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NUCLEAR REGULATORY COMMISSION

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NRC HEAF PHASE II INFORMATION SHARING WORKSHOP

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WEDNESDAY

APRIL 18, 2018

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The NRC HEAF Phase II Information Sharing Workshop met in the 02A14 Classroom of Three White Flint, 11601 Landsdown Street, North Bethesda, Maryland, at 8:44 a.m., Michael Cheok, Deputy Director, NRR, presiding.

STAFF PRESENT

MICHAEL CHEOK, Director, Division of Risk Analysis, Office of Nuclear Reactor Regulation

THOMAS AIRD, General Engineer, Division of Risk Analysis

THOMAS BOYCE, Branch Chief, Regulatory Guidance and Generic Issues Branch

ROBERT DALEY, Branch Chief, Region III

STANLEY GARDOCKI, Program Manager, Regulatory Guidance and Generic Issues Branch

NICHOLAS MELLY, Fire Protection Engineer, Office of Nuclear Regulatory Research

KENN MILLER, Office of Nuclear Regulatory Research

MARK HENRY SALLEY, Branch Chief, Fire and External Hazards Branch

DAVID STROUP, Project Manager, Office of Nuclear Regulatory Research

GABRIEL TAYLOR, Senior Fire Protection Engineer, Office of Nuclear Regulatory Research

MICHAEL WEBER, Director, Office of Nuclear Regulatory Research

ALSO PRESENT

JENS ALKEMPER, FM Global

SCOTT BAREHAM, NIST

JANA BERGMAN, Curtiss-Wright

ROBERT CAVEDO, Exelon

FRANK CIELO, KEMA Laboratories

MARK EARLEY, NFPA

KENNETH FLEISCHER, EPRI

DANIEL FUNK, Jenson Hughes

FRANCISCO JOGLAR, Jenson Hughes

CASEY LEJA, Exelon

ASHLEY LINDEMAN, EPRI
DAVID LOCHBAUM
SHANNON LOVVORN, TVA
MATTHEW MERRIMAN, Appendix R Solutions
ALICE MUNA
FRANCESCO PELLIZZARI, EPM
ROD PLETZ, AEP
SUJIT PURUSHOTHAMAN, FM Global
ANTHONY PUTORTI, NIST
ROBERT RHODES, Duke Energy
BRENDA SIMRIL, TVA
THOMAS SHUDAK, NPPD
STEPHEN TURNER, Independent Consultant
BAS VERHOEVEN, KEMA Laboratories
BETH WETZEL, TVA

C-O-N-T-E-N-T-S

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

8:44 a.m.

MR. TAYLOR: Okay, we're going to go ahead and get started. For those in the room, just beware that there's some cords for the transcriptions and please be safe as you move about the room. With that, we already went over the logistics and the administrative stuff, so I will go ahead and turn it over to Mark Salley to open up and introduce him.

MR. SALLEY: Opening the meeting up -- thank you all for attending. And Mike Cheok, my division director in Research, is going to open up for us. So, Mike?

MR. CHEOK: Well, thank you and welcome to the Public Workshop on Phase II Testing of High Energy Arcing Faults, or HEAFs. And first of all, thank you for all your patience as we set up and we have some logistics, too, that came up. And as Mark said, I am Mike Cheok and I am the Division Director for the Division of Risk Analysis in the Office of Nuclear Regulatory Research.

So now, HEAFs is an important topic for us. And we would like to better understand the phenomenon and to better characterize the safety significance in nuclear power plants. It is also very important for us to reach out to you all, to all our stakeholders, to get your input as we move forward to the next phase of HEAF testing. So one of the lessons learned here in our first phase of testing was that we need to get stakeholder input earlier in the process to guide future tests. So your experience and expertise are important to us and we value it as we move forward to Phase II of the testing.

In addition to all the participants in this room, which there is a lot of, we have also a number of people on the webinar. I would like to point out that this week in France, their OECD nuclear energy agency's fire modeling program led by the French regulator of IRSN, is also meeting to discuss their current activities. So many members of their program are also members of the International OECD HEAF Program and many of them are on this webinar. So I know it makes for a very long day for those participants, and I want to thank them for taking the time to participate in both meetings.

As you will see from the agenda, we have more information to cover over the next two days. We encourage your active participation and your input into each one of these sessions. So, starting with it in mind, this slide shows the desired outcomes from the workshop. First, we hope to develop clear and concise definition of the arc flash and the HEAF phenomenon. We will work with you as experts in the nuclear industry and as well as from the National Fire Protection Agency, NFPA -- NFPA Factory Mutual and KEMA Labs to develop definitions that are consistent with the needs of the nuclear community and with the commercial industry as well.

Next, as I have mentioned earlier, there was a lot of discussion about the Phase I testing, which said that on testing -- that the test needed to be more realistic and representative of what was found in nuclear power plants. So our second desired outcome as far as to get your input towards Phase II testing. We will discuss the proposed test parameters and methods and we hope to accomplish -- and what we hope to accomplish for Phase II testing. Then we will open up the discussion to your opinion, insights and input. We will include the new and relevant information that's made available to us during this workshop.

Finally, I would like to mention that Mike Franovich from the Office of Nuclear Reactor Regulation and I are co-chairs on the panel for the ongoing pre-Generic Issue on aluminum HEAF. The NRC's generic issue process is a phase process where we evaluate the issue is safety significant enough and if there are generic implications to warrant further study or action. We hope to get additional information from this workshop and from subsequent testing to help us inform the resolution of this issue on aluminum HEAFs.

So, again, I thank you all for taking the time to support this workshop. I know your schedules are very busy and demanding. So I appreciate the interest and you attendance today. Your insights will help us perform the necessary research needed to better understand and resolve the issue in more than high energy arcing faults. I am confident that the results from this project will be useful for guiding the safety decisions for both the nuclear and commercial industries. Thank you, and I will hand the proceedings over to Mr. Mark Henry Salley who will lead us through the rest of the workshop. Mark?

MR. SALLEY: Can Nick and I go back and forth?

PARTICIPANT: Let me turn this off so we don't get too much feedback.

(Pause.)

MR. SALLEY: All right, thank you very much for coming in today. We've got some special guests, Mark Earley from the NFPA is going to be with us at a presentation. We got Bas from Netherlands all the way from -- what? Netherlands? Going to give us a presentation. He runs the KEMA lab over there, which I guess is the mother ship of the one that we work with in Pennsylvania. And also, Ashley -- I see Ashley got a presentation for what EPRI is going to be showing. In addition to that, we've got a lot of NRC folks to talk -- N.J. Taylor, Nick Melly, Stan Gardocki is here, he can talk about our Generic Issue Process. And we've got Kenn Miller back there. He is going to talk about some of the work we're doing with the definitions. So I'd just like to introduce -- if everybody just go around and introduce themself here to get started. If we could, Gabe?

MR. TAYLOR: Gabe Taylor, Officer of Research, NRC.

MR. MERRIMAN: Matt Merriman, Appendix R Solutions.

MS. BERGMAN: Jana Bergman, Curtiss-Wright.

MR. TURNER: Steve Turner, Consultant.

MR. BAREHAM: Scott Bareham, from NIST.

MR. PUTORTI: Tony Putorti, Fire Research at NIST.

MS. WETZEL: Beth Wetzel, TVA.

MR. CAVEDO: Rob Cavedo, Exelon.

MR. LEJA: Casey Leja, Exelon.

MR. RHODES: Bob Rhodes, Duke Energy.

MR. JOGLAR: Francisco Joglar, Jenson Hughes.

MR. FUNK: Daniel Funk, Jenson Hughes.

MR. ALKEMPER: Jens Alkemper, Research, FM Global.

MR. PELLIZZARI: Francesco Pellizzari, EPM.

MR. PURUSHOTHAMAN: Sujit Purushothaman, Research, FM Global.

MR. GONZARIO: Tony Gonzario, NRC Office of the Chairman.

MR. DALEY: Bob Daley, NRC, Region III.

MR. MILLER: Kenn Miller, Office of Research, Division of Engineering.

MS. SIMRIL: Brenda Simril, TVA.

MR. LOVVORN: Shannon Lovvorn, TVA.

MR. STROUP: David Stroup, NRC Office of Research.

MR. GARDOCKI: Stanley Gardocki, Office of Research, Generic Issues Program.

MR. MELLY: Nick Melly, Office of Research.

MR. SALLEY: Okay, thank you. Oh -- yes.

MR. EARLEY: Mark Earley, NFPA.

MR. CIELO: Frank Cielo, KEMA Laboratories.

MR. VERHOEVEN: Bas Verhoeven, also KEMA Laboratories.

MS. LINDEMAN: Ashley Lindeman, EPRI.

MR. FLEISCHER: Kenn Fleischer, EPRI.

MR. SHUDAK: Tom Shudak, Nebraska Public Power.

MR. PLETZ: Rod Pletz, American Electric Power.

MR. SALLEY: Okay, and we also are doing this on a webinar. Who do we have on the webinar?

(Off-microphone introductions.)

MR. MELLY: Thank you. All right, mute the line. We will have a few people joining in occasionally at the webinar, like we mentioned earlier. There are some time differences and some meetings going on in Europe right now. Many of the members for the OECD Program are -- have that conflicting meeting. So they will be joining in occasionally throughout the meeting.

MR. SALLEY: So, again, we are doing it with -- live here. Sorry the room is small. We had a little trouble booking it, but I guess it will be -- it will be comfortable. But we are doing this via the webinar. You folks on the webinar, if you would email your information to Tom Aird and he will get that for you there. Also, this meeting is going to be transcribed. We figure there is going to be a lot of discussion, especially tomorrow. So we wanted to make sure that we captured everything. So as we look at the test plan moving forward, we can go back to remember what was said and to get the input. So again, we are going to transcribe this. So when we do get to the discussion piece, if you could introduce yourself before you speak, it would be easier for the court reporter to do the transcription. And again, our end goal is -- we've got a lot of good presentations. And I look at some of the stuff form EPRI and the NFPA, and I am sure the stuff from KEMA is going to be top-notch. So we wanted to capture that. We are looking at doing a NUREG/CP. A NUREG/CP is a conference proceeding. So it would be a standard NUREG with all our presentations and anything that comes out of this meeting in there. So again, we can capture this and use this moving forward with the HEAF Program. Next slide, Paul?

MR. MELLY: And like Mark said, we do have a microphone in the back of the room. It would be beneficial today if anyone -- any -- for any discussion -- so the people on the phone can hear you if you use that microphone when -- while asking any questions today.

MR. SALLEY: So, the purpose of this meeting, again, we have a number of things we would like to accomplish. We would like to share with you what we've learned to date. Different people coming into this -- this program at different points, so we'd like to bring everybody up to speed with what we've got, what we've done and where we're at. As Mike said, very important -- as the NRC is a transparent agency, we'd like to solicit your input as we move forward. That's very valuable to us. You guys are the ones who read the plans, doing the work and that information is very valuable as to how to move forward.

Again, we want to learn from each other. And we've reached out to people like the NFPA who have done a lot of work in this area. I think we can gain some of that. FM Global is here and I hope we can get some insights and information from you also. Again, we have the meeting going on in Europe at the same time. We look to move forward with our partners as we did in the first phase, which we will talk about in a little bit. And again, the Generic Issue Program -- you know, you guys are familiar with plans with generic letters. Generic Issue is a different thing. We haven't done one in Fire for a while. So it is going to be worth a little time that Tom Boyce and Stan are going to walk us through the process. I know there is -- when we issued the information notice, there was a little bit of apprehension -- okay, what comes next? What do we have to do? And again, we put this into the Generic Issue Process, which is a very formalized process the NRC has had since the 1970s and I think it's worth Stan walking you through, so that will explain how this is going to work out in the long term. Next slide?

So we broke this presentation down, basically, into two days. We could have done it in a week, there was so much to cover. But we thought two days would be about right. They're going to be long days, so I hope you're all up for that. The first day we wanted to really share a lot of information with you -- wanted to get you up to speed where we're at. The information we've done to date and get a lot of those presentations.

The next day -- the second day -- the second day we look for a lot of interaction with you. And that's where we really want to have -- after loading everything up today, you think about it tonight, then tomorrow we have a lot of good discussion as to how are we want to look at that test plan, and how do we want to move forward? So today is going to be a fair amount of getting presentations, getting information down. Second day we'd -- like I said, we would really engage for a lot of discussion.

Path forward, again, we've put our test plans out. You've seen them in the Federal Register. We've gotten a number of comments on them. We've also got some small-scale testing we're looking at doing with the lightening research out at Sandia. And that test plan is also out there again. Again, we're soliciting information, comments from you on that so we can get the -- the best product we possibly can. And again, we'll work with our partners over in Europe and Asia in the second phase of OECD Program. But again, we want to -- we want to do this in a methodical manner. So, we'd like to have this well thought out and well planned.

We haven't procured our equipment for the second phase of testing too much yet. We've got a little bit from some of our European partners. We haven't drawn and done that. And again, the second day, tomorrow, I hope there are a lot of electrical engineers who can really give us some insights as to what we need to look at for the -- for the biggest bang from our buck as far as doing the testing. We were hoping to get a test off in the fall, that was our target -- it still is. However, with the international agreement, the OECD -- OECD, the NEA and our legal departments, there's some questions on some wording that changes with the international agreements that truthfully -- like everything, our lawyers need to work out before we can move forward. So, right now, our agreement with working with the international group is with the lawyers. So, we would have worked that through the process.

Again, at the end of the day, in the long term, what do we want to do? In the nuclear area -- you guys are all familiar with those things in depths. Where we use a defense in depth principle, and that's who we like to do things. I don't see the HEAF issue as anything different -- with the elements like we do in Fire Protection and other areas, we always want to do the preventive activities if we can. If we can't prevent it, we want to detect it and mitigate the hazard. And if we can't do that, at the end of the day, we need to start a safe shutdown for the reactor. So again, I see this process as it evolves over time with different parts of the testing feeding into different parts of this, operating experience, et cetera -- as we develop a defense in depth process moving forward.

Last line as we get started here is the NRC -- our mission is safety, you know. So there's our statement. And again, it is about protecting the public, the environment. Safety is our business. But I will tell you something else about -- that I've learned doing fire research is fire research is bigger than the NRC, it's bigger than the nuclear community. Things that we learn in fire protection we can reach out and share with our other partners. For example, one of the things Nick and I do with this program is the thing called the Federal Fire Working Group. So all your three- and four-letter agencies belong to that -- NASA, DOE, DoD. And we get together once or twice a year and we share what's going on in our area. The last two years Nick and I have been sharing what we've been learning about the HEAF with that larger federal community with the idea that these HEAFs are not -- or, these arc flashes are not unique to power plants. Anybody who is using electricity has this same thing. And we see a lot of this in the general industry as Mark Earley is going to share with us later. So again, if we can benefit the greater area and greater good, we are all for that. Again, partnering with those NIST and that -- we can get this information out to different areas.

So, with that being said, the first thing we'd like to do is a quick review of what we've got.

MR. TAYLOR: Yes, while Nick brings that up. One thing I did want to mention, for those on the webinar, if you have questions -- and this is a category three public meeting, so it's kind of a free-for-all. There is no designated time like a category two. But for those on the webinar, if you have a question, there's two ways to bring it up. One, you can text a question into the webinar box and our webinar controller will then bring that question up. Or, two, you can raise your hand. And then the webinar controller will un-mute your line and you can then ask your question that way. For those on the webinar, two ways to bring up questions.

