen Out Cables that Cannot Impact the Ability of a Component to Complete its Credited Function

Task 9: Detailed Circuit Failure Analysis

- Public and Peer Review Comments
  - Interface Between Task 3 and Task 9 Better Defined and Explained
  - Elimination of Control Room Assumed Actions
  - Enhanced Guidance to Focus Analysis on Failure Modes of Concern
  - Added More Examples to Augment Guidance for Specific Circuit Designs
  - Incorporated Guidance for Human Factors Interface Where Manual Recovery Actions Could be Affected by Circuit Failure

Task 10 – Circuit Failure Mode Likelihood Analysis

- Probabilistic Based Circuit Analysis
- Two Methods Presented
  - Expert Panel Results
  - Computation-Based Analysis
- Requires Knowledge About Circuit Design, Cable Type and Construction, Installed Configuration, and Component Attributes
- Generally Reserved for Only Those Cases that Cannot be Resolved Through Other Means

Task 10 – Circuit Failure Mode Likelihood Analysis

- Key Insights
  - Our Knowledge is Greatly Improved but Uncertainties are Still High
  - For This Reason, Implementing Guidance is Cautious and Conservative
  - Practical Implementation is Challenging
  - Further Analysis of Existing Test Data and Follow-On Tests Would be Beneficial:
    - Reduce Uncertainties
    - Reduce Conservatism Where Appropriate
    - Solidify Key Influence Factors
    - Incorporate Time as a Factor
    - Incorporate "End-Device" Functional Attributes and States (e.g., latching circuits vs. drop-out design)

Task 10 – Circuit Failure Mode Likelihood Analysis

- Public and Peer Review Comments
  - Several Questions Involving Interpretation of the EPRI Test Data Lead to Extensive Discussions Regarding the Most Appropriate Way to Tally Spurious Actuation Probabilities (Many Subtleties for Implementation)
  - Team's Consensus is that Expert Panel Values are, in General, Conservative
  - Additional Independent Review of the Computational Method was Solicited as a Result of Peer and Public Comments (Review was Favorable, However the Team Acknowledges the Inevitable Limitations With a "Version 1.0" Release
  - Modified Task 10 Examples to Include Only Spurious Operation failure Mode

Support Task B – Fire PRA Database

- Provides High-Level Guidelines for Required Functionality and Structure
- A "Nuts and Bolts" Part of the Analysis, but Critical to Success
- Impractical to Manipulate and Correlate the Volume of Data Developed Without Robust Relational Database
- No Significant Pubic Comments

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EPRI/NRC-RES FIRE PRA METHODOLOGY:

Fire Specific Tasks 1,4,6,7,8,13 and Support Task A

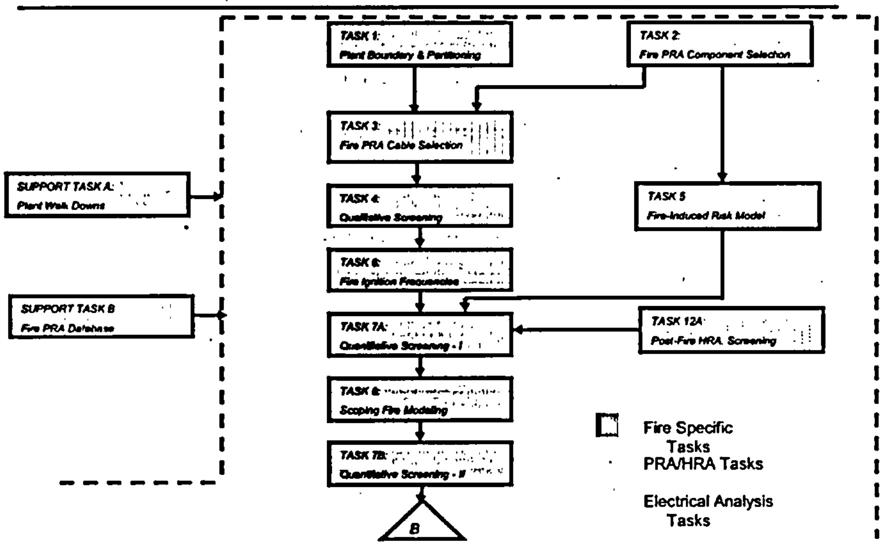
Steve Nowlen, SNL

ACRS Fire Protection Subcommittee
May 4, 2005
Rockville, MD

Topics/Tasks Covered Here:

- Support Task A: Walkdowns
- Task 1: Plant Partitioning
- Task 4: Qualitative Screening
- Task 6: Fire Ignition Frequencies
- Task 7: Quantitative Screening
- Task 8: Scoping Fire Modeling
- Task 13: Seismic/Fire Interactions