MR. SALLEY: Thank you, Gabe. So quickly, moving forward here, we are going to give you a Reader's Digest of what we've done over the last six, eight years and where we're at with -- with this program. A key to this presentation is that this really is -- is the roadmap of where we're at and this is the reference. There is a lot of links in here to different reports. If you want to download them, they're all publicly available on the web. You'll also see a thing -- ML. And when you see that ML, that ML number is the NRC's document control system. We call it ADAMS. And those are the identifiers for the documents to bring it up. So again, you can find us on the NRC's public web page. Any of the ML numbers will be the identifier that will bring that report, that memo or whatever that document is for. So again, the key to this is to do a review for you and it's also the Reader's Digest version of all the references of where we're at. Next one, Nick.

So, when we started this, we first looked at getting going for this, we looked at the document NUREG/CR 68-50, this is EPRI 1011989. It was a joint project we had done with EPRI a number of years ago. Francisco is here. He was very intimate with that back in the day when that was written. He can answer a lot of your questions.

But again, this was a chance for the industry and the NRC to work together to develop a five PRA method to do a five PRA for a nuclear power plant. So it's a very big document. It's got a lot of different things in it. And it was one of the first times where we really identified the HEAF and said, hey, this is a -- a hazard that you need to look at when you're doing your risk analysis for your power plant. And they had done some work on it. And looking at the enclosures, as we're going to see here in a little bit, that we had postulated two types of failures. You could have the thermal failure where an electrical enclosure caught on fire and caused damage. Or you could have the explosive force of the HEAF. So it was a -- a binary thing.

Cutting ahead a little bit, as we've looked at that and we started down that road, we've kind of put it in neutral for a little bit and we stopped because some things that we're going to talk about here in a little bit, that Nick's going to discuss, is that -- and again, this gets to the testing. Not every time we have an electrical failure does it immediately go to a HEAF. There's other things that happen in there and things we're learning from the NFPA where they have arc flashes, arc blasts and HEAF. And we're going to get into a discussion on that.

So this is a point where we've learned something going through the process, kind of want to slow it down and stop it for a second and get a little more resolution.

Next slide? This is a slide that Kelly Gosing (phonetic) presented at our RIC conference this year. She's from EPRI. And it looked at the hazard that we see in the power plants from the different risk drivers. And you can see in the back, you can call this is a skyscraper -- skyline?

MR. MELLY: Skyline, skyscraper chart.

MR. SALLEY: Yes, skyline chart -- you'll notice that we see the big risk driver is from the thermal fires in the electrical enclosures. That's the lines in the back. Moving forward a little bit you'll see that, I think, number three on there is the high energy arc faults. So again, as far as the risk in power plants, this is something that's important in a risk-informed environment this is something we want to look at. This is something we really want to understand. Next slide, Nick.

MR. MELLY: Moving forward we kind of wanted to provide the background, history of all the links and things like that that Mark mentioned. And you'll see here that we provide a link to all the documentation that we're going to be discussing throughout the workshop. Starting with NUREG-6850, it provided the methods for doing the Bin 15 electrical fires as well as the Bin 16 -- the high energy arcing fires. One of the lessons that we learned is that our -- Bin 15 is fairly broad. It encompasses all electrical enclosures. And for the Bin 16, the high energy arc faults, it's a one size fits all model. So having a very broad BIN for all electrical cabinets, using a one size fits all model proved to be a problem when there's not much that you can do to mitigate the effects of the high energy arcing faults. So one of the things that we're kind of focusing on with a couple of our presentations as well as -- YMPA is here and the discussions that we've been having with them -- is to really define what we mean by the high energy arc faults and separate them into appropriate BINS with the appropriate frequencies that you can use in your

PRAs.

One of the other major efforts that we've done recently is the HELEN-FIRE work as well as our RACHELLE-FIRE work. It was a focus on looking at Bin 15 and creating realistic heat release rate profiles associated with them so that we could advance the main risk driver that we saw from that skyline chart. A lot of this work was done with EPRI and it has been done as relatively -- a success in advancing the state of knowledge. And that focused directly on the thermal fires associated with electrical cabinets and did not take into account the electrical energy associated with the fire itself. It may have started the fire, but it wasn't a prolonged electrical event.

This is the second part to that. The HELEN-FIRE report that was on the previous slide was the actual testing program, which was done with NIST, testing over 100 electrical cabinets to evaluate the heat-release rate profiles. And the follow-along was done as an expert panel to create appropriate Bins and do the application of that research. And as we discussed earlier, we are really going to try and focus a lot of our effort on the subdividing Bin 16 into the appropriate Bins. As we'll see in our further definition -- or, further presentations, we are going to be looking at separating the terminology for arc flash, arc blast and the high energy arcing fault. And we want to link that with how we are going to be doing the modeling.

So again, we are going to have another presentation from NFPA on their work in this area. A lot of it is primarily focused on personnel protection where we have a little bit different mindset moving into the protection of a plant and plant equipment in PRA models.

MR. SALLEY: And keep your -- keep your eye on these slides, this pictures, in the back of your mind because, you know, the picture is worth 1,000 words. When Kenn Miller does his talk about these differentiating -- how we are going to differentiate the categories between an arc flash and a HEAF, this will be in -- a lot of this in more detail in Kenn's presentation. So keep these pictures in mind as Nick goes through it.

MR. MELLY: Yes, and to kind of explain these pictures at a high level is that, whenever you have the breaker trip or these flash events, a lot of them go into the Bin 15 fires where it may have -- you failed circuit protection, or you had a short or a fault in your cabinet, but it doesn't lead to this large damage state that we're seeing. It can just generate a small fire in the cabinet, or no fire at all. Typically, that's going to be in Bin 15.

Another category that you can see is that you have this blast -- where you have the pressure effect damaging things in the room. What you're seeing on the screen right here is the event that happened in 2017 at Turkey Point where you don't see that large cabinet damage. There was a pre-phase fault in this cabinet, lasted for approximately half a second, which was a success of their circuit protection -- or, operated as designed. But you still saw that we had -- that there was a breach of the fire door from the over-pressurization in the room. This fire door was located 15 feet away from the cabinet of origin -- so clearly outside the three-foot horizontal distance that's currently in 6850, but again, you saw that breach of the door into the 4B switch gear room. So essentially, you -- you had a area breakdown between a 4A and a 4B, which can be a potentially serious problem.

Again, another instance of this, you see Brunswick in 2017. You see that severe cabinet deformation from the pressure wave, but you didn't see this large damage effect that's in 6850 upon exam, and you don't see then, during fire condition. So these are the things we kind of want to focus in on moving forward, how we create the frequency of these events occurring.

Some of the more classical examples of what you do see as HEAF is the San Onofre fire in 2001. This is a SONGS event. This is essentially what was used to model what's in 6850, Appendix M. This event was well documented and gave the authors of 6850 a good picture of what they were trying to prevent with this damage state. So that's kind of what led to the three-foot, five-foot and the caveats that is in Appendix M of 6850. You see on the right-hand side, this is the damage associated with the Onagawa event in 2011. From the earthquake itself, they had a hanging magnet blast breaker that created -- stads (phonetic) got crossed up from the shaking of the earthquake itself. This plant was the closest to the epicenter, so it did have the highest ground fall acceleration, and you saw that problem. This fire lasted for seven hours because the onsite brigade couldn't get into the room. It damaged seven pieces of equipment and it was a very difficult fire to fight. If Fukushima wasn't occurring, this is probably what would have been in the news headlines.

And again, it's not only the electrical cabinets that we're worried about. It's also the bus ducts. You see these two events from Diablo Canyon and Columbia, where you see the large damage states. There was approximately eight feet of bus ducts and four feet of the bus bars inside the bus duct that were damaged here. And you also see that this kind of brings up the problem of aluminum that we're currently facing and looking at in the generic issuing program. You can see in the Columbia bus duct event, you have that -- everything looks like it is white-washed around the event, and that's because in this event the bus ducts themselves, as well as the enclosure, was made of aluminum. And again, I mentioned four feet of the bus duct conductors and eight feet of the enclosure was vaporized during this event, and it had a lot of people scratching their heads in the root cause analysis.

The center picture you see is the Zion bus duct that we tested in 2016 where we vaporized seven inches of the enclosure material and one-and-a-half inches of the conductor. We will see a video of that moving forward that you can kind of keep in your mind -- the energy associated with the release of this amount of material. One of the other important aspects that we're going to really dive into tomorrow during our discussion is the duration that's associated with how we test these events. Electrical protection comes into play -- it's extremely important in the durations of -- a primary driver for how much energy is released during the event. We are trying to base it off operating event history that we actually see in these plants, and this is one piece of information that we want to do better on in the future at collecting how long these events actually last in the plant. Some of the information is a little hard to find on -- in LER information and the condition reports. But it's something we want to do better on and dig deeper into so we can inform the testing program.

This is just a sampling of some of the events that constitute the Bin 16 high energy arcing faults. And you can see the duration of these events is longer than you would normally expect if your circuit protection works. Like we talked about at Turkey Point, that was half a second, which is fairly long for a successful operation of a breaker, but we do see these events occurring. We range anywhere from two seconds that we typically see, to the Fort Calhoun, which is a little weird of an event. It was a low-voltage system that was holding in on an upstream transformer that did last for 42 seconds until operators actually manually terminated the event. And we can look at some pictures of the damage associated with that event moving forward. Again, that was an aluminum event and there's some indication that it may have led to some -- a conductive environment that led to later faulting.

MR. SALLEY: So duration is going to be one of the topics, I guess, that we're going to discuss a lot tomorrow. And then we will be looking for a lot of your input. Swinging back to the regulations a little bit on how we -- the NRC regulates the plants -- the safety significance of this, is we have a thing, Appendix A to 10 CFR 50, which is a code of federal regulations. Appendix A is the general design criteria. And there's two of them that apply to this area, GDC 3, of course, is fire protection. And for the fire hazards analysis done by the Fire Protection engineers, one of the key things is that you'd postulate the fires and explosions. I guess the question comes of how rigorous in that FHA were you at postulating explosions from electrical equipment? And it was easy to do the hydrogen and different things in the plant, but the question comes up, do we consider -- consider the heat for the electrical?

And the other area, GDC 17, that's for our electrical engineering colleagues. And again, that's the single failure that should prevent these type of events. So again, this is codified in the regulation. And again, it will tie back to the work Stan's doing with the Generic Issue Program.

So how do we -- how did we get into this, and you know, what brought this up? And I like to think of this with what we're doing as almost connecting the dots. We belong to the international group we talked about, the OECDNEA. And we work a number of programs internationally sharing safety information. One of the things we look at is the Fire Events Database. And it's a -- it's a fairly inexpensive program. It's a good program for the NRC. The part that I like about it is that we can look at the events that we've had -- the LER, licensed event report fires, which are typically between three and nine a year. We can look at those fires. We can take that to the international community and say, hey, we've had this, this and this. What are you seeing in your plants? Is there something we're doing wrong or unique in the United

States that you've done better in Japan or Korea or Germany or France? Or, are you seeing the same type of events that we are?

And when we first brought up the high energy arc faults, it was interesting because all of the sudden, everybody started saying hey, we've had one or two of those. And we all started exchanging information. So we saw it that this wasn't something that was unique to the United States nuclear plants, but we were seeing this worldwide. And then when we started tallying it up and we started seeing that, hey, of all the fires that we're talking about in this group, ten percent of them are HEAFs. Wow, how much do we know about this? Not that much. This is a significant issue. Do you think we ought to do some research to do something with this? And everybody, pretty much, around the table agreed, yes, this is a -- this is a risk driver that we need to think about and we need to do some work on. So this was the genesis for bringing the High Energy Arcing Fault Program and why we went with the international approach in what we saw here.

MR. MELLY: And in the most recent database update that we're going to be completing later this year, that number has jumped to 64 out of a -- I believe it -- we're at 475 events. And again, it may be skewed a little bit in this ten percent because everyone reports these events. There's no chance you're missing a high energy arcing fault occurring in your country because they're typically the larger fires that have severe consequences and difficult plant shutdowns associated with these events as we see in our history as well.

MR. SALLEY: So we started doing some work in that area and one of the other groups picked it up -- one of the risk groups -- and they started looking at the methods. Okay, so you see these events, how do we postulate this event? How do we do the analysis? And basically you can read the report, but it all comes back to what we had done with Francisco and company and 6850 and the Appendix M. And that seems to be about the state of the art, the best information that's out there. A little additional work the Canadians put into this report, and again, the key here is for you, there's the links, and you can download all this.

Again, with our testing we hear realism. You know, everybody wants realism in PRA -- realistic tests, realistic -- so that's kind of where we're going with this. We're not trying to do worst case, conservative tests, but again, something that's realistic that we can get a realistic model, an accurate model and we will be discussing that at some of the later presentations as to -- to what that is going to take.

MR. MELLY: Again, we are going to quickly go over these because we are going be touching on them later -- primarily in the discussion phase. But a lot of the comments that we've received on the initial Phase I of testing was that we -- plants do not see these three-phase faults like we are initiating in the program at KEMA using the IEEE standard wire to initiate the faults. We went back and reviewed the LERs and we do see that while the event may occur phase-to-phase, or phase-to-ground initially, that the ones that last for a long period of time quickly progress to a three-phase fault because of the ionization with the cabinet itself.

So we do see these three-phase faults occurring in event history, and that's what we're trying to recreate in our test program. Again, the over-pressurization is something we're going to be taking an enhanced look at in the second phase. We did collect pressure information in the first phase of testing. However, there was little that could be drawn from the pressure information that we collected to extend to how it would affect a enclosed room. So that's something we're going to be looking at moving forward because of the Turkey Point event, as well as some events that we've seen internationally where we have breached fire doors. We did see this in 6850, one of the -- I believe it's Event 3 in Appendix M -- did breach a fire door. However, there was -- again, no associated enduring fire with that event, so it wasn't a main area of focus.

Mr. SALLEY: So, let's talk about how we're going to do this testing. And in this testing, it's quite interesting -- it fits kind of where we are in our money and research. This isn't something that I can take NFPA 2519 and say I am going to test a firewall or an assembly and we have a well-established standard on how to do that testing -- for fence seals, fire doors, building construction. For looking at things like the HEAF, we have no standard. So we are kind of venturing off in the unknown here. The closest thing that we could find -- a lot of the work that was done by the IEEE and the NFPA was done for personnel safety. And again, the goals are personnel safety versus reactor safety are somewhat different. And in their test they had to be a little a shorter. Again, they were looking mainly at the things you guys are familiar with -- the PP that the electricians wear when they are servicing the cabinets in the plant. And that's where we've seen all the research. And it's good research. I mean this is a significant hazard. You can see a lot of different numbers out there if you're reading the safety journals where I think there's -- they postulate -- the last journal I looked at, two people a day -- two workers a day in the United States die because of electrocution. So that could be in the plants working, and it also got the guys who are working on the high-tension lines outside.

So it's a significant number. It's something that needs research. And that's where the work was done. Of course, with reactor protection, we're looking at something different. We're looking at protecting the plant. We're preserving the diversity and redundant systems. And we have a different problem in the nuclear environment. So we set our tests up a little bit. And again, we're inventing as we go. And we hooked up with our partners in NIST. Tony and Scott are here. They've done a lot of the testing with us as well as the expertise from the labs like KEMA to help guide us. And a lot of the things we tried didn't work. And we moved along as we went. We also had Sandia work with us a bit.

So here was our basic set up that we came in for the first days of testing. You'll notice the piece of equipment is in the center that we're going to fail in the test. We put up racks and we set the racks up specifically at three foot. Why three feet? Because our model in 6850 says that anything within that three-foot window should be damaged. Anything three-foot-one-inch should be safe. So we set our instrument racks with our slug calorimetry on it to get a measurement at three foot.

We also did some things that we thought would be observable. For example, you will notice the cable tray that we set above the top. You know, you can equate this to ASTM E-119, how we used the cotton waste on back of the firewall to make sure that we don't get emission during the test. The same thing here. We says, hey, typically we find that the enclosures -- you'll find cable trays above it. What do you say we put some cables above it and see if we get emissions in the cables. That will give us an indicator of the -- of what's coming off the HEAF.

One area that we tried real hard was the collection hood. And this is something, again -- us being fire protection engineers, we fall back to what we know. We like to talk in terms of heat release rate to describe the power of a fire. The way we do that is we put the capture hood up. We capture the energy that comes off and we can go and say how big the fire was in terms of it. So we set a portable hood up and we tried to capture that.

Final thing we did was a lot of cameras. And we've got a lot of high-speed videos we tried. We've got some infrared stuff that we're working with NIST to -- we'll have a report coming out shortly this year that shows some of the IR work we'd done. And just the regular camera work. And that tended to be some of the most valuable stuff we saw. So again, it was very much of a learning experience for us as to just how do you do this test? So this is a basic setup you're going to see. We're going to run through a number of videos here, and Nick is going to show you what we learned in the first phase of testing.

MR. MELLY: I'm trying to get this set back up because we can hardly hear it. Okay, so let me walk you through this before I do show the video.

As Mark did mention, you see the heat-release rate hood that you have there. You're going to notice from the test immediately that this hood is completely overwhelmed by the amount of smoke that's created initially on the event. So, while the hood was valuable in collecting heat release rate information for the enduring fire, the initial blast -- there's just no way that we can create it at a -- a non-fully enclosed laboratory that has a much larger hood.

There were also some limitations at the KEMA facility of what we can do. Again, this is open air in -- right outside of Philadelphia in a suburb, and there's a Metro line running directly behind the facility. Whenever we tested, coincidently, the train was always there. We got a lot of calls to the fire department and a lot of shocked people. So this test -- this is test 3, one of the first tests that we ran on a Korean-donated piece of equipment. We initiated the arc in the back of the center cubicle using the three-phase, IEEE guide wire -- it was a 10-gauge wire that we used for this test for a low-voltage power standard.

This cabinet itself was built very sturdily. The insulate -- it is '70s vintage -- '60s vintage. The insulation material is actually mahogany wood. This thing was battleship grade. So you will see this test was run at 35 kA for eight seconds. This was a low-voltage, 480-volt cabinet. Again, all copper material inside the cabinet. The sound is not coming through quite well. Do we need to do something to get it to come through the room? All right, we'll just role.

So you can see it's an impressive looking test. You see the flames and everything shoot out. The arc did hold in for eight seconds, which was a problem for some of the low-voltage cabinets. You see the amount of smoke that's initially created. And you can see the problems that that would case in a switch gear room itself. You're immediately filling the entire volume with smoke. It's very difficult to fight these fires.

Again, that is the color of the smoke. It was a dark black smoke with this event. And you will notice the difference when we look at the aluminum. For this event, and other low-voltage cabinets that we saw with copper -- for this specific event we did not breach the cabinet itself, even though the arc was fairly close the exterior barrier. We had no arc through and there was very limited damage. Again, this was early on in the test program when we were thinking this is a good sign, we have a very clear way to differentiate low voltage and medium voltage, potentially, moving forward.

Moving on you'll see some of the -- this is a German cabinet. We tested 10 kV, 15 kA, three seconds. This was an oil-filled breakers that were donated. We did have to remove the oil for concerns of the explosion associated with vaporizing the oil itself during the event. Again, copper bus bars and we have the cable tray above this cabinet. And the three seconds was very close to the KEMA limit on what their generator can perform for this type of voltage test. There's some wiggle room. We've been talking with them about what we can do. But again, that three seconds is close to what we can do. So when we talked about the operating experience at the Robinson, eight to eleven seconds at this type of voltage level cannot create that at the KEMA facility.

(Pause.)

MR. MELLY: Again, this test was one of the medium voltage. You see that immediate fire condition. We immediately ignited everything within the cabinet. The cable tray that was above the cabinet reached full ignition within 30 seconds after the event. So we had a fully involved fire 30 seconds after this event.

PARTICIPANT: What was in the cable tray?

MR. MELLY: I don't know off the top of my head what type of material. I believe that it was -- is Gabe in the room? I think it was thermo-set cable above the cabinet. But I'd need to confirm that.

MR. SALLY: Scott, Tony, you guys know?

(Simultaneous speaking.)

MR. MELLY: PEPVC.

MR. SALLEY: It was some new PEPVC.

MR. MELLY: So now we are moving on to some of the later testing. This was the cabinet that had aluminum in it. This was tested 480 volts, 40 kA for seven seconds. We initiated the arc in the center of the cabinet -- right about there. And we did see the arc migrate to the more substantial portion where there was more aluminum. Again, our rack is located right here at three feet.

(Pause.)

MR. MELLY: So I am going to pause it here, and you can see the color of the smoke is completely different than we saw in the other events.

After this event itself, you see -- we saw the entire KEMA facility essentially white-washed. We have some picture of moving forward, but there was a lot of damage to the KEMA facility itself, which we apologized for. But we're learning as we move through this.

Again, we did see the arc migration, and after the test itself, we saw that we had vaporized a lot of the equipment on the test stand itself. So all of this material over here was completely white-washed and it was a little bit of a shock for us in the control room. We were not expecting this type of damage. Like I said, for some of the previous 480s, it was even difficult maintaining the arc itself. We would have extinguishment almost immediately and not be able to maintain it for the full seven seconds. We did not see that with this test. Again, aluminum inside the enclosure, pull up some pictures.

MR. SHUDAK: I think after that one, Nick, we had to stop, right? Because the -- the facility was completely coated.

MR. MELLY: Yes, we -- you will notice that there is not heat release rate hood. In this next test I will show -- because after that test we had to shut down for a week because we couldn't perform any more testing in that test cell because of the damage that was caused from that event and the aluminum coating all of the --

MR. SHUDAK: Yes, we had to basically scrub the cell.

MR. MELLY: Yes, and for quite a while it was still -- problems. This is the bus duct test that was designed -- bus that could be pulled out. This had copper conductors, but an aluminum enclosure -- which we did not realize before we ran the test as an important factor knowing. We squeezed this in with some of the Japanese test program that occurring at the time. We didn't have the hood. We thought, copper material -- this shouldn't be a big deal for testing for a short duration. We thought we knew what was going to occur for the test. This was again, 4160, 26 kA for three-and-a-half seconds.

(Pause.)

MR. MELLY: And again, we saw that white smoke. It's difficult to explain the violence of this event. People in the control room were running away from the viewing screen during this event because it was so explosive -- an interesting event. We weren't prepared for that at the time. And that's really -

(Simultaneous speaking.)

MR. CIELO: DEP showed up an hour later.

MR. MELLY: What?

MR. CIELO: The Pennsylvania DEP showed up an hour later.

MR. MELLY: Yes, they did. There was a lot of smoke involved with this event. So this is kind of what led us to kick off the Generic Issues Program is that we'd -- we've ran two tests. The only two tests that we ran with aluminum during this test series showed the extreme difference from the ones that we ran with copper -- much larger damage zone, much -- there were many more consequences at the facility itself with coating material, damaging cables further away and a major disparity.

MR. SALLEY: And again, with the aluminum, that -- that's what we're kind of seeing here. We really have two data points. We did have some aluminum in some of the early tests with -- like tests 4, 5 and 6, which were very well separated buses. And we didn't see that. As a matter of fact, we had trouble trying to hold an arc in. So there's a lot here that we need to learn as to where the hazard exists. So just because something is aluminum, doesn't immediately mean failure. But based on these two data points, we've seen something here that clearly warrants additional resource -- research, excuse me.

MR. MELLY: So again, what we saw was that there's potentially much larger zone of influence associated with events with aluminum. Here you can see, of course, the amount that was in the cabinet that was from the two tests. And the top pictures are from the test 23, the low-volt cabinet, and the bottom are the bottom are the bus ducts, higher risk of propagation and potentially the greater likelihood of maintaining the arc at lower voltages. Again, there's a potential new failure mode that's associated with the conducting material release during the event itself. You can see the white-washing effect that I saw -- that I was talking about earlier. The entire facility was coated in this white material. We will be taking efforts to -- to analyze that material in future testing. We also have NIST as well as Sandia looking into methods for evaluating products --

MR. SALLEY: And again, that's another reason for us to put this into the Generic Issue Program because we potentially are identifying a new failure mechanism. Okay? Where the material is --

if it's conducted in the aluminum form -- you can envision in your mind micro switches and such that would be shorting out due to that. Or, if it's aluminum oxide, it would be an insulator that would be insulating the conduct. So again, that's another reason we want to put this into the Generic Issue Program and get a better understanding.

MR. MELLY: Yes, and if you can see this panel here that's on the wall that's slightly at an off angle, we did melt the hinges off that panel that was 26 feet away from the bus duct itself. And this bus -- or, you see this ventilation fan which was newly installed for our testing. You can see the color variation from the event itself. That one still is white and despite the cleaning efforts.

MR. SALLEY: So, you can think back to those earlier pictures we showed -- especially of the bus duct. And you can see that the operating experience with that bus duct, the damage was much greater than we could reproduce in the laboratory. So just looking at what we did in this video with the test, you can envision what this -- this looked like in the plants. And again, you know, as we learn things from the research and the testing, it helps us better understand what the plants were dealing with.

Reading their LERs they'll talk about conductive smoke, okay? And now we kind of get an idea, okay, what that conductive smoke was and why it was doing what it did. So again, we gained that from the research.

So with all this material, what do we do with it? Again, working with our international partners, we took all the tests, we brought them forward -- worked very closely with NIST and KEMA and we published this report, which you can download here. One of the things I wanted to have for you today was the DVD with all this stuff on it. And we have a lot more test video that we made public. But we had a problem with RIFO (phonetic) and we'll see if we can get that taken care of here and get those redone and I will give you those videos. Anybody on the webinar, just send your mailing address to Tom and we'll be happy to mail it. Like I said, we made that all public. So anyhow, the report is published and this is our Phase I results of the research we've done to date.

MR. MELLY: Moving forward, some of the things that we've talked about was that this is a one-size-fits-all model that's in Appendix M and there's difficulty dealing with it. There has been some postulation of mitigating these events with what are called HEAF shields, referred to in some applications for the transition to NFPA 805, which is proposed shielding to limit the damage from a HEAF event.

Typically what we've seen is postulated metal barrier installed above an electrical cabinet to protect the cable trays that are above, usually leaving the -- or, driving the risk calculation of the CCPD. Some of the questions that have arisen during this testing is, what's needed to make those HEAF shields successful? What's design basis, acceptance ratings? The typical things that would be associated with ensuring that these can work the way that they're designed.

MR. SALLEY: And again, I think we've -- lessons learned from things like thermal lag and penetration seals that you've got to have a clear, you know, test standard and acceptance if you're going, you know, credit this equipment. So again, that piece needs to be developed here and it's just something we want to flag that we've learned from operating experience.

MR. MELLY: And what we've seen through testing is that potentially a metal barrier may not be the most effective at limiting these events because you, again, can breach that metal barrier directly with the products of the arc itself, or lead another part to anchor on that barrier itself.

MR. SALLEY: And this next slide is to why we get to the testing, which Nick is going to describe to you here that, you know, as engineers we can sit down and think things through and say, okay, hey a solid top is going to stop it, or we're going to have this nice laminar flow-off event for the cabinet. And as engineers, we want to think that way and postulate that. But when we run the experiments, we see something different. Rich, Nick?

MR. MELLY: Yes. So that gets to another effect that we've seen in some applications that we'd -- a louvered design cabinet will direct the flow of energy away from the cables that are above. Or, a solid top will always stop the event from damaging cables because the cabinet itself is serving as a barrier. What we see from this test is that once the event occurs, we can breach directly through the louvers like they're not even there. And can breach the cabinet top. In the event that we see here, this was test 11, when we do the videos -- where the arc is generally directed upward, or follows the magnetic path of the event itself -- the power direction -- and in this event a bend occurred there and directed all the energy upwards. We actually lifted the cable tray which we, at this point, had not bolted down -- lifted it, moved it and knocked all the cables out of the tray during that event. But we see that these are things we need to think about that general engineering judgment typically is not always correct when dealing with something as energetic as this event.

So we discussed a little bit about the Generic Issue. We are going to have two presentations on that moving forward. It's specifically focused in on the enhanced damage states potential from the aluminum. And we are going to discuss how we want to move that forward using a two-phase approach, short-term actions and long-term actions, as well as trying to get some feedback on how to tackle this problem. So I am not going to touch on it much here today because we have a few presentations later today that will go over the whole framework as well as how we want to move forward with our fire protection program.

MR. SALLEY: So as a regulator, if there's one thing we've learned Three Mile Island, it's the importance of communication and how we have to communicate what we have and get it out into the public. As Nick and I sat down and started looking at this, and the work with the internationals and going back in time and pulling all the different LERs that were coming out of the plants, basically, for us, it was almost a connect-the-dots exercise. And that's kind of how I refer to looking at that OpE. So again, going through that OpE, we see a number of these events. And we thought it was important that, if we're seeing a trend here, that we communicate that.

So the whole purpose of this information, though is, with the aluminum HEAFs, was that we get this together. This is what we're seeing and do we have a trend here? And this is why we need to move forward looking at this form of research. So again, the whole purpose of that information was -- as you know, there's no actions required by that information notice -- but it was to communicate to the larger nuclear community of what we're potentially seeing here as a trend. Again, that was obviously last year we issued that.

MR. MELLY: Yes, like Mark said, it is connect the dots because these are rarely infrequent events. And we are all reading the LERs and the CRs, you see them scratching their heads during the root cause as to why was this as damaging as it was? Why did we see more damage than we would expect? And what is this white material that's coating everything in the room? There's also postulation as to where did the -- were the bus ducts themselves -- were the conductors thrown? Where did they go? So you see a lot of questions being raised in the root cause, and looking at the full picture, we wanted to communicate that effect.

MR. SALLEY: So, moving forward in the processes that we work, one of the tools we use for expert elicitations is a thing is a thing called a PIRT. A PIRT is a phenomena identification and ranking table. And again, it's to look at something like this in an expert elicitation and try to rank the different things -- the different phenomena that we're involved with. Kenny Hamburger, one of our young engineers, ran this and what we did was we brought all the international partners in, we spent a week here. KEMA was with us, NIST, over in the ACLS hearing rooms, and we had this discussion. From that we documented the report. You can take a look here. And again, the whole purpose of this was to start giving us a roadmap and to start guiding us forward into the next areas of research and what we needed to do. So again, that's a somewhat unique process that we use in the nuclear industry and moving forward with the expert elicitation.

Another important piece that we've got is Japan. Japan has been a very powerful partner with us. Steve Turner who is here, he has worked a lot consulting with the Japanese. They have gone through some regulatory changes here, post-Fukushima, as you can well imagine. I know Dan, Dan Funk is here. He has spent a lot of time over there working with them. But they have a whole HEAF program that they are trying to really understand what happened in Onagawa. And they've been very gracious with us in inviting us to come to KEMA with them, stick some additional instruments in, get the data and learn from what they're doing. Of course, the work is done and it's in Japanese, which doesn't buy us much. But we do have a vehicle, and it's a NUREG/IA through our MOU with Japan. We're able to take this, write the reports with them -- again, put it in English and then put it out as publically available in the open literature. So again, we can learn from the work we're doing. And like I said, Japan has been a very,

very gracious partner to work with on this one.