FIRE PRA PROCESS FLOW CHART



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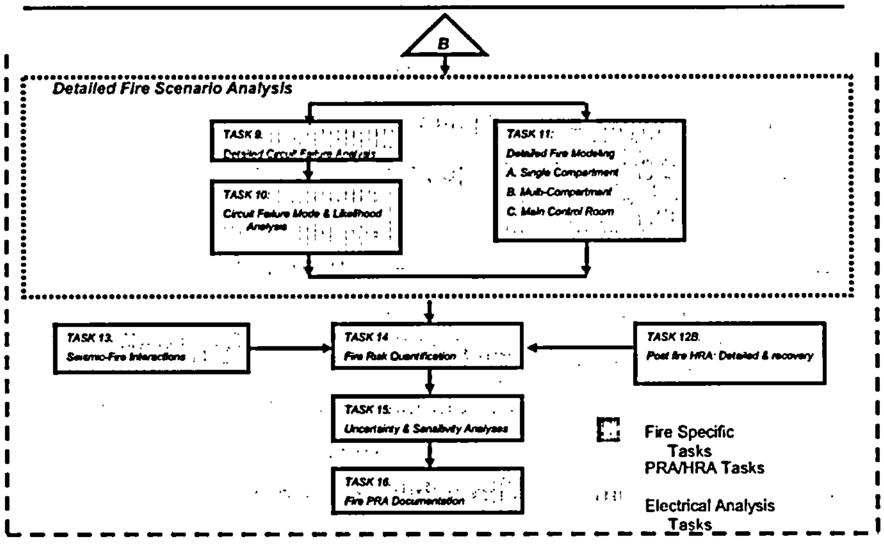

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Support Task A: Walkdowns

- Walkdowns remain integral to Fire PRA
  - Verification of spatial features, fire sources, target locations, protective features, etc.
- Supporting guidance is provided, but generally represents a consolidation of current best practices
- No public comments of particular note on this task
  - Handful of editorial comments

Task 1: Plant Partitioning
Task 4: Qualitative Screening

- *Plant Partitioning*: divide plant into analysis compartments
  - Consolidates current best practice
- (Tasks 2 and 3 trace/map equipment and cables to compartments)
- *Qualitative Screening*: first pass – identify and eliminate very low risk compartments
  - Consolidates typical current practice
  - No Fire PRA equipment or cables, no trip initiators, no short-term demand for shutdown (e.g. tech specs)
- No significant comments on either task – handful of editorial

Task 6: Fire Frequencies

- *Fire Frequencies*: significant improvements made here
  - Most fire sources now use component-based frequency
    - Allows for more consistent, refined, and reasoned compartment and scenario frequencies that reflect plant specific configuration
  - Extensive analysis of event data
    - IPEEEs typically used full unscreened event set for frequency and applied generic severity factors
    - We screened events for risk-relevance (potentially challenging)
    - We also utilize fire severity profiles that have implicit links to the final frequency event sets (more on profiles shortly)
  - This area was the subject of much discussion and adjustment during peer review
  - Several public comments requested clarification of specifics, no major changes

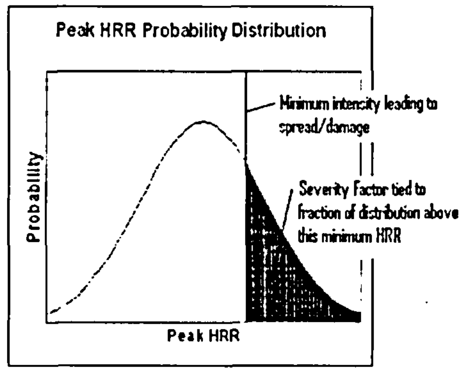
Task 7a: Quantitative Screening I

- *Quantitative Screening I:* typical of past practice:

  (compartment fire frequency) X (room-loss CCDP)
  - Quantitative screening criteria were simplified based on public comments
    - Original approach to establishing criteria found to be confusing and overly complicated
  - Final recommendations:
    - Compartment screening CDF no greater than 1E-7
    - Sum of all screened compartments <10% of internal events CDF
    - Corresponding LERF, ICDP, ILERP criteria
    - Intended application could lead to more stringent criteria

Task 8: Scoping Fire Modeling

- *Scoping Fire Modeling:* eliminate non-threatening fire sources (no fire spread, no damage)
  - Consolidates and expands on methods used successfully in IPEEEs
  - Tie is established to fire severity profiles
    - Screening uses 98th percentile fire severity
  - No major public comments, some editorial and clarification



Task 7b: Quantitative Screening II (III, IV)

- *Quantitative Screening II:*

  (refined compartment frequency) X (compartment loss CCDP)
- *Optional Refinements - Quantitative Screening (III, IV):*
  - Incorporate detailed circuit analysis insights (Task 9/10)
  - Incorporate detailed fire modeling insights (Task 11)
  - Incorporate detailed HRA/recovery values (Task 12)
- No major public comments on these tasks, some editorial

Task 13: Seismic/Fire Interactions

- *Seismic/Fire Interactions:* Consolidates current practice
  - Approach remains qualitative assessment separate from fire risk quantification
    - Identify and address potential vulnerabilities
  - Consistent with recommendations from the original Fire Risk Scoping Study
  - Some additions/clarifications based on lessons learned from IPEEE
  - No major public comments, some editorial/clarification

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EPRI/NRC-RES FIRE PRA METHODOLOGY:
Detailed Fire Modeling – Task 11