MR. MELLY: Yes, their initial insights moving forward is they're going to be handling this in Japan in a regulatory aspect requiring plant changes to protection schemes rather than understanding the PRA -- or, rather than focusing on the PRA impact and dealing with it in a PRA terminology.

MR. SALLEY: Again, so they're going to work it out in their nuclear environment and they're looking real heavy at the prevention piece, like we showed earlier in the defense-in-depth approach.

So the next thing is, we went to the next phase and getting close to where we're at right here today. The test plan -- we put the test plan out for public comment. You can see we got quite a bit of comment on it and tomorrow Dave and Nick are going to have a lot of discussion, but we want to understand the comments and we want to understand the best way for us to move forward. You can see we had 64 comments received through the public process. EPRI liked it so much, it commented twice. So, thank you, Ashley. And we've also got some small-scale testing that we've come up with. And again, we're getting some comments on that. I know we've extended the period of comment a little bit here for additional comments. And again, we want to get involvement and we want to get input and we want to move forward that way.

MR. MELLY: And again, we have updated the test plan that was first put out on June 30th, it has been made available for this public workshop. I believe it's -- the ML was put on the website associated with this workshop, and it will be updated again based on feedback from this workshop. So it's an iterative process that we're working on. We want to make sure that we have the parameters dialed in that we need to test, and this is -- the primary goal of this workshop is to have the discussion on the current duration and things that we're going to be testing so we can update this test plan.

MR. SALLEY: So, in conclusion -- and whoa, we're just right on time. That was purely by accident. In conclusion, this is where we're at today. We've seen things and again, with research like this, sometimes you're -- you're on a path and you have to realize maybe you need to change the path a little bit. That's one of the things we're thinking. And again, it's so important, our discussions we've had, the webinars with the NFPA, that we just don't jump -- everything becomes a heap and it becomes that worst case.

We are going to change direction a little bit and Kenn Miller is going to have a good discussion hopefully this afternoon on how we want to do this. And also, we want to stay in process and make sure we do this in a very methodical manner, which is going to be the driver of the Generic Issue Program. So with this document, it kind of -- like I said, use it as a Reader's Digest version of where we're at. And it's also got all our references in there that if you want to take a look at some particular issue, you can go through the ML number or the link. So, if anyone has any questions? If we don't have any questions, it will be time for a break. Then we can pick it back up. Any questions? Comments? Concerns? Complaints?

MR. MELLY: And again, this is -- we're kind of just -- everything has come at you, a lot of information here on what we did. Tomorrow, when we go over the comments as well as some of the information that Gabe put out for testing information and things of how we're going to be testing, it is going to be much more of a discussion format where we really would like input moving forward.

MR. SALLEY: Any questions on the webinar, Tom?

MR. AIRD: No.

MR. SALLEY: No questions, so with that --

MR. TURNER: I have a question. On the bus duct test, did we actually check if the white stuff was conductive? You say in your slide ---

(Simultaneous speaking.)

MR. MELLY: We did not material testing afterwards or collect the particulate from the test. The indication came from the KEMA facility ---

(Simultaneous speaking.)

MR. CIELO: Yes, we didn't do any -- any material testing either, Steve, we just ---

MR. MELLY: It is being done during the small-scale testing, as well as -- we're going to be doing it across --

MR. SALLEY: Yes, Gabe is going to have a good thing. And that's something Sandia can look at -- and it's really going to be fascinating what you see when they start looking at it at the microscopic level. And Gabe is going to get into that in his presentation on small scale.

MR. MELLY: We are also going to be

leveraging Jose Torero from the University of Maryland to try and look at the potential for creating a model of the conductivity versus distance of the cloud -- mix up. Anything else?

(No audible response.)

MR. MELLY: Take a fifteen-minute break and I guess we'll see on the schedule. Be back in here at 11:00.

(Whereupon, the above-entitled matter went off the record at 9:47 a.m. and resumed at 10:12 a.m.)

MR. GARDOCKI: Well good morning. I'm Stanley Gardocki. I'm one of the program managers for the Generic Issues Program at the NRC. I've been in the program for about two or three years now. I want to give you a quick, high-level viewpoint of the Generic Issues Program on this presentation. And then the next presentation will go into a little bit of specifics on this individual generic issue.

All right, next slide.

The purpose of the Generic Issue Program, it was started a long time ago by Congress, mandating the NRC to come up with a program to evaluate issues, as they come in, for generic implications across the board of problems. We've been doing it a long time and we've gotten pretty good at it and we've got a good process down.

I would say the Generic Issues Program itself, right now, is designed to take an issue, screen it, assess it to see if it's significant enough for the NRC and industry to spend money and time to put it in what we call the last phase, the Regulatory Office participation stage.

Right on time. We're way ahead of it. You walked in -- perfect timing.

This is our supervisor of the Generic Issues Program, Tom Boyce. So he is responsible for the program and the branch chief.

MR. SALLEY: Tom, we got a little bit ahead of schedule. So I apologize for that and you're up.

MR. BOYCE: Well, thanks. If I had waited a longer, I could have had Stan do the whole thing. Unfortunately, I called him.

Well good morning. I'm Tom Boyce. I'm a branch chief in Research. My branch does regulatory guidance on generic issues.

The project managers, that's our core capability. I don't know whether I should be sitting down or standing up but you've already done the intros.

MR. TAYLOR: I think if you move away from the SharePoint and put a mike on.

(Simultaneous speaking.)

MR. BOYCE: Well all right, so we're on, I guess. Can you go to the first -- maybe this is the first slide.

MR. TAYLOR: That's the first slide.

MR. BOYCE: All right, let's see. Fundamentals -- sorry. It'll take me a second to get caught up with you guys.

All right, well this is what we're going to cover here in a little bit. We are going to cover fundamentals and you'll see that on the next couple of slides. Then we're going to look at the screening criteria for proposed generic issues, and then we'll look at some of the documentation that will come out of the program.

This is really a process discussion. It's to tell you where the HEAF with aluminum issue is in the process. I'll try and field questions, process-type questions. If you want to ask me something technical, I'll definitely defer to my colleagues.

So the Generic Issues Program has been around at the NRC for a long, long time. It originally came from when we were licensing a lot of nuclear power plants in the '70s. And what would happen is is that we'd be going through the licensing process and issues would come up, a variety of issues, because it's the first time we've really done such large-scale development of nuclear power in the U.S.

And as a way to manage these issues that came up, the licensing process moved forward. Plants were being built and the issues were put, I'm going to call it a parking lot but they were put into the Generic Issues Program so that they could be worked aggressively. And as solutions developed over time, they would be I'll call it backfitted onto the current generation of plants in whatever stage of construction that they were in. So, that's the origin of the program.

There's been -- I may be getting ahead of myself -- maybe close to a thousand generic issues over the three decades that we've been running this program. We're down to a handful, which is an indicator of the maturity of the industry, as well as I would give credit to the NRC staff, the aggressiveness of us trying to work the issues off.

Okay, so there's now three stages of the Generic Issues Program. The first stage is a screening stage. In general terms when we get an issue, what we're trying to do is validate that the issues is worthwhile spending resources on. We'll make a determination whether it's an allegation and we need to deal with it in allegation space, or make sure that it's got some kind of connection to safety. It's not a very high-level comment like NRC should license plants faster. That would be something that we would screen out. We're looking for more technical content.

And we'd be trying to make an early determination of the risk significance. Like a meteor strike would have high consequences but would have a low initiating event frequency. So that would probably screen out a meteor strike. I'm just trying to set the stage.

All right, once it passes the screening stage and we say this has got sufficient risk/safety significance, now we need actually to do some work to develop the issue. What does it really mean? Technically, what is the phenomenon that we need to be concerned about? What are the systems that are in place to address the issue? What are the potential consequences? And what is the -- what are the potential ways that we could take regulatory action? Backfitting is not the ultimate answer. There's a variety of ways that we can address the issue, perhaps working with industry.

Implementation, that's where we've actually decided okay, after all this development work, we've decided this issue actually does need to be addressed in some way. And so examples of regulatory actions may be as simple as an information notice.

For example, there was an information notice that we issued about a year ago, I think, where we identified the HEAF with aluminum issue to industry. It may be, after all development work, that an IN or nothing is the answer. It could be a generic letter. It could be a plant-specific order, or even some kind of generic order across industry. It really depends on what comes out of the assessment stage.

So here are some of the roles and responsibilities. First of all, the Director of the Office of Research, who is Mike Weber, provides overall strategic direction for the program and overall management. The Generic Issues Program Manager is myself. And the responsible Project Manager is, in this case, Stan Gardocki.

When the program was more robust, there were a lot more project managers working on the issues. Stan, to his credit, has worked off the backlog. So he's an army of one at the moment. I do have capability of hiring more, if we get more issues.

Okay, so how does this process really work? It's not just up to Stan and me to say here's the risk significance. We actually need to bring in people that are more expert. So we bring in a variety of different people and we call the panel that is formed a Generic Issues Review Panel. It's got this acronym called a GIRP. We might have done better if we had thought about it but GIRP is what we came up with.

So the purpose is really to bring the resources to bear on the problem. In Research, we can research an issue to death but that isn't really the goal of this project. The whole point is to bring in regulators, technical people, and bring the issue to a state of maturity that we need to take regulatory action. It's not a long-term research project. So we're actually trying to drive resources to a decision here.

So the GIRP panel includes people from across the Regulatory Offices and Research but they aren't necessarily the people who are doing the day to day work in the assessment stage. They will meet periodically and provide direction, say what are we missing, but there is a core group of people that are actually doing the work who are the experts. I think it's going to be Nick or maybe some other people that are on the Assessment Team. These are the people who are actually developing the information and will be providing it to the GIRP for more robust consideration. More robust, in this case, might be a more robust risk analysis, for example, that the GIRP would bring to bear.

If we get to the end of the assessment stage and the decision is made to take some kind of regulatory action, the GIRP just doesn't provide a report and throw it over the fence to, in this case, NRR probably, we actually expand the GIRP and form a transition team so we don't lose knowledge as we shift over into the regulatory arena.

So basically, the core group of people who are involved in the assessment stage will form a transition team and then we'd say okay, NRR, you take the lead. The Generic Issues Program doesn't have the lead anymore because we are in the Regulatory Office implementation. And they're into more understood processes between the utilities and NRR as far as actual regulation.

Next slide.

So everything I just said we tried to capture in one slide. It's a little bit of an eye chart but this is what we think is -- if we have to, we can talk from one slide.

So if I work from the top, the three stages that I just talked about are on the top line. The organizations that are responsible are on the second line. And you can see that in the proposed GI, that's a terminology issue, in the proposed GI, and this is a proposed GI right now, that stays a proposed GI through the screening and the assessment stage if we decide to take regulatory action. Then it becomes officially a generic issue. Okay? That's just how -- our parlance that we use.

The next level down is who are the decision-makers at each stage, try and identify that so it's clear who is doing what.

And then the next stage down is who is actually doing the work. Okay? So hopefully, it's clear, based on what I had said previously.

Now the next level down, it gets a little more detailed and we try and outline what are the specific deliverables that are coming out of each decision point.

I may end up needing to walk around. Can I just pick this up and hold it for a minute?

So this right here below the colored blocks, for those who are on the bridge, is the milestone documentation. And you'll notice that it says it's publicly available. And I'm pointing that out because the question comes up are we going to see it and the answer is yes. Okay, we tried to make the process as transparent as possible.

So we get a proposed GI. We put that in ADAMS and make it publicly available. And by the way, this is all up on the website, also. I'll get to that in a second.

Then there's a memo from the GI Program Manager, saying hey, we're starting the initial review and oh, by the way, we need resources to form this Generic Issues Review Panel so please identify resources.

The formality of the process actually ensures that we get the resources from the Regulatory Offices to work on it because they are very busy taking care of operational issues at the moment.

And then we, at the end of the screening stage, there's a memo from the GRIP panel to the Director of Research saying this is what we found and we recommend either discontinuing further work on this issue or continuation into the assessment stage. That has been issued. So you are about right here in the process, meaning just past that third arrow down, again, for those on the bridge.

When we get to the assessment stage, the documentation gets a little more robust because we're heading into the potential to take regulatory action. So here's a -- we have a summary memo and here's the more specifics of what you might see in that memo.

One of the critical things is -- well first of all, you've got to have enough technical information to support any kind of regulatory action but one of the things that we identify here is something called a limited regulatory analysis. And what that really is is a discussion of various options for regulatory actions. Should we do an IN? Is that sufficient? Should we do an order? Should we do a generic letter? What is the form of regulatory action we're talking about? Maybe it's simply inspections. Maybe NEI might have stepped up to the plate and said we would like to do some various things and maybe run a pilot. Those are the types of pros and cons that would be in a limited regulatory analysis. Okay?

When we get here, this is, again, when I'm in the Regulatory Office implementation stage, this is where they finally the Regulatory Office says okay, we understand this issue. Thank you, Transition Team, we're taking the regulatory action and we're moving forward with it. Okay, that's where -- that's this far right arrow.

So coming down here, the bottom line says stakeholder engagement. Where can stakeholders provide input? Well first of all, I think this workshop is one of the primary means of providing input. So I haven't been around but I hope you're providing your opinions and insights along the way.

So here, public proposes a GI. The ACRS has an opportunity to engage right here. The ACRS has not indicated that wanted to engage just yet. I would expect them, at some point, to engage.

They have another opportunity at the end of the assessment stage. This is probably more likely before we actually get into Regulatory Office implementation.

And then here, before we take regulatory action, our typical practice is to hold public meetings and talk about it. In the case of generic communications, we have in the past but not necessarily required issue draft generic communications and invited public comment. So those are the types of opportunities for public engagement.

And this is just in our formal process. I think Mark and his team may provide other opportunities, such as this workshop, to provide additional opportunities to engage beyond just what the GI Program is offering here as our standard approach.

Yes?

MS. WETZEL: Will the limited regulatory analysis go out for public comment?

MR. BOYCE: So the question is would the limited regulatory analysis go out for public comment. And it wouldn't be public comment, per se. This memo would be made publicly available right here but it wouldn't be out for public comment, per se. And I would envision it just to be a pro-con type argument.

So the extension of your question then is okay, when do we get to engage. And I would say that, although it's not shown on this chart, the transition team, when we get to the Regulatory Office, would decide how much input they want into that regulatory decisionmaking.

Like one option would be okay, like if you were doing an analogy for rulemaking, which this is not rulemaking. An Advanced Notice of Proposed Rulemaking lays out concepts and invites comments. That's one path the Regulatory Offices could take.

I would expect that they would actually say this is the path we're choosing, here is our draft whatever, and put the draft whatever out for public comment. But I'm actually projecting what the regulatory offices might do and they might choose a different path.

So I hate to be fuzzy. We just, everything seems to have a unique nature.

Other questions?

Okay, next slide and I'll stay standing.

So here are the criteria that the Program uses. And this is really our screening criteria. If an issue doesn't meet these criteria, we will actually take it out of the Program. And so if we take it out of the Program, there is a question about where it goes but it generally would go into additional research until it's ready for primetime if it warrants it.

But to continue on in the Program, it's got to meet these criteria at each of the stages and I will try to go over them briefly.

First of all, the issue affects public

health and safety. So the example I give is when somebody says go faster in licensing. Okay, good comment. Doesn't meet the first criteria. We would not take that comment and pursue it in the GI Program.

The second issue, it applies to two or more facilities. A lot of times somebody says I found a problem at Plant A and I think it applies to Plants B and C. Well, maybe, maybe not.

But if we can establish that it applies to Plants B and C, actually just B, now we have a generic issue. So it's two or more plants, okay? It's not a plant-specific issue is the point.

Number three, the issue is not being addressed using other regulatory programs. So this issue isn't being addressed in any formal regulatory manner right now. That's why it meets this criteria. If NRR, and I'm picking on NRR, had said I want to move forward and do something, then we would say NRR is doing something and it would not stay in the GI Program because the Regulatory Office has assumed dynamic control of the regulatory action associated with it.

The issue can be resolved by a new or revised regulation. It's not enough that we study it. We have to be able -- it's got to lead to something or else it belongs in some other process. We don't want to just study something to death. We want to focus resources and arrive at a conclusion.

The issues of safety significance can be adequately determined. I don't know if this is the best example but I used the meteor strike as the example. Can we really assess the risk and safety significance of a meteor strike? We can come up with these qualitative estimates and maybe even put numbers on them but it's probably not something that I would say would meet this criteria right here. We're looking for something more tangible. I could probably do a better example, if I had more time.

Then the issues is well-defined, discrete, and technical. Again, people tend to broad-brush topics but if it can't be brought down to something that is researchable and tangible, we would say okay, this is interesting academically. It belongs in an academic argument. When it's ready for prime time and we can talk about nuts and bolts, then it meets the criteria for the program.

Okay and then number seven is can we actually do something with it. Again, that's the specificity. Do we have enough of a nugget of technical information that we can actually research?

In the case of Al HEAF, I think Stan is going to talk about some of the long-term, short-term test programs. And we think it can clearly meet number seven.

Now going up to the next level up, the big picture. Why did we put these screening criteria in? Well, like I said there were about a thousand issues in the Program and what happened is is that early on we needed to get on with the business of licensing plants and we were learning. So a lot of issues were dumped into the GI Program.

And the problem is is that everyone felt good because it was in a process but no one devoted sufficient resources to bring in the issues to resolution quickly. So then the problem became we had issues that were just stuck in the program and not moving forward and we realized that we weren't able to apply enough resources and these were the types of reasons why they were not coming to fruition.

So we took these screening criteria in place to avoid the situation where somebody dumps an issue into the program and doesn't address it themselves. Like if an inspector in the field has an issue, if a member of the public has an issue, there are ways that need to be -- that should address it. The GI Program is not intended to be a catchall for everything. It's intended to be just those issues that merit doing research and working on.

Next slide.

Okay, the repository of knowledge for this approximately thousand issues is in NUREG-0933. It's available on the web. We do periodic updates of it as we -- as issues are brought to maturity. We document what we did as an agency here. So, I don't know, Stan, you might be getting more into this in your presentation. But this is available up on the web. Okay, so if at any time you wanted to see some examples of what we've done in the program, here it is. Provide suggestions, anything like that. We'd definitely like to get better.

Next slide.

This tells you -- this is also on the web. It's a nice presentation. It's got some visuals. These needles move like a speedometer when you actually bring the page up. They kind of go over to the far side, come back. It looks really cool. Works like you're starting the engine. So we like it.

But the main point is is it tells you about where you are in the process, and the process being we've taken regulatory action. How many plants have actually implemented changes to their plants? So that's what the big needles are for.

So GI-191 has been around for a while. And if you look visually, we're a little over halfway at trying to implement changes at all the plants.

Now, there's a lot of plants that are affected by GI-191. So this is a nice high-level look but usually not actionable. So if you click on these details -- we're actually doing a demo. That's great.

If you click on details, you get a description of the program. For those on the bridge, we're at the bottom of one of the dials. There's a word called details and that's where we are. And what it gets into is a description of the issue, a description of the status at the end of the high level.

And then somewhere down here, if you pull down, there should be individual plants that are affected. And then keep coming down. And then there's milestones.

There's plants. You can pick each plant and you can say what's the status of each plant. Now, I'm further down the road than the Al HEAF issue at the moment. Okay? Let's assume that something needs to happen on the plants. This is where you'd find out what's the status of each plant.

And then there's another section on milestones. And the milestones would say okay, for this group of BWRs, it doesn't apply to GI-191, but in this group of BWRs, they're expected to submit their initial response to the NRC by spring of 2019. And I'm totally making this up.

The next stage would be GE completes a study of the generic effects and issues topical report, fall of 2019. The plants take action based on topical report 2020. That's the kind of thing you'd see in the plans of actions and milestones.

Anything else you think I ought to point out, Stan?

Okay, so if you have questions on this, I love it, Stan the Man, he's the guy to talk to. Stan worked with our office as Chief Information Officer to develop this. And so there's an awful lot of information here. We're trying to be as transparent as possible. If there's information that's not here, again, please ask u.

MR. MELLY: Again, for those on the phone, this is the Generic Issues dashboard on the NRC public website.

MR. BOYCE: Thank you. Next slide.

So just to tell you, here's some of the

recent proposed generic issues. If you remember the process slide I put up before, proposed generic issues are not issues that have transitioned over to Regulatory Office implementation.

So if you look, there's 20 proposed generic issues. The one in bold -- the ones in bold are the ones that are still open. Okay? So many of these actually did not make it past assessment into Regulatory Office implementation, for various reasons. The documentation of the staff's assessment of the issues is also available publicly. Okay?

Can you get to it on the dashboard, Stan? I don't think --

MR. GARDOCKI: Publicly, no.

MR. BOYCE: Publicly, no. So if you want to know anything about these, they are publicly available and we can certainly get you the information. But the message out of this slide is is that actually the majority of the issues actually screen out and don't make it into Regulatory Office action. Okay?

Next slide.

So, if you ever want to know more, I didn't tell you everything that you needed to know today, we have some references. These are also publicly available. We have the ADAMS ML number. They are available in the NRC Library under document collections. I find that a little easier to find than the ML number. We have a Research Office instruction that provides the next level of detail down in the program. And it's also got that one-pager chart, which I find useful.

Just to tell you how NRR looks at issues in the short-term, they have an office instruction called LIC-504. Remember I said sometimes an issue should be addressed by the Regulatory Office directly? This is the process document that NRR uses. Okay?

So if we aren't addressing it in the GI Program, NRR should be evaluating it in an analogous process in-house.

Okay and I already talked about NUREG-0933, where the repository of knowledge is. That may be my last slide.

MR. GARDOCKI: Yes.

MR. BOYCE: Are there any questions in the room? Beth.

MS. WETZEL: So where is the backfit process for the GI Process?

MR. BOYCE: So the question, for those on the line is where does the backfit process show up.

And it really would come in in the Transition Team. After we get past the assessment stage, let's assume that the Transition Team decides that they're actually going to take action, like a plant-specific, a generic order, let me say, or a rule. Those individual regulatory processes would engage the backfit process, as appropriate.

Like in the case of rulemaking, there is a backfit analysis that is already built into the rulemaking process. If we went with an order, that backfit process would also be part of the development of the order. So, it would be part of the regulatory process. It's not part of the generic issues process.

In the case of generic communications, not all generic communications go through Our Committee to Review Generic Requirements, or CRGR, but generic letters, I believe, do for example, bulletins do. So, if the agency decides to take regulatory action and chooses that vehicle, then CRGR would be engaged early on before issuance of those documents.

Did I get to what you needed?

MS. WETZEL: Yes.

MR. BOYCE: Other questions in the room?

Questions on the bridge?

Okay, then thank you very much.

Stan.

MR. GARDOCKI: Okay, thank you.

All right, so now you've heard what the whole program is about. So where are we at with this specific issue?

All right, first slide, we already did a screening. So we accepted the GI into the Program last year. We did the initial screening. We did what they call a quick shot to see if there's an immediate safety concern. And NRR looked at it and says do we need to act on something immediately right now. And they said no, not right now. You know take the time to do an in-depth analysis and come back and let us know what the analysis is and make the determination a little bit later. But we do what they call an immediate safety determine to see when somebody identifies an issue if there's an immediate concern to the plant safety, to take action right there in the very beginning. We don't wait around for the process to go through its churning of wheels.

So we did the NRR safety determination and they found out, no, it's not an immediate concern but you need to do something. And that's available on the public documents called ADAMS in the ML numbers.

MR. MELLY: It is as well referenced in

the screening report that was issued. We reference the ML associated with that NRR review.

MR. GARDOCKI: Correct.

Now you saw the dashboard on the public side but we have a dashboard on the internal NRC side and we list a lot of these documentations on that. We don't put it on the public side because it's not ready for GI yet. We're still in that determination stage. So we put everything on the internal site until we're ready to launch into the GI, per se, and then everything will go onto the public dashboard.

But all the documentation that you saw on that overall screen, those are all ML numbers in ADAMS. So you can see all the documentation, the screening report, the receipt inspection, the immediate safety concern. All that is available, you just have to go through ADAMS at the point to get that. You don't have the quick links that the dashboard provides.

So as far as this PGI, we screened it in and we wrote a screen report. And you're available to get that off of ADAMS. And now we're in the assessment stage.

You know this is a, like I said, this a review of the big overall process screen. We've gone through the screening. We've got the proposed. We did the screening report. We presented it to the office manager. He says, good report; go to assessment. He makes the final determination. And we actually brought in the office's, NRR, office director to make our joint decisions on important issues like this.

So now we're into the assessment stage. Okay -- we've got the screen review. Go back one. There you go. Okay, there it is.

There's the screening review is complete. Like I said, it's publicly available. It met all the seven criteria. And we did a little bit extra work on this so it can be more defined in the screening report and we came up with some action plans, not just say put it in assessment but our GIRP Committee says well, when you go to assessment, here's a plan on how to resolve the issue. Here's some short-term milestones that we think you need to do in a two-phased approach to get this assessment done to determine if it's risk-significant enough to go to NRR. Okay?

And then at the very bottom, you'll see the ADAMS number at the bottom of the screen.

Okay, like I said, the GIRP report and the screening identify what they call short-term actions.

Now the short-term actions we generally say they're going to be done in the assessment stage, which usually takes between one and two years. We're into what six or eight months into the assessment. So we're getting a good kickoff what this means.

And I'm not going into every individual task here. If you have specific questions on the task, Nick is the coordinator for developing all the actions needed to achieve all these tasks. But the Generic Issues Committee said these are important enough to identify them on the screening report as a logical progression to resolve this issue.

And again, in the full report, the screening report that was issued, some of these tasks you'll see in parentheses if needed. So the determinant, the development of an interim guidance, to perform additional testing, and proceed to the Regulatory Office implementation stage. These are tasks if it's needed. If our assessment and determination sees that we need to do these things, we're going to move them forward.

The perform additional focused HEAF testing, we have decided to move forward on that and that's the purpose of this meeting. Again, with some of the task 3 here, you'll see determine electrical fault characteristics. We're handling that in a public manner through these workshops, as well as through comments on the Draft Test Plan that has been developed.

Again, there was a time table associated with typical GIRTH assessment phases and we're trying to move things quickly because test programs take a while to get contract employees following the NRC program. So we're moving in parallel and we're trying to get as much industry involvement as possible.

MR. TAYLOR: If I can just add to that a little bit.

Some of these actions aren't NRC-sole actions. You know some of them we're looking for participation with EPRI or other stakeholders to help us work through the process. So, you know developing a ZOI, we'd like to solicit some input from industry to sort of help support that. But if we don't get any support from stakeholders and whatnot, then we'll go ahead and do that on our own.

So there are some actions that aren't sole NRC responsibility.

MR. MELLY: Yes, in the next presentation that I'll actually be giving on the potential to involve pilot plants and have industry involvement for the risk-safety determination is going to be a large area where we're going to be looking for involvement from the industry to have a robust assessment.

I'll give an example of some of the things that we can do without industry involvement but it's going to be beneficial for everyone involved to have as much participation as possible.

MR. GARDOCKI: And I'll reiterate what Nick and Gabe said. We're looking for industry involvement. If industry doesn't get involved, the NRC will gladly go out there and help you get it done. Okay?

All right, long-term actions. I use the word commonly here because it's a flexible program. The Generic Issues is made to handle such a wide variety of issues, we sometimes deviate from the process a little bit.

So in this action here, regulatory action, we typically send out generic communications during this stage called Regulatory Office implementation. But in this case, we sent out an IN last year. So we actually issued an IN to the industry prior to getting into the Regulatory Office implementation stage.

So the flexibility of the program is there and we use it and utilize it to our benefit.

The long-term actions of the GIRP identified -- you can see continuing on is those steps revising technical guidance, as necessary, issuing additional generic communications or orders, or rulemaking. All that is going to be done in the long-term actions in the next stage called regulatory office implementation.

Okay, go to the next one.

There's a couple more long-term actions that are identified in the report. I think the PERT has been completed, is the publicly --

MR. MELLY: The PERT has been completed and is publicly available. We don't have the ML on this slide but we will provide -- or the ML is publicly available in our ADAMS system. It was published in August of this year.

MR. GARDOCKI: August?

MR. MELLY: Last year. It's been a long year.

MR. GARDOCKI: So in the Generic Issue Program, we try to be very transparent and make just about everything publicly available at the appropriate time. So if the screening report says they're being developed and reviewed are not publicly available until they are approved by the Office Director of

Research and made publicly available.

Any more from Gabe or Nick on the long-term actions?

MR. MELLY: So the long-term actions we're going to discuss here. There's some overlap between the short-term and long-term and that's based on the level of effort that's going to be involved with them, and specifically on how the test is performed and the assessment of risk. There's different options of how we can tackle that program, as well as the amount of resources that's going into it. So that's why you see some overlap between the short-term and long-term actions is time line of when we can get things done and what level of detail we can get them done to. That's associated with the documentation that you saw on the overall process of the Generic Issues Program.

We're here today and tomorrow to talk specifically about the focused HEAF testing, as to what parameters are of importance. What's realistic? And what's representative of out there in the plants?

The assessment of risk, again, we're going to be talking about the potential to have pilot plants to work with, which I'll talk about next, but we see that when we do get pilot plants and we get industry involvement, everything tends to be much more successful moving down the road, rather than fighting of what was done or what could be done.

MR. GARDOCKI: Okay, these are some actions that are in progress or completed. Like I said, the report was published by a GIRP. These said these are our actions that we need to complete to get the assessment done correctly and it's a phased approach, stepped approach. And like I said, the Regulatory Office implementation, those are projected actions. We don't know for sure, until we get to that stage, whether we'll do all those actions, some of those actions, or additional actions. But the GIRP will kind of think in advance in the future what possibly could come out of the assessment stage. So those are kind of proposed.

But here you can see how far we are in the process and what some of the things that we have completed. The dates and times are starting to get developed. I think Nick and Gabe can talk more about when actually the tests are proposed and dates.

MR. MELLY: Yes, in the Phase II presentation that I'll be giving, we have some time lines associated with testing and things moving forward.

In terms of what's on the screen right

now, there was an informal survey performed by NEI, essentially questioning how much aluminum is out there. Again, that was informal, voluntary-based and NEI performed that.

I have an ML in a later slide. It is public. We have made that publicly available, what has come in. The plant names are anonymous in that report but that is one area where it was important to our assessment for this issue is understanding how much aluminum is out there in the fleet, to see how big of a problem this is or could be.

Again, the next stage, also, is to invite personnel to potentially join NRC expert elicitation solicitation process, which will help determine the zone of influence that will be used for that risk assessment moving forward.

So essentially, the high level in 6850 Appendix M right now is the three-foot horizontal five-foot vertical and the expert elicitation would lead down to what it would potentially be for this aluminum issue, taking into account the potential of both conductive material as well as enhance the zone of influence.

Like we said previously, we can perform this in-house in the NRC but we'd like to do this more open and with a semi-formal or some level of expert elicitation to capture that issue.

Again, we're here to develop the future test plans and this is the workshop that is on the screen right now.