B. Najafi, F. Joglar

ACRS Fire Protection Subcommittee
May 04, 2005
US NRC, Rockville, MD

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Task 11: Detailed Fire Modeling

- Scope: Define and evaluate specific fire scenarios
  - Single compartment fire scenarios
  - Multi-compartment fire scenarios
  - Main control room fire scenarios
- General approach follows traditional pattern:
  - Identify and characterize fire scenarios – fire source and target sets
  - Fire growth/spread/damage analysis including fire severity
  - Fire detection/suppression analysis
  - Final output is conditional probability of fire consequences given fire ignition

Severity Factor & Heat Release Rate

- Previous methods (e.g., IPEEE) used a fixed HRR and a fixed severity factor derived from review of fire records
  - No distinctions based on scenario-specific features
- New approach ties severity factor to a distribution on peak fire intensity
  - Severity factor based on percentile of the smallest fire leading to spread/damage
  - Accounts for variability in the peak fire intensity (heat release rate) – an aleatory uncertainty
  - Approach captures scenario-specific features such as distance to secondary combustibles, distance to targets, room size, etc.
- HRR distributions developed for various ignition sources
  - Expert judgment based on evidence from relevant fire events and tests

Fire Models

- Generally computational fire models are developed to estimate extent and timing of fire growth
  - This document does not recommend specific computational fire model
- There are fire scenarios critical to NPP applications that are beyond capability of existing computational fire models

"Special Models"

- High energy arcing faults (new)
  - Critical to switchgear room fire risk
  - An empirical rule set type model based on operating experience
  - High-energy phase, defined by a "zone of influence"
  - Thermal phase (enduring fire) treated like other fire sources
- Main control board (new)
  - Critical to control room fire risk
  - A probabilistic model for fire propagation inside the main control board
- Cable fires (modified from IPEEE approaches)
  - Critical to cable spreading room and cable tunnel fire risk
  - Fire spread in a single tray or cable tray stacks

Other "Special Models"

- Fire propagation to adjacent cabinets (consolidation)
- Passive fire protection features (consolidation)
- Hydrogen fires (new)
- Turbine generator fires (new)
- Smoke damage (consolidation of research – new risk analysis guidance)

Detection & Suppression Analysis

- Probability of Non-Suppression = conditional probability that fire lasts long enough to cause postulated damage
- Approach credits:
  - Prompt detection & suppression (by plant personnel or fire watch)
  - Automatic detection and suppression
    - Reliability (Generic)
    - Availability (plant-specific), and
    - Effectiveness (Scenario-specific)
  - Manual detection
  - Manual suppression by fire brigade
    - Model based on operating experience – fire suppression time curves
- Improvements over previous methods:
  - More rigorous review/analysis of event data
  - Explicit calculation framework (event tree)

Public Comments on Task 11

- Editorial/clarification comments including consistency with fire protection SDP, and NEI-04-02
- One reviewer recommended additional modeling method references – Our approach for referencing is:
  - Cite reference when a specific approach, value, or quote was imported
  - Cite references that establish link to an important historical context
  - Do not provide general references (not intended to be a reading list)
- V&V of fire models
  - NFPA 805 requires that fire models are verified and validated.
  - Our report documents fire PRA state-of-the-art – broader applicability
  - "Models" are cited when team consensus concluded need is critical, and identified method represents a reasonable approach and/or current best practice
    - e.g., the "special models" discussed previously
  - We did not V&V recommended approaches

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EPRI/NRC-RES FIRE PRA METHODOLOGY:

PRA/HRA Part 2: Tasks 14, 15, and 16

Alan Kolaczkowski, SAIC

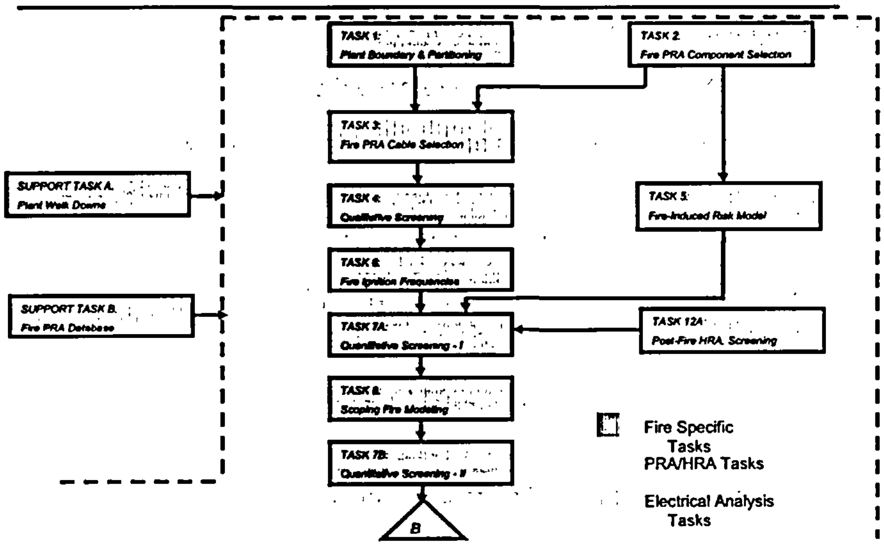
ACRS Fire Protection Subcommittee
May 4, 2005
Rockville, MD