MR. GARDOCKI: Okay. As far as the initial testing that was done, they identified an issues with the aluminum in the cabinets or bus bars, or even the enclosures. So we said okay, now we have to additional testing to find out what extent of aluminum causes what extent of damage. And we can't really do any kind of regulatory actions until we know that knowledge and that's why we're developing these other test plans.

So that's why we're kind of developing our assessment right now and we need further testing to get further in the process.

MR. MELLY: And we also did focus on the fact that this is an international program that we're working with, the OECD and the NEA. We will discuss the members who are going to be potentially in the Phase II and we've also been doing these actions in parallel with them, trying to figure out is aluminum an international issue. And what we found is that not very many other countries consider the -- or have aluminum within their plants, either in the enclosures for bus ducts or the cabinets themselves. It's very country-specific what material was available at the time and what they were requiring to put in the plants.

We do see a large amount of aluminum in Japan, specifically within their enclosures, however, they do not have aluminum for the enclosures of their bus duct material, due to seismic concerns during their design phase.

So as we've learned more, we've seen that the aluminum may be a U.S.-specific problem, rather than the larger OECD international community. For instance, Germany has found one plant that had aluminum and it shut down.

So we're trying to tailor the next stage of the program to take into account both this issue and we may be taking the heavier lift, in terms of resources, to solve the aluminum issue, rather than the international countries.

MR. GARDOCKI: All right, I think that's the last slide there.

There's not a lot of dates associated with these steps right now because were still developing the dates to perform the additional testing. And based on some workshops, participation from industry, we'll be doing some site visits and hopefully get out and do an actual realistic PRA inside of a plant to say if you extend the zone of influence from 10 to 15 or 20, what's the change in risk to the plant.

So we're actually looking for some plant involvement and that kind of aspect. And Nick will get a little bit more into that in our workshops. So, I just put a plug in now that it would be very helpful in developing what they call the risk significance of this specific generic issue if we can get some actual plant data, say.

MR. MELLY: Yes, in my next presentation, I'm going to discuss some of the potential options moving forward. This is the first time that we're really engaging EPRI as well as industry on this path forward. And we would like to -- we'll discuss some of the pitfalls with doing it in-house and the resources associated with moving forward to do this risk assessment. And it will be something that we definitely further engagement and potentially more meetings to discuss how these pilots and things will work.

MR. GARDOCKI: So that's a very detailed approach on how we're getting to this issue. I know it sounds like it's going to take a while but we want to make sure we get it right before we make the industry or regulations applicable. We don't want to drive costs up anywhere that we don't have to or we want make sure safety is important.

Any questions? Kenneth.

MR. FLEISCHER: Yes --

MR. GARDOCKI: Hold on one second.

MR. FLEISCHER: Yes, sure. Kenneth Fleischer with EPRI.

So the item regarding international, what was the level of rigor and detail into that assessment, whether they have or don't have aluminum? Did they do similar to like an NEI study, where you got down to the actual individual engineering organizations that really do their plant well or is that just a high-level regulatory assessment?

MR. MELLY: It varied on country to country. Germany held a workshop much like this with their industry and it was a questionnaire form that went out. But if very much varied from country to country as to the level of detail they went into to figure out if they had aluminum in their plants and to what extent.

For instance, the cabinet we received from

Finland did have the aluminum in it and they identified aluminum as being an issue for their plants. However, it's very country-specific and there was no formal process in figuring out how much aluminum is out there.

We provided each country that was a part of the OECD program with the questions and questionnaire form that we provided to NEI and it was up to each country specific how they wanted to engage their fleet.

So that is something we will most likely try and enhance in the Phase II of the program working with the internationals is conducting the formal surveys as to the extent possible.

MR. VERHOEVEN: Hello. Bas Verhoeven from KEMA Laboratories.

The discussion about aluminum versus copper, the use, it was my global experience when I see it, and I traveled to many countries worldwide, you see that use of aluminum in the sectors, not only the neutral but overall, the use of aluminum is increasing very rapidly at the cost of copper because of lower rate and the cheaper design. That means that much more systems generically will include aluminum instead of copper. That's a trend that you see happening everywhere.

So an exhibit in Saudi Arabia, they changed overnight, basically, that whole distribution transformers should have aluminum wirings rather than copper wirings. Cables are being transferred to aluminum conductors instead of copper.

So it's happening everywhere. And primarily, cost-wise, that's been the main reason and secondary is the lower weight.

MR. MELLY: Yes, so we have seen some international evidence of these high energy arcing faults occurring as well as at different types of facilities. However, for a different facility, if they lose an entire room, the plant is shut down for a day, rather than the risk -- the potential risk that we have within the nuclear industry of larger consequences.

Any other questions in the room?

MR. CHEOK: This is Mike Cheok from Office of Research.

So when Nick talked about the risk assessment, and so one parameter of it was the zone of influence. So that's something that we want to look at plant-specific data on.

The other element of it is the frequency.

So we also talked about this in the beginning. So we talked about trying to you know characterize the arc flash better, characterize what HEAF is and not all arc flashes result in HEAFs.

So in a lot of this, we all try to get a lot more information about this as part of the Phase II testing and as part of the expert elicitation, as part of looking at Op E and things like that. So that's the other part of the risk analysis, which we will be looking for a lot of input on.

MR. MELLY: Yes, and as Mike said, that is the other piece, rather than we've kind of separated it right now. We have the zone of influence part of this and we have everything else, which is the frequency, the circuit protection, some of the durations, plant-specific design. And we plan on capturing all of that.

Right now we have a memorandum of understanding with EPRI and all of that, hopefully, will roll into the work that we were planning to do with Ashley and EPRI on the heat. If we're going to be looking at frequency, 1E equipment versus non-1E equipment and things like that will all be captured under the MOU work that is planned for later this year and next year.

Francisco.

MR. JOGLAR: So what you just said on probabilities and frequencies, is that what that last bullet means when you said the NRC will calculate potential risk increase?

MR. MELLY: No, so the calculation of the potential risk increase, that's what we're going to be discussing next is the pilot plants and the risk assessment associated with the GIRP and the assessment work phase that we're in.

What we were discussing with frequency and the definitions is currently the bin 16 is split bus ducts, the electrical cabinets, as well as on the low voltage and medium voltage equipment in Supplement 1 to NUREG-6850. We're talking about potentially increasing that and doing more -- a little bit more refined work there as to splitting out the arc blast type occurrence versus the high energy arcing fault, as well as the potential to roll in the safety-related versus non-safety-related, and refining the frequencies associated with those in our work under the MOU.

But the calculation of the potential increase I'll get to next as to an example of how we would like to do that and through the potential of pilot plants.

MR. GARDOCKI: And just to add on to that, the Generic Issue Program, like you said, the seven screening criteria, there's risk aspect of it.

So when we calculate the risk here in the assessment stage, if it doesn't meet a threshold, it will not go to Regulatory Office implementation. So it's not risk-significant enough to go to that stage to require regulations or industry to do any action on it.

We use the threshold very similar to what's in the Reg. Guide 1.174 for plant changes. If a plant requests a change to the NRC and say we're going to change something in our plant, they do a risk analysis and says it's safe to do. Well, we reversed that philosophy. If that risk is unacceptable, then it should proceed as a generic issue into the Regulatory Office.

So we use the same kind of screening in that Reg. Guide but we use it in reverse. If it's not safe to implement the design change, then it's something -- a threshold that would go to Regulatory Office for generic issues. So we use the risk in this stage of assessment to go Regulatory Office, not just -- we don't do it just qualitative. We try to do a quantitative analysis to get this risk increase. Okay?

MR. JOGLAR: Thank you.

MR. GARDOCKI: Bridge line or more?

MR. FUNK: Can I just get a little clarification on one point? I think it was in one of Mark's earlier slides. He had highlighted general design criteria 3 and then the single failure criteria collection of blood and guts electrical engineering.

But in the generic issue right up to what has been presented by Michael and what I see here today, so far, it looks this problem is only being approached strictly from fire PRA perspective or are you back questioning is Class 1E traditional separation criteria acceptable?

MR. MELLY: It is -- we have been focusing on a lot of discussion on the NFPA 805, the probabilistic aspect. However, the deterministic is also identified in the safety evaluation, as well as the information notice, as a potential area where this can affect.

So it is both. It's not just probabilistic. We have been focusing in on the zone of influence and things like that for the probabilistic design and the frequencies as well. And we're still trying to tackle how we are going to assess the issue for the deterministic plants, the separation criteria, as well as some exemptions to that separation criteria that are in regulations.

So that is all still on the table at this moment in time.

MR. FUNK: And by deterministic, do you mean Appendix R deterministic or Class 1E Reg. Guide 1.75 determination?

MR. MELLY: I was referring to the Appendix R right now. But again, I haven't given that much -- I haven't looked at the overall picture to know exactly what's going to be affected. But the 20-foot separation criteria from Appendix R is what comes to mind right now.

MR. FUNK: Thank you.

MR. PELLIZZARI: Francesco Pellizzari, EPM.

Following along that line of thought, my understanding of Appendix R was that it was generally based on consideration of hazards that were floor-based, where the floor area burned but it really didn't consider explosive hazards.

So just a thought in terms of a concern and the plants that are deterministic is like a fire barrier wrap that would be within the zone of influence for ZOI. Essentially, that wouldn't afford any protection from an explosive hazard. So I think that's somewhere. That needs to be, obviously, explored.

MR. MELLY: Yes, I agree and those are all areas that we're going to be looking into, as well as the other additional concern is that intervening combustibles were generally as floor-based whereas, if you have a bus duct, it typically would not have been considered an intervening combustible because it's not combustible. However, if you have a bus duct running through your separation or across, this potential issue can occur.

So these are all areas that we are going to be investigating, as part of this program.

MR. GARDOCKI: In the screening report, also, you can see there's a little differentiation between the NFPA 805 plants and the Appendix R. So there's a little bit of difference there and we identified that difference in the screening report and tried to come up with some different tasking to how we're going to address those different aspects. So some plants are Appendix R and some are NFPA plants.

MR. MELLY: The specific differences were also addressed in the NRR assessment to the immediate safety risk and I believe it's in the communication plan moving forward.

Mike? Oh. Do we have questions from the phone?

MR. AIRD: No, we just got a message that if you're using a microphone, speak kind of loudly into it because some people are having a hard time hearing you.

MR. MELLY: We'll also start repeating the questions.

MR. AIRD: That would help.

MR. MELLY: All right.

MR. SALLEY: Nick, before you move on, a couple things.

MR. TAYLOR: Hold on Mark.

MR. SALLEY: So before we move on here, a couple things before we get to the next presentation, as you close this one out.

Dan, your question is on the electrical engineers. That's specifically why we requested a lot of the electrical engineers to come to this. And we're doing that internally in Research also. You notice Kenn Miller is here and we've got Ronaldo Jenkins, and Tom Koshy, Bob Bailey. So we're trying to also, we see if this is a bigger issue and we wanted to involve the electrical engineers. It started out in fire protection but, again, we're looking to bring the other ones on.

The question of aluminum, as we see, you know we're taking the biggest problem first, and we see the aluminum as the first place we really want to go. And we are seeing that most of it is in the United States, which would kind of beg the question if I was German or a country that didn't have any aluminum, why do I want to continue on with the research. And I think talking with them and the other countries is we can do a more accurate zone of influence model for the copper ones and we can learn more about it.

So I think everybody wants the most realistic, most accurate model. So I think that's a lot of the reason that we'll do it.

What you'll see here is probably parallel pilot testing, where we do the bigger OECD program and then we have some specific aluminum stuff that we need to solve in the U.S. and Nick's discussion will get into that.

And one final thing. I noticed our Office Director, Mike Weber, has stopped in. Mike, if you had any words or anything you'd like to say to the group, we'd appreciate it.

MR. WEBER: May I have a microphone? Thanks.

The only thing I would add is I'm happy to see a crowded room. So this is good. You know we really, as has been emphasized several times, we really benefit from your participation, not just here in the room but also on the phone.

We want this to be the kind of experimentation, testing, and analysis that we do where when we come up with our conclusions everybody says well, yes, of course; we all agree this is reasonable, this is appropriate, and it's focused on safety. We're not trying to impose additional burden that's not justified but we are trying to ensure that the results of our experiments, or our analysis are credible and that they ensure that we support the overall Program results in accomplishing safe and reliable operations.

So, that's the only thing I would add. Thanks for participating.

MR. MELLY: Next?

MR. MILLER: This is Kenn Miller. Just to piggyback a little bit on what Nick and Mark talked about, the deterministic separation criteria, from an electrical perspective, from electrical design GDC 17, it's been an issue in my mind as well but perhaps drives us to issues with separation criteria and division separation. Of course, that tempered with the required criterion defined in GDC 17 but certainly I would agree that that's on the table as well, depending on what we find out from this research.

So, I just wanted to put that out there.

MR. TAYLOR: Any other questions from the room?

Tom, is there anything on the Webinar?

Okay, so I think, Nick, you're up next.

MR. MELLY: All right, thank you, Tom.

So we eluded to this a little bit in the previous presentation. This is a look at how we -- how I envisioned the pilot plants coming off for this risk assessment. Again, overall, we are in the assessment stage and, as part of that assessment, we want to look at what the potential is and understand what the risk from these events is to the current fleet.

This is a very difficult problem because the zone of influence, as well as the potential damage is very scenario-specific, very plant-specific. It's a problem that can't be broad-brushed. We need to kind of run sensitivity studies, and things like that, and have an appropriate model when we get to a pilot plant.

As we have looked at the risks from this from a larger picture, we have the skyscraper chart that EPRI has done as part of a study to look at the risk drivers. And what you're seeing is primarily on -- down the side here you see the different categories. You have electrical cabinets, transient heat, and you do see that HEAF is the third largest risk driver. It kind of mirrors the electrical cabinets, in that the overhead cables are a large area of concern. They drive a lot of the risk and the conditional core damage probability.

So this is one tool that we've used to kind of try and understand what the current risk to the fleet is. And if we focus in on just looking at the HEAF, we see that it can range anywhere from 37 percent of the overall -- the total plant contribution to risk to zero or to a little bit -- to a very low value. So you can kind of see that it's all over the board. It's a very scenario-specific problem and we're trying to understand it without the broad brush.

So there are a couple ways that we can do it and we'd like to work with industry to accomplish this and select appropriate plants to use as pilots, whether it be by design, PWR, BWR, or we use a tool like this to look at three different risk drivers, or a number of different risk drivers. It's selecting one with a high level of risk, a medium level of risk, and a low level or risk and adjusting our zone of influence of damage for these aluminum-specific components.

Some of the important drivers is also going to be does that plant even have aluminum? Maybe for these larger risk drivers, it's an all-copper plant, all copper design, this isn't even an issue.

So it becomes a larger picture, one that we want to work with industry hand-in-hand, as a pilot program to really understand the risks.

There are ways that we can do it in-house but they may be conservative or take a larger picture. I hate to use the word conservative. It's a red button word but if we're going to be trying to solve this in-house without the resources that the industry can provide of their plant models and things like that, that is a fairly appropriate term.

And I'm going to discuss some of the methods that we can do it in-house without using pilot programs to give you an idea of where we are trying to head with this, some of the options, as well as why we would really like industry involvement with this program.

So one of the ways that we can do this is we can use the SPAR All Hazards models that the NRC has in-house. There are several plants that we have fires associated with. We've used plant fire models to enhance the SPAR models and give us an idea of fire risk. In doing that, with the information that we have in-house, I ran one of these assessments and I'll run through some of the assumptions that I had to make to come out with results, as well as the conclusions of that analysis.

So we had a plant model in-house. And when I went through this, I had to assume that every component that had a HEATH identifier was aluminum, without -- that every single cabinet had aluminum inside of it. And I had to do that because I had no way to differentiate whether it was copper internals versus aluminum internals for the conductors or the enclosed material.