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Topics/Tasks Covered Here:

- Task 14: Fire Risk Quantification
- Task 15: Uncertainty and Sensitivity Analyses
- Task 16: Fire PRA Documentation

FIRE PRA PROCESS FLOW CHART



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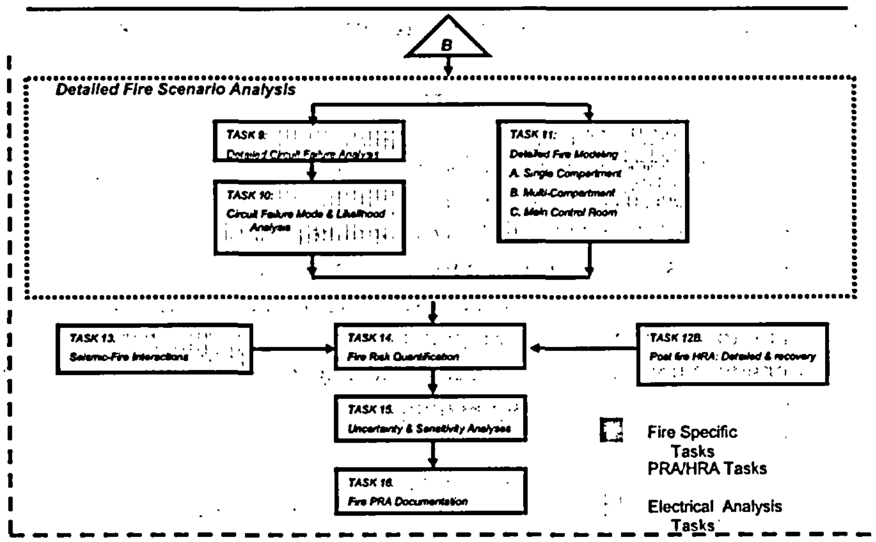
FIRE PRA PROCESS FLOW CHART



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Task 14: Fire Risk Quantification

- Addresses final quantification of fire risk
  - Core damage and large early release metrics
  - Propagating uncertainties and performing sensitivity analyses (based on Task 15)
  - Identification of main contributors to risk
- Only minor changes made as a result of internal writing team and public comments
  - This is largely a "turn-the-crank" type task; received few comments
  - Minor clarifications and editorial changes included

Task 15: Uncertainty and Sensitivity Analyses

- Addresses the *process* for uncertainty and sensitivity analyses
  - Modeling and data uncertainties
  - A comprehensive list of *specific* uncertainty sources for each task has been developed
  - Explicit guidance on quantification (e.g., uncertainty bounds) for each identified source is NOT provided
    - May be able to add as more demonstrations are performed
- Some changes were made as a result of public comments
  - Consolidated discussions of uncertainties from individual tasks under Task 15 (clarification issue)
  - Separated uncertainties to be addressed from technical quality issues
    - Discussion of both remains – see Appendix V
  - Added discussion on usefulness of sensitivities for screened compartments
  - Other minor clarifications and editorial comments included

Task 16: Fire PRA Documentation

- Covers the documentation of the Fire PRA by consolidating best practices
  - Suggested outline for main report
  - Suggested outline for supporting documentation
  - Compatible with that covered in ASME Standard for Internal Events PRA, BUT specifically addresses unique aspects of a fire analysis
- Only minor clarifications and editorial changes made as a result of public comments

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EPRI/NRC-RES FIRE PRA METHODOLOGY:
CONCLUDING PRESENTATION

J.S. Hyslop, NRC/RES

Bijan Najafi (for R. P. Kassawara, EPRI)

ACRS Fire Protection Subcommittee

May 4, 2005

Rockville, MD

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

INSIGHTS

- CDF Insights (in the author's judgment compared to IPEEE)
  - Expect overall range of CDF for fleet of plants to be maintained
  - Expect individual risk profile of some plants to change
    - Multiple spurious actuations, high energy arcing faults
    - Control room
  - Similar changes expected in risk rankings
  - Continued use of this methodology needed
- Cable tracing to support fire PRA still major resource requirement
  - Address via iterative, screening nature of fire PRA

STATE OF ART IN FIRE PRA

- Best available method to estimate fire risk and obtain insights.
- Improvements in state-of-the-art recommended
  - Spurious actuations
  - Post-fire HRA
  - Low power and shutdown operations
  - Plant-specific assessment of fire fighting

Verification and Validation of Selected Fire Modeling Tools

Presentation at the Nuclear Regulatory Commission Headquarters

ACRS Fire Protection Subcommittee Meeting

Rockville, Maryland, May 4, 2005

NRC/RES	EPRI:
Mark Henry Salley, P.E.	Bob Kassawara/Gary Vine
Jason Dreisbach	Bijan Najafi (SAIC)
Kendra Hill	Francisco Joglar (SAIC)

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Need for V&V of Fire Models

- The use of fire models is becoming increasingly important in a risk-informed environment
- Gain a quantitative understanding of the predictive capability of the models in typical NPP fire scenarios.
  - Significance Determination Process may use deterministic models in Phases II and III
  - Deviation/Exemption requests from licensees may use deterministic models
- NFPA 805 Section 2.4.1.2.3
  - Validation of Models. The fire models shall be verified and validated.

Background

- NRC/RES and EPRI is jointly developing a verification and validation (V&V) study for selected state of the art fire modeling tools
- NRR requested 5 tools be reviewed
  - FDT^{s} (NUREG 1805) spreadsheets
  - EPRI's FIVE-Rev1 spreadsheets
  - NIST's CFAST zone model
  - EdF's MAGIC zone model
  - NIST's FDS field model
- The V&V study follows the guidelines of ASTM E1355 *"Standard Guide for Evaluating the Predictive Capability of Deterministic Fire Models"*

Project Plan

- NRC/RES and EPRI joint report consisting of 7 Volumes:
  - Volume 1: Project overview and summary of results
  - Volumes 2-6: V&V of each fire modeling tool
  - Volume 7: Description of experiments
- Draft for public comment May 2005
  - 60 day public comment period
- Final Report to be issued December 2005

V&V Project Approach

- Compared experimental data with model simulations of experiments to obtain model accuracies

- Examined 13 different fire dynamics parameters:
  - Hot Gas Layer Temperature
  - Hot Gas Layer Height
  - Plume Temperature
  - Ceiling Jet Temperature
  - Oxygen Concentration
  - Smoke Concentration
  - Room Pressure
  - Radiant Heat Flux
  - Total Heat Flux
  - Wall Heat Flux
  - Wall Temperature
  - Target Temperature
  - Flame Height

NPP Fire Scenarios and Experimental Data

- Used experiments that were representative of NPPs and that were used by model developers for validation
- 26 different experiments for comparison
  - Control and Switchgear room scenarios
  - Pump Room scenarios
  - Turbine Building scenarios
  - Multi-compartment scenarios
- Evaluated the results of a modeling study done on the HDR experiments

Quantification of Accuracy

- Calculate an accuracy for each parameter in each experiment:

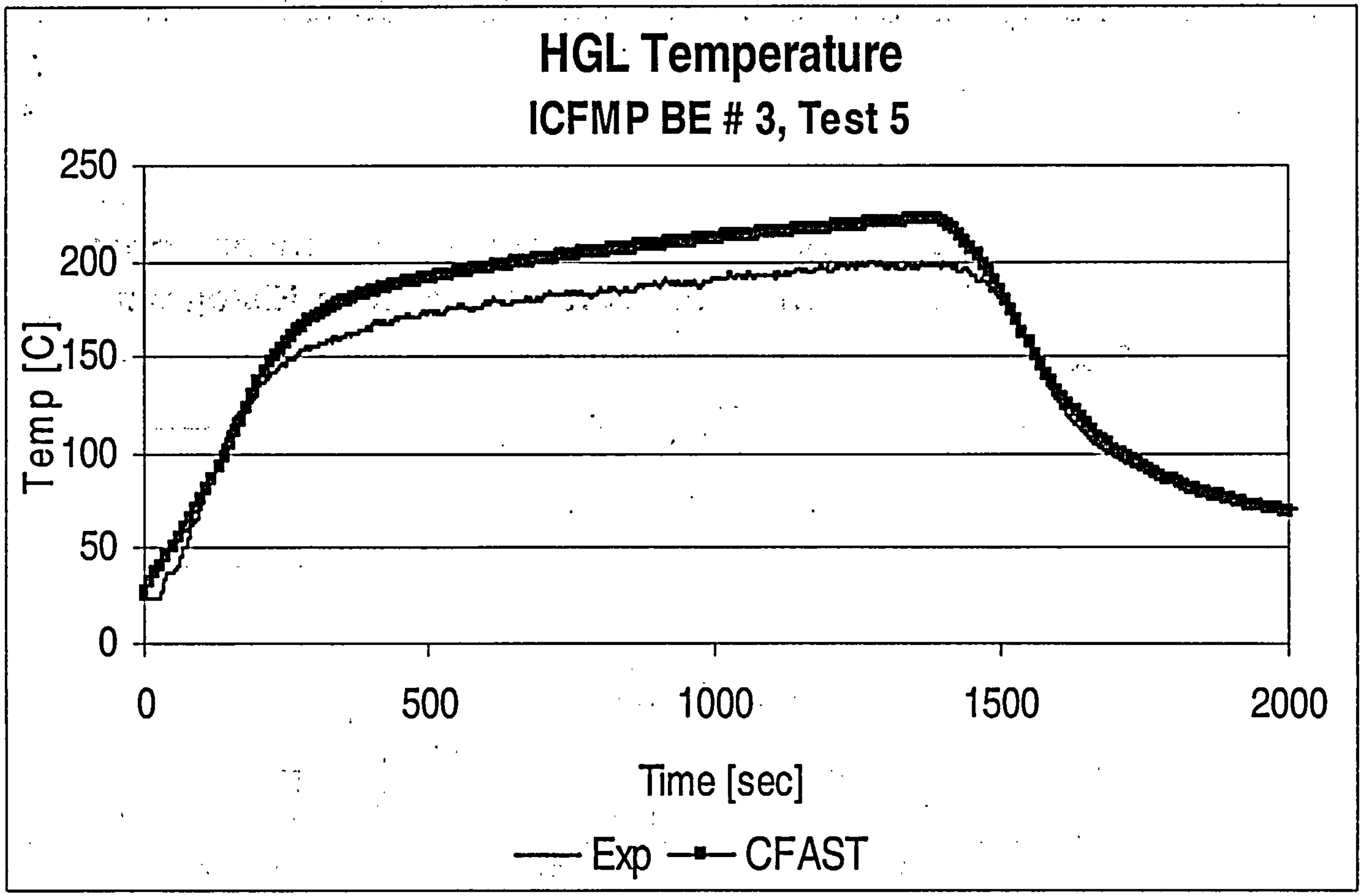
$$\varepsilon = \frac{\Delta M - \Delta E}{\Delta E} = \frac{(M_p - M_o) - (E_p - E_o)}{(E_p - E_o)} = \frac{M_p - E_p}{E_p - E_o}$$