Again, I say that's potentially conservative. However, from the survey that's listed here in the ML, there were a large number of plants that had aluminum components.

The next assumption that I had to make is that I had no way to determine where components were located in the plant to come up with an increases zone of influence. So from changing to the three-foot horizontal to five-foot vertical, I had no way to determine what components were four-foot, five-foot, six-foot away with the internal information that we have.

So I, instead, mapped every single HEAF scenario to a hot gas layer scenario for that compartment, which essentially involved all of the components within the compartment that were not protected by some other -- by some means of protective barrier. That brings me much closer to an Appendix R type analysis that is total room loss. So that is inherently conservative. It essentially says that everything within the room is damaged and I have to do that in-house in lieu of performing the plant walkdown or doing an evaluation of what equipment would be damaged.

If we wanted to do this just in the NRC, there are potentials that we could do walkdowns. We could work with the inspectors and try and bring this forward but right now, for illustration purposes, this is what I did. I mapped everything I did to a hot gas layer scenario.

I also had to take away credit for the automatic suppression or manual suppression. We had no way to alter those within the current model. So all non-suppression values were set to one. We had no way to evaluate whether the sprinkler systems or any suppression methods would be damaged by the event itself.

The one area that is potentially non-conservative is that the model that we had to work with in-house had no bust duct scenarios listed. In that scenario, at the time that we received the information, the bus ducts were screened out of the analysis using a sensitivity study. So there was no way for me to map a bus duct scenario to any specific room hot gas layer. I didn't know where the bus ducts were in the plant.

So you can see from the SPAR model results themselves, these are the rooms where you would typically high energy arcing faults. We have our V switchgear room, our turbine building room, the A switchgear room, and HEAF identified scenarios in the reactor auxiliary building.

On the left-hand side here, is the plant fire CDF. You can see this was the core damage frequency identified in the SPAR model prior to me altering these events. And you can see the difference compared to when I did change the event to a hot gas layer damaging scenario which, essentially, would take out the entire room. And you can also see the total difference down here.

I only listed the compartments that had HEAF scenarios identified and my change to the plant model. But you can see prior to my alterations, the total plant CDF was three to the minus -- or 3.06 E to the -5. And with the increased zone of influence or the mapping to a hot gas layer, we're down in the area of 1.95E to the -4.

As you can see this large increase in risk, which I necessarily don't believe is true or realistic, based on the way that I had to make assumptions and model it but, without eliciting help from the industry through either EPRI or the individual plants themselves to establish a pilot program where we can work to really understand a realistic risk increase, we're limited with our ability to recreate these events without a larger, more robust model.

So this is where we currently sat -- sit right now with our level of analysis and what we can do in-house. We can make this a little bit better with plant walkdowns and working with the Regions and actually going out to plants but I see that as Plan B. Plan A is much more can we work collaboratively. Can we leverage the plant models themselves and move forward in a way that's really going to capture what that interim zone of influence and that interim risk could be?

So that's really what I wanted to stress here with this presentation is that there are some -- as part of the Generic Issues Program, we must do this risk evaluation and it would be much more beneficial to do it with the industry as a collaborative effort, rather than being potentially conservative on our own. It will help understand the realistic risk associated with the events involving aluminum and we can leverage the existing plant PRA models with the use of pilot plants.

How we select those pilot plants becomes very important and we really need to work together on how we do that selection. Again, we'd be following the technical office instruction that Stan mentioned earlier as to the threshold levels for if this -- where this risk assessment will fall and how we progress forward in the generic issues process.

So this is kind of what I wanted to discuss is how we can select these pilot plants. So we wanted to get volunteer pilot plants that have identified aluminum components. As I mentioned previously, the NEI survey that we have has anonymous plant names. So right now, we cannot determine which plants did have the aluminum from that survey.

And we also want to have volunteer pilot plants that have modeled HEAF scenarios within their PRA. What I mean by that is we need the volunteer plants that have done a zone of influence approach following Appendix M of 6850 as well as the bus duct guidance that is in Supplement 1 to 6850, which is FAQ 07-0035.

That becomes very important because if plants went and did a scoping approach, where they already modeled their high energy arcing fault scenarios to a hot gas layer, selecting them as a pilot plant will not be beneficial because it will show absolutely no change because they've already used conservative methodology in their approach. And there are several plants that did that because if they could live with the risk, they did not move into further stages of going to zone of influence approaches.

Additionally, as I've mentioned before, these may involve plant walkdowns and some NRC interaction will be decided on the as-needed basis. If we can receive all the information we need just from interaction and meetings through GoToMeeting or some other needs, we won't need specific walkdowns. And we're trying to limit the amount of resources necessary to perform a robust risk analysis.

Are there any questions on the pilot plant approach? Rob.

MR. CAVEDO: Go ahead.

MS. LINDEMAN: So how many pilot plants do you need? I thought you mentioned three but --

MR. MELLY: That's still up for discussion. Our initial thought was that three may provide a good picture, if we can get three that are different enough where it would show us a range of risk. As we've said, it's very plant-specific. It's very scenario-specific. So we're still making the determination of how many pilots do we need to really understand what that risk will be on a broad brush.

Because, again, this assessment is supposed to give us an idea of what the overall risk and the assessment of risk for everyone, for not just one plant-specific. So we need to select as many as possible to have a comfortable feeling of what the plant risk is.

Three is our initial idea.

MR. CAVEDO: So I have a couple of questions on this. I agree with you -- is this causing the sound?

MR. MELLY: I don't know.

MR. CAVEDO: So I agree that we want to get a realistic estimate of this and I also agree with everything that you've been saying about it's very important that we get the frequency right when we're doing these bigger zone of influences.

Is your vision that this pilot effort will be done when you have the frequencies corrected or did you envision just putting in these conservative zone of influences without adjusting the frequencies?

MR. MELLY: That comes down to a timing issue. I believe the frequencies are going to be handled in several stages. What I mean by that is the safety-related versus non-safety-related is currently being addressed in an FAQ. If that is ready in time for the pilots, we can roll that in.

Additionally, if we can make the differentiation with the definitions to frequency, that can be rolled in as well.

MR. CAVEDO: I don't think it's a binning issue, as much as a breaker performance issue. Because if the breakers are going to work, then they're going to be smaller. If they're going to be failed and they're going to be larger, and those would seem like they would be a much lower frequency, and if that's not being addressed in here and you're asking for people to volunteer and you're telling them they're going to put conservative results in and see big number changes, what's the reaction going to be to the plant's management and among the NRC when they see big number changes where they forced conservative evaluations to be done?

So if we're doing frequencies at the same time, then it's realistic, nobody can argue, and then the results are what the results are. But if you force conservatism in and you haven't addressed all the conservative issues on the frequency side, that seems like there could be some concerns.

MR. MELLY: I agree with you and I think it's still down to a timing issue.

Now even before we get to the pilot plants, there will be that expert elicitation that we would like to perform with industry as to what that zone of influence or what the increased area of damage will be for the aluminum events. If the frequency is also an issue that we want to touch on in that work prior to going out to the public or to the pilot plants, that is something that is up for discussion in that effort.

MR. CAVEDO: I think that it would be important to get that frequency thing done before you go to the pilot plants because I don't know how other industry members feel but I don't think you're going to have a lot of volunteers who are going to be interested in showing super high numbers for conservative evaluations. That's a downside across the board. I don't know if any other utilities want to comment.

MR. CHEOK: So this is Mike Cheok again.

So I guess we all know that the risk analysis has several elements, consequences and the frequency. So I think it makes sense for us to, you know when we present the risk numbers they come with the correct frequency numbers.

And so also I think as we do more tests to develop the characteristics of a potential HEAF phenomenon that might also define what kind of plants or what characteristics you're looking for in the pilot plants. So it makes some sense but you know, we build a discussion.

MR. MELLY: Yes.

MR. AIRD: We also have a comment from Ken Z from Jenson Hughes.

He says it would be important to have an understanding of any latent sources of conservatism in the pilot results before further decisions are made related to the GI treatment.

MR. MELLY: I agree.

MR. AIRD: And he also says there needs to be some level of assurance limitations related to the schedule, which are not driving the GI action.

MR. MELLY: Agreed.

MR. TAYLOR: Any other questions?

MR. MILLER: First one back.

MS. WETZEL: I may have missed it, but what kind of schedule are you looking at to get these pilot plants?

MR. MELLY: Stan, can I lifeline you on that one?

So this is part of the generic issue process, which has a defined schedule and time -- milestones that are supposed to be met as part of that process. And those milestones are in place so that a generic issue process does not last for 10, 11, 12 years, as some of them have in the past.

So the milestones are fairly aggressive, which is where the timing issue that I was discussing with Rob come into play but Stan can elaborate a little bit.

MR. GARDOCKI: Typically for the assessment for generic issue, we like to get it done within a two-year period. It's pretty important. You saw it was done within 6 to 18 months. So if it's going to extend past the two-year mark, we would start taking some action on the management level. That's my role as the Generic Issues Manager -- Project Manager for Generic Issues, make sure it doesn't drag on forever.

So we would start taking actions. Well, we can't get the pilot plants, we can't get this done. Then, we start doing the conservative analysis and that would maybe accelerate the process a little bit and the other actions to say well, if we're not ready to go the regulatory action, we could kick out of generic issue, and put it into research, and then come back, and then we're done five or ten years later.

So the time frame we're basically looking for is try to get the assessment done before the two-year mark. I mean that's not set in concrete but that's kind of a target for the program.

So within the next year and a half, I would say, we would try to get that pilot stuff done so we can wrap up the assessments.

MR. CAVEDO: And I understand the need for meeting the schedule. That's very important. But you have accelerated the testing because you recognize that we don't have a lot of insight as to what that damage should be. And so you made that a high priority and you're going to accelerate that within the process.

All I'm saying is the frequency and the damage go hand-in-glove. So whatever acceleration you're planning on applying to the testing, put that same level of acceleration on the frequency. Don't just say we're going to use a conservative frequency because that expedites things for the same reason you don't want to -- you want to do the testing. You want to have -- make sure you have correct insights and a realistic evaluation.

MR. GARDOCKI: I understand that and I think we got pretty much the testing done for expanding the zone of influence. So you get the mark to say go to the plant and say okay, the zone of influence is 12, 15, 18, or 20 feet.

Now as far as establishing the criteria for --

MR. MELLY: And let me clarify. He's just using those numbers off the top of his head. They don't have any basis for what it potentially could be coming out of that expert elicitation. So don't run from here and scream 20. It's not where we're at.

MR. GARDOCKI: The only thing we see now is the testing and you saw videos yourselves how far the zone of influence has gone past what we saw when we set up for the testing. So we need to do additional testing to get a defined expansion of the zone, if it's going to be expanded.

As far as the frequency, I don't think we have an exact milestone in our plan for this frequency evaluation. I thought we --

MR. MELLY: It's identified in the screening report as a task. There's no set milestone for it right now. It is an area where we'd like to focus in on because I think that it can be done in a quicker time frame. There are like limited events for high energy arcing faults. And if we can establish the correct definitions and what goes -- what's considered the blast versus the HEAF, we may be able to accelerate the frequency as well.

Ashley or -

MS. LINDEMAN: I think it was Brenda first.

MR. GARDOCKI: Brenda, yes.

MS. SIMRIL: So I think I know at least an overview of this or a little bit about it. But just to be blunt from the industry perspective, can you give a little bit of a what's in it for us type of feel for being a pilot plant?

MR. MELLY: I can give my perspective. I don't know -- I'm not giving an NRC perspective at this moment in time. And based on the initial assessments that I have done using what we have in-house, the results do not look very appealing to where if I was to do this assessment as an analyst in-house without plant resources as to what modeling changes I can make, the numbers would look fairly dire, which will then potentially lead to the risk -- the office implementation stage, leading to regulatory changes.

Wherever we end up, I believe from having done this assessment, that if we do have plant involvement, we'll get a much better picture of the risk, which will enhance things moving forward.

MS. LINDEMAN: Yes, I guess I'm still confused about schedules. So I know we also talked about the interim ZOI. And to me, this dovetails on Rob's question. If you don't define the scenarios, what are you defining the ZOI for the worst case? So I guess they all need to be thought out in a parallel manner.

I know we're working on it but to me I'm just not sure of the schedule. I think that would really help going forward is communicating all the pieces and stuff.

MR. MELLY: Yes. And like I said at the beginning, I think that this whole effort, the expert elicitation that we are potentially doing, the frequency, that all will come before pilot plant selections. And we would like to get moving on that in a relatively short time frame to have further discussion on this potential.

MR. TAYLOR: What I started to put on the board up here is action items for us to help clarify issues or bring information. And the few things I've put up there right now is GI milestones for all the short- and long-term. It would probably be a good idea to put something together that we can track ourselves to and also communicate clearly on what our expectations are from that program. And Stan mentioned that earlier as well.

And the other thing is just what Rob brought up about the frequency, as well as what Nick brought up on the classification to make sure that the assessment that we do complete is as realistic as we can with the information that we have.

Any other questions?

MR. MILLER: And I'm not hip on all this stuff at all. So on the GI milestones part, is it also the logical linking between the GI milestones, how they're related and have to be scheduled together?

MR. TAYLOR: Yes, right. So that's a good point. There will be. It would make sense to provide some linking to that.

Obviously you guys weren't there during all the deliberations but there was quite an extensive discussion within the group of when they came up with that, those milestones, the action plan, the short- and long-term of how things would work. And I'm not sure it got documented or report that well.

So I think we'll take that back and try to come up with the milestones, the linking, and other things to help support the GI Program -- proposed GI Program.

MR. AIRD: We go to comments from the same commenter before, Ken Z from Jenson Hughes.

His first comment is the current industry of PRA results are constrained by methods acceptable to the AGH. I hope the methods that are used to address this GI do not impose the same constraints.

And then his second comment is I am not a licensee but it is my belief that in order to get licensees to volunteer, there needs to be some level of assurance that constraints on acceptable methods are not going to be driving results.

MR. MELLY: I think that we may be outside of the acceptable methods for this endeavor because, again, this is going to be a risk assessment for the Generic Issues process that's going to be used -- that's going to use a zone of influence to predict damage from an expert panel. It's going to be conducted much more in terms of a sensitivity study, rather than something that's going to drive any plant changes for these pilots or things like that.

This is only for the Generic Issue Program trying to do a risk assessment. It's going to be much more of a sensitivity study than anything else.

MR. TAYLOR: Yes, if I could just add to that. You know kind of what Tom Boyce brought up this morning, I look at the GI Program as basically you're walking a tight line and anything that's going to kick you out of it, you're going to go somewhere else and do it.

So the way that it got structured for the short- and long-term, we want to do this interim review, this interim risk assessment to see whether it is significantly risk significant to take it off into the Regulatory Office for their implementation. So, getting to the question, then, you know the method that we do that interim review in, I wouldn't expect it to be extremely detailed or high level because we just don't have that much information right now to advance the model or the methods that are currently out there.

So it would probably be somewhat course. Hopefully, it will be a little more refined than what we currently have but it wouldn't be the final end product that we would then expect licensees, in the end, to implement in their PRA as an approved method.

So I guess you kind of look at it as a tool for us to assess risk from an interim standpoint.

Any other questions from the room?

MR. MELLY: Or any follow-ups from Ken?

MR. AIRD: Yes, he has two follow-up comments. It's more than ZOI. It's everything else associated with the examination of the progression of the event. For example, the HGL event is driven because of the burning secondary combustible but we're forced to use the HEAF NSP rate.