- M_p: Peak value predicted by the model
- M_o: Base value (ambient) predicted by the model
- E_p: Peak experimental measurement
- E_o: Base experimental measurement (ambient)

Reporting Preliminary Results

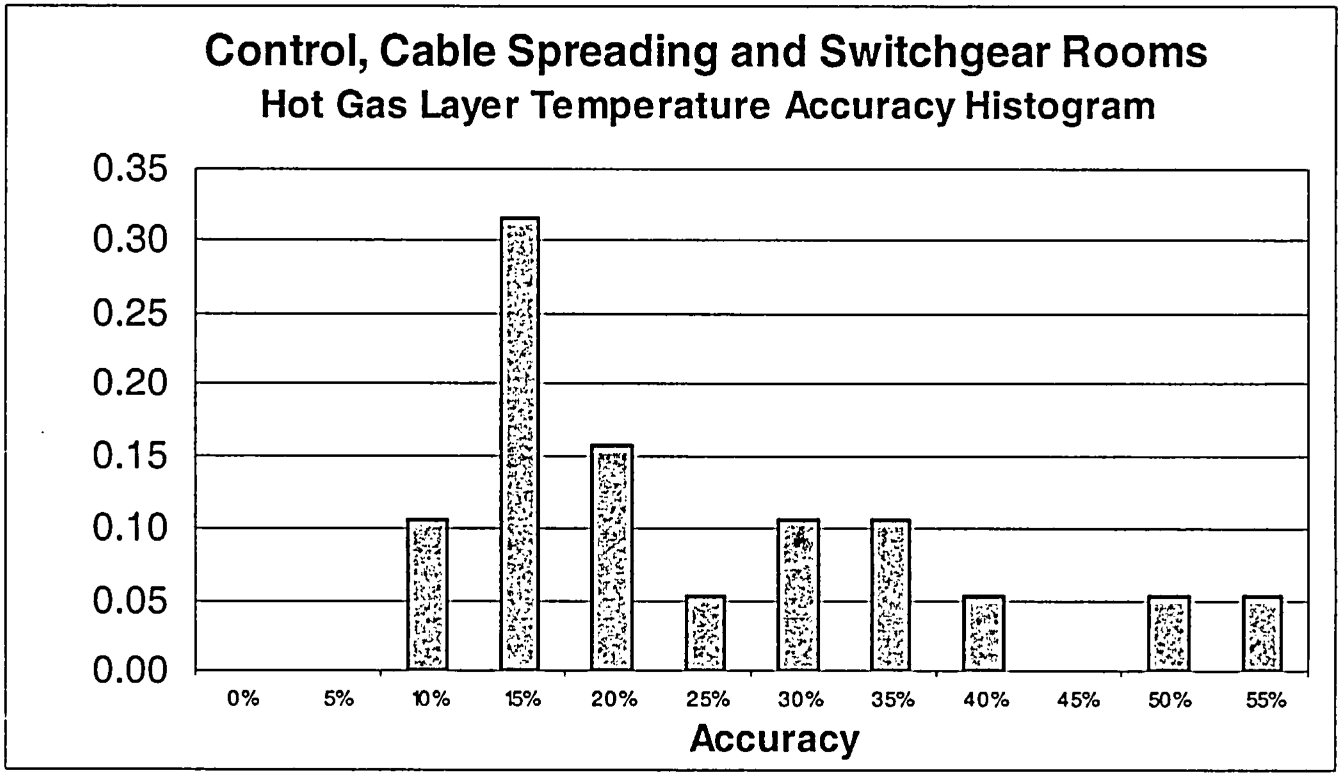
- Graphical comparisons of the experimental measurements and the model output
- Accuracies are classified by parameter and NPP fire scenario
- Histograms: A distribution of accuracies for each parameter for each scenario calculated from a collection of experiments
- Table of ranges of accuracies: The lowest and highest accuracies for each parameter for each scenario calculated from a collection of experiments

Sample Graphical Comparison



Sample Histogram

- Created histograms to summarize the accuracy data
  - Sample-CFAST

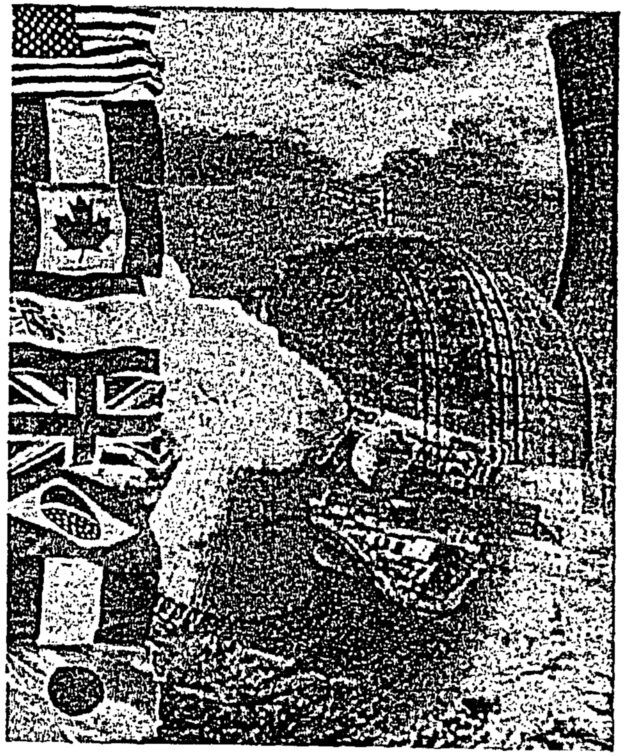


Sample Tabular Results

Configuration: Switchgear, Cable Spreading, Control, Battery, Diesel Generator, and Computer Rooms Geometry: 300 to 2940 m^3 compartment volume, door: 2-4 m^2 HRR: Results applicable up to 2 MW					
Computed Parameter	FDT[s]	FIVE	CFAST	MAGIC	FDS
1. HGL temperature	+ 32% to + 1460%	+ 9% to + 243%	8 % to + 54 %	- 17% to + 59%	
2. HGL height	- 36% to + 21%	See note 12	- 7 % to + 26%	+ 6% to + 20%	
3. Ceiling jet temperature	No Model	- 49% to + 170%	No Model	- 39% to + 42%	
4. Plume temperature	- 85% to + 8%	- 20% to + 196%	No Model	- 20% to + 89%	
5. Flame height	No Data	No Data	No Data	No Data	
6. Radiant heat flux to target (cable)	- 93% to + 170%	- 96% to + 171%	- 90% to + 150%	- 96% to + 169%	
7. Total heat flux to target (cable)	No Model	No Model	- 93% to + 32%	- 93% to + 144%	
8. Total heat flux to walls	No Model	N/A	- 1% to + 262%	- 53% to +54%	
9. Wall surface temperature	No Model	- 24% to + 401%	- 69% to + 256%	- 69% to + 147%	
10. Target (cable) surface temperature	No Model	- 24% to + 401%	- 35% to + 99%	- 72% to + 220%	
11. Smoke concentration	No Model	No Model	- 3% to + 613%	- 47% to -11%	
12. Oxygen concentration	No Model	No Model	- 16% to + 144%	- 62% to + 14%	
13. Room pressure	No Model	No Model			

Summary

- This is an important and technically challenging project
- External review by fire science and fire modeling community is essential



EPRI/NRC-RES FIRE PRA METHODOLOGY:

Detailed Fire Modeling – Task 11

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A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Task 11: Detailed Fire Modeling

- Scope: Define and evaluate specific fire scenarios
  - Single compartment fire scenarios
  - Multi-compartment fire scenarios
  - Main control room fire scenarios
- General approach follows traditional pattern:
  - Identify and characterize fire scenarios – fire source and target sets
  - Fire growth/spread/damage analysis including fire severity
  - Fire detection/suppression analysis
  - Final output is conditional probability of fire consequences given fire ignition

Severity Factor & Heat Release Rate

- Previous methods (e.g., IPEEE) used a fixed HRR and a fixed severity factor derived from review of fire records
  - No distinctions based on scenario-specific features
- New approach ties severity factor to a distribution on peak fire intensity
  - Severity factor based on percentile of the smallest fire leading to spread/damage
  - Accounts for variability in the peak fire intensity (heat release rate) – an aleatory uncertainty
  - Approach captures scenario-specific features such as distance to secondary combustibles, distance to targets, room size, etc.
- HRR distributions developed for various ignition sources
  - Expert judgment based on evidence from relevant fire events and tests

Fire Models

- Generally computational fire models are developed to estimate extent and timing of fire growth
  - This document does not recommend specific computational fire model

- There are fire scenarios critical to NPP applications that are beyond capability of existing computational fire models

"Special Models"

- High energy arcing faults (new)
  - Critical to switchgear room fire risk
  - An empirical rule set type model based on operating experience
  - High-energy phase, defined by a "zone of influence"
  - Thermal phase (enduring fire) treated like other fire sources
- Main control board (new)
  - Critical to control room fire risk
  - A probabilistic model for fire propagation inside the main control board
- Cable fires (modified from IPEEE approaches)
  - Critical to cable spreading room and cable tunnel fire risk
  - Fire spread in a single tray or cable tray stacks

Other "Special Models"

- Fire propagation to adjacent cabinets (consolidation)
- Passive fire protection features (consolidation)
- Hydrogen fires (new)
- Turbine generator fires (new)
- Smoke damage (consolidation of research – new risk analysis guidance)

Detection & Suppression Analysis

- Probability of Non-Suppression = conditional probability that fire lasts long enough to cause postulated damage
- Approach credits:
  - Prompt detection & suppression (by plant personnel or fire watch)
  - Automatic detection and suppression
    - Reliability (Generic)
    - Availability (plant-specific), and
    - Effectiveness (Scenario-specific)
  - Manual detection
  - Manual suppression by fire brigade
    - Model based on operating experience – fire suppression time curves
- Improvements over previous methods:
  - More rigorous review/analysis of event data
  - Explicit calculation framework (event tree)

Public Comments on Task 11

- Editorial/clarification comments including consistency with fire protection SDP, and NEI-04-02
- One reviewer recommended additional modeling method references – Our approach for referencing is:
  - Cite reference when a specific approach, value, or quote was imported
  - Cite references that establish link to an important historical context
  - Do not provide general references (not intended to be a reading list)
- V&V of fire models
  - NFPA 805 requires that fire models are verified and validated.
  - Our report documents fire PRA state-of-the-art – broader applicability
  - "Models" are cited when team consensus concluded need is critical, and identified method represents a reasonable approach and/or current best practice
    - e.g., the "special models" discussed previously
  - We did not V&V recommended approaches

Peer Review and Comments on Fire PRA Methods Project

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Peer Review Team, Joint EPRI/NRC Fire PRA Project

Duke Energy

Outline

- Positive Aspects
- Areas for Improvement
- Recommendations

Positive Aspects

- Team represents some of the best in the fields of Fire PRA, Fire-Induced Circuit Failures, HRA, Fire Modeling, etc.
  - Quality of the work reflects the excellent team.
  - Team focused on getting the right answer and developed the best product given the resources available.
- Process demonstrates that collaboration takes more time, but can result in a better product than if performed separately by the NRC or industry.

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Positive Aspects

- Final Product is a step-change improvement over previous methods:
  - Control Room Fires (untested, but promising).
  - Fire Ignition Frequency Methods and categories
  - Circuits and Multiple Spurious analysis
  - Scoping Fire Modeling
  - Fire PRA Human Reliability Analysis (again, untested, but promising)
  - Fire Risk-Quantification – New Accident Sequences and Initiating Events.
- New Fire PRA methods are a primary input to the ANS Fire PRA Standard, and are considered "State of the Art"

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Areas For Improvement

- Overall, Fire Procedures are Untested, and very few people have read all of the 600+ pages:
  - Scheduled to be used in 2005/2006.
  - Need to ensure procedures are improved based on feedback from sponsored and un-sponsored projects.
- Initiating Event Frequencies are still conservative:
  - 25% of Fires are Undetermined for Challenging Fire Criteria (results in ½ a fire).
  - 34% of fires labeled as Challenging, were conservatively assigned (Event 1322: Hot Sparks).
  - More recent data has better descriptions, and trends show lower fire frequencies. Part of this may be due to less conservatism in the categorization.
  - Many ignition frequencies are about a factor of 2 conservative as a result.

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Areas For Improvement

- Suppression:
  - Suppression involves a "generic" duration curve:
  - No way in the present method to incorporate plant specific attributes:
    - Continuous Fire Watches or occupied locations
    - Remote location or location near control room.
    - Had recommended using Upper Bound or Lower Bound valves for some cases: not incorporated.

  - Suppression curves based on Fire Duration:
    - Common to have fire brigade control fire without suppression (removing power, etc)
  - Issue is noted in Volume 1 of the Fire PRA Report.

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Areas for Improvement

- Circuit Analysis Probabilities:
  - Present probabilities are conservative estimates that a valve or circuit will spuriously operate.
  - Does not account for:
    - Direction of operation (open/closed).
    - Final position.
  - Issue is noted in Volume 1 of the Fire PRA Report.
  - Generally, values are a factor of 2 conservative. However, in rare cases, the values can be non-conservative:
    - Errors are multiplicative when looking at multiple spurious.

- Results: Sequences involving multiple spurious, long suppression times and Fire Initiating Events with a conservative frequency could be calculated with greater than a factor of 10 conservatism.

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Recommendations

- Ensure feedback from upcoming applications is considered and incorporated.
- Consider additional research in the areas discussed above:
  - Fire ignition Frequencies
  - Fire Duration
  - Spurious Operation Probabilities.

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