MR. MELLY: Yes, we're going to be evaluating which aspects of the current zone of influence that's in Appendix M of 6850 or the FAQ on bus ducts as part of that expert elicitation.

So anything for the interim risk assessment that we think would need to change from the currently accepted methods will be evaluated from that expert elicitation, moving forward to the sensitivity study. That is the planned path forward.

MR. TAYLOR: And just to add you know we're going to be focusing a lot on ZOI because that's your initial explosive area, where you get damage from the initial event. But there is also other assumptions in Appendix M that we need to look at, too. Assuming you that you have peaking release rate as soon as the event occurs, you know that is something that I view as being conservative and there's probably room there to make some improvements, especially from the first phase of testing, where we had the calorimetry equipment taking measurement.

Anything else from the webinar? Okay, I'm going to turn it over to Mark Salley.

MR. SALLEY: Yes, so we're all like thank you. We understand the relationships and that and what we're trying to work through with a lot of this, it's kind of one equation and five unknowns and we're trying to bring that together, as well as what comes first on this. It would be nice if we had all the testing done, we had a lot of the side pieces of it and we could bring it.

Frequency, yes, I mean that's a big one. That's kind of what you're going to see the presentation this afternoon with Kenn Miller, where we're changing horses a little bit and saying not everything is a HEAF and we need to get it into the correct bins for our arc flash, arc blast, and HEAF. And I think that's going to be your biggest driver for frequency so that we can get it right.

Again, we're seeing these kind of things as we're moving on. And Ashley, I guess we got the fire events database and we can go back and harvest anything out from that to improve that. So, again, there's a lot of different pieces that we're working toward. These will be the discussions we have this afternoon.

We're a little ahead of schedule, which is --

MR. MELLY: Well Mark, on that point, we realized we needed additional work in this area because in briefing our internal management, when we're discussing an event, it's well, was this a HEAF. And the answer was it depends. It depends on the damage states and things like that.

So the event that we discussed earlier, that Turkey Point event, in the classical way that we've defined it previously for Bin 15, Bin 16 fires, yes, it was an arc. Yes, it held in for half a second. Yes, it created that pressure wave that opened the door. However, there was no fire.

So if that event came in for the event review that we've done for NUREG-2169, yes, there was an arc flash. Someone was damaged or someone was injured during the event but there was no fire. So that would have come close to being screened from the event reporting in entirety.

So we wanted to find with these definitions how do we bin these better so that we can answer the question of and link it to how we model the events.

MR. LOVVORN: Shannon Lovvorn with TVA. I'm at the Browns Ferry Plant.

I'm just going to kind of tag on. I think the idea of getting a pilot plant and helping with sensitivity to help you with realistic is a good idea. I think there's certainly conservatisms in what you did.

For those of us in the industry that might be -- it would help with that -- you know it would be really important for us to make sure we think about where we model ZOIs for HEAFs versus boring burns.

I think at Browns Ferry we have a mixture of some places we did one or the other but it wasn't consistent with every HEAF. So that could greatly influence even the impact result for that pilot plant in a conservative or non-conservative way. In other words, it wouldn't necessarily be representative if you always modeled a HEAF as a boring burn in places where you didn't have a large CCDP and vice-versa.

And so it will be important to us on the industry side to think about who has the right modeling and the insights to be a pilot plant to maybe help give you best information.

MR. MELLY: Yes, I agree.

MR. MILLER: Did you have a comment, Rob?

MR. CAVEDO: So I just want to be clear. I'm not expecting the final frequencies that are going to go into a NUREG. But I think for a pilot effort we can do exactly what you suggested, which is we have fairly good insight about what the HEAF definitions are. And if they are at Turkey Point, then that wouldn't be the one that has the larger zone of influence. That would just be the traditional.

So if we could just get the reduction proportional to what we've seen in industry experience, then that would be something that is realistic and would be more easily sold to our management as being able to volunteer for a pilot.

Because as I said, I don't think you're going to be able to get anybody in the industry to volunteer for a conservative pilot plant unless they've done something where they always assumed that it was a full room burn and they're going to show no delta risk. And that's not going to give you any insight.

MR. MELLY: Exactly.

MR. CAVEDO: So anyone who knows that putting in this conservatism is going to show unrealistic results isn't going to want to do it. But if you've got something that's at least in the ballpark of realism, then people will probably volunteer because they want to see how things are going to go early before it becomes something in the

NUREG that we have to put in.

MR. MELLY: I agree and that's how I envision the pilot program going, as a collaborative effort so that we can understand the risk and instill realism into the process with the expert elicitation. Like I said, this is a sensitivity study. It's not going to be a hard-in-stone NUREG or telling plants to do something. This is just an effort to understand where the current risk is.

So we do have the flexibility to have a collaborative working process here where we can take into account these things.

MR. SALLEY: Yes, so again, for the discussion, Gabe's going to have a little bit I guess this afternoon, Gabe, on the zones of influence or are you tomorrow?

MR. TAYLOR: The modeling today.

MR. SALLEY: The modeling. So yes, this afternoon Gabe's going to talk a little more about the zone of influence.

And also don't forget about where we lock into that three-foot, five-foot, some dimensional zone that when we're talking about the conductive cloud, that may be a whole different type of zone of influence we need to keep an open mind to is the right way to do it. So again, don't put yourself in a corner.

With that, I guess we're ready to take a break for lunch here. It's ten to 12:00. We've given I think an hour and 15 minutes for lunch. So if people could be back at 1:15 downstairs in 2 White Flint and we'll get back up here and get started at 1:30.

Now, if you're not familiar with the area, a couple places you can go. When you go out the front of the building, there's fast food across the street. There's a McDonald's and Arby's. Then there's a Mediterranean place.

Going the other way, there is a Harris Teeter. Nick, you're going down to Harris Teeter?

MR. MELLY: I've got to do this here.

MR. SALLEY: Gabe is going down. So if you guys want to go down to Harris Teeter with Gabe, he can walk you down. We've got a few escorts here to get you there.

And Mark Earley, if you could hang around for a minute and talk with Kenn and I, we're going to do some changes on the next presentation.

So with that, let's take a break. Let's pick it back up at 1:30 Easter Time. And we're off the record.

(Whereupon, the above-entitled matter went off the record at 11:50 a.m. and resumed at 1:40 p.m.)

MR. SALLEY: Are you guys ready?

MR. MELLY: All right. If everybody's ready, hold on a minute. You're going to want the --

MR. SALLEY: What do I want? Oh, the microphone.

MR. MELLY: Yeah. The dead microphone.

MR. SALLEY: All right. For those on the webinar, we are going to get started again very quickly. I'm Mark Salley, and I'm going to open it up real quickly.

Again, I'll have clarification on that power plant discussion.

(Off-microphone comments)

MR. SALLEY: Okay. So, we'll welcome everybody back here in the second half after lunch. And we'll get started again.

A little clarification this morning on the pilot piece. And we understand your concerns on that.

And we're looking at some of the questions especially what Kenny had sent in via the webinar. As we're talking about the pilot, you could actually think of two pilots, okay?

The pilot that Nick is referring to is the piece that we need for the generic issue program. So, that's the pilot there.

As far as if we develop the new method or a new way to address the zone of influence or whatever. That would be a totally different pilot. And that's three years out.

So again, with the piece that Nick was talking to here, was the piece that we need for Stan to do the risk assessment and the generic issue.

So, they're two different pilots there.

MR. MELLY: Yeah. And with the part associated with the generic issues process, it's much more of a sensitivity study to look at the risk.

When we're looking at down the road after the test program is complete, and potentially piloting a new method for evaluating higher arc for both copper and HEAF in a more dynamic approach that's not one size fits all.

That's down the road three years for in align -- it will be on the line with a new methodology. An improvement upon 6850 Appendix M, as well as the guidance that's in the back contract.

MR. SALLEY: And you know, a lot of these programs, a lot of these ideas, a lot of these concepts, a lot of these things that we're working on, they're really moving in parallel.

I mean, the testing is a big one. And that's a big part of it. But it's moving in parallel with a number of other issues.

You know, case in point, the talk that Kenn Miller is going to give you right now is something that we alluded to earlier in Nick and mine's presentation that you just don't have thermal fires and HEAFs, okay.

There's a whole spectrum in between here with arc flash and arc blast. And this is something we really want to redefine it, so that we get things properly identified.

And then we can get the proper frequencies to it. And once we get that, we can then develop the appropriate risk to the zone of influence.

So these are things that we've learned from some of the fire PRA realism workshops. Some of the thing we saw with 1015 and the ZFI plant, going through it. And a number of those things.

So again, this program is dynamic. And as we see something and we learn something, just like we did in the testing, you know, we stop it. And we make the correction and we move on.

So again, when we looked at Bin 15 and Bin 16, we saw that wasn't going to get it. We reached out to the NFPA, Mark's going to have a -- Mark Earley's going to have a talk a little later.

And this is where we want to get the refinement. So, to be able to do that one of the first things we said, you guys all work from codes and standards.

You've got to be able to define it to understand it. If you can't define it then it's hard to move forward. So definitions become very, very important.

Any standard you pick up, any NFPA standard or code, the first thing you see in the first chapter is what? Definitions. When I say AHJ, this is what I mean. When I say fire resistant, this is what I mean.

So again, as we move into this high energy arc faults and the arc flash, I think we need a real clear definition so we know what we're talking about and what we mean. Especially when we tie that to risk.

So, without further ado, I'm going to turn it over to Kenn Miller. And Kenn's going to take it from here.

MR. MILLER: Yeah. Thanks Mark.

MR. SALLEY: Um-hum.

MR. MILLER: That's slide one. So as Mark said, we took a stab at several items to define, again for the purpose of common understanding.

First five up there. You can go to the next slide. And then the three different, you've got fault arc. Arc fault severity classifications.

And so again, I'm going to present to you some proposed that we've come up with so far, proposed definitions for these terms. And the idea is to gather input from you folks, from the industry, from our counterparts, and hopefully get to a good definition that we all agree to.

And then if we can use as terms of understanding and directing the research we're talking about here. Go to the next slide.

So the first one here, arc or electric arc. And you see the definition we've got here. An arc is a high temperature luminous electric discharge across a gap through a medium such a -- such as charred insulation.

This term does happen to be defined in NFPA 921. One of its definitions. Next slide.

The next one is arc flash. Arc flash is

a release of energy caused by electric arc, characterized by a rapid release of thermal energy to the vaporization and ionization of materials by the arc.

This one was developed from NFPA 70E out of the definition of an arc flash hazard. The term itself wasn't defined. But kind of pull it from that.

Another note about it, when electrical protective systems as designed, the arcing event is typically loaded to a flash on the order of cycles rather than seconds, depending on breaker subpoints, or protective relay subpoints.

Arc flashes typically are associated with self-extinguishing fire events.

MR. MELLY: That means these things that you're seeing under here in the notes are our takes on trying to match the classification and the definition that we have with somehow how we treat them in PRA space or modeled space.

So how we bend these and how we put them put them on the report in the model mode.

MR. MILLER: Yes. Next slide. And we go to arc blast. An arc blast being a rapid release of thermal, mechanical, and acoustical energy caused by a rapid heating and vaporization and ionization of materials resulting from sufficiently energetic arc flash.

Arc blasts are more energetic then flash events depending on electrical characteristics of the system during the initiation event. Such as phase angle current voltage characteristics.

This definition was also developed out of NFPA 70E, although it wasn't defined specifically. There's an affirmative Annex K4 that talks about blasts.

Again arc -- and again, going back to the PRA factors for it, arc blast can cause room over-pressurization effects that could potentially lead to missile damage effects from thrown equipment or enclosure material.

Arc blasts are associated with flashes. But not all flashes are blasts. And arc blast events still occur when electrical protective systems work as designed.

Next slide we've got goes to the HEAF. We see our HEAF here, we've got a high energy arc fault, it's a type of arc flash that persists for an extended duration.

That duration indicative of a level of circuit protection failure and/or protection design flaw. One of the comments we had early on, we had set in there typically two seconds or less.

And it's kind of hard to, you know, pin down an actual time. So, I changed the definition just to say tying back to the premise that, you know, the HEAF is probably due to some failure in the protection circuit.

High energy arc faults are typically associated with events contingent with a failure or lack of circuit protection or adequate circuit protection coordination.

High energy arc faults are associated with arc flashes. But not all flashes are high energy arching faults.

High energy arching faults may produce varying levels of arch blast.

MR. MELLY: Yeah. And this issue of duration that Kenn was talking about has come up on several of our phone calls with NFPA, IEEE, and other folks because the duration is very important to the overall damage sustained.

In a lot of literature and for safety personnel protection you'll see two seconds listed in a lot of places. And we've been kind of digging into where that two seconds comes from. And it's nowhere.

It was generally defined from certain people that were talking about is that's the typical reaction time for a human hearing a blast event and being able to react. And it was a general time frame.

So, there was no duration that we could pinpoint as to what duration ties back to the amount of energy released. And that's still something that we're kind of working towards right now.

And that ties direct specs into the test program as to what's the minimum duration that we are going to be testing it at now. It gets to a lot of the comments that we'll discuss tomorrow for the test program.

MR. MILLER: You know, and again in terms of, you know, protection system functioning, you know, we're used to those kind of systems performing in cycles versus seconds.

So, you know, a long duration is typically indicative of some failure of some kind. A relay failed, or a breaker's stuck, or the design itself is flawed.

So, again that being a -- that failure being a contributor to the creation of the HEAF. Next slide.

So then breaking down a HEAF into three

different classes. The Class 1 damage is contained within the general confines of the component of origin.

These events are associated with minor damage and minimal bus bar degradation from melting or vaporization. So this will be the lowest level HEAF.

Next one, Arc Fault Class 2, at arc blast or HEAF.

(Off-microphone comments)

MR. MILLER: This damage is contained within the general confines of the component or origin. However arch blasts have to the potential to damage surrounding equipment through pressurized effects, sever equipment defamation for doors to create fire barriers.

Typically, they do not create ensuing fires. Typically associates with the design and electrical coordination breaker performance.

Pressure effects are highly dependent on route configuration and electrical characteristics of the event. So that's the medium level.

And the Arc Fault Class 3, damage includes the component of origin as well as spread to surrounding equipment within the fire zone.

This damage includes pressurized effects on a severe equipment deformation from doors, degraded fire barriers, which protect -- potentially can affect equipment in other fire zones or in an electrical world, other separation groups or divisions.

These events are typically contingent with ensuing fire conditions. Typically indicative of a level of circuit protection failure and/or design flaw allowing for extended duration arc events.

And pressure effects are highly dependent along the room configuration and electrical characteristics of the event.

MR. MELLY: And in terms of what we've been discussing earlier as to redefining these per PRA, like right now we are trying to overall create a definition that's not just nuclear specific.

But in terms of how we would use it in the PRA community as well as nuclear. You can think of Class 1 being -- Arc Fault Class 1 typically those events would be included in the Bin 15 fire events, where it's just the component of origin.

Class 2 and Class 3 are typically right now how we look, or how we're classifying HEAFs. And we want to make a specific effort to separate those events which do not have this larger zone of influence of damage from the ones that have potential pressurize effects.

So hopefully that will marry up with the methodology on how we treat these events. We want to be able to split the frequency, align the frequency definition and the methodology.

And this is our attempt to do that and align with the definitions.

MR. MILLER: So this next slide shows the three arc fault classes and some pictures of, you know, examples of each type. And some description of the two levels, three levels.

MR. MELLY: Yeah, and again, you can tell from the pictures here, we actually pulled these events directly out of the fire events that constitute the frequencies currently.

You can see that -- I pulled some of these from Bin 15 fire events. And you see that there's largely damage to the internal components.

There's some material degradation of the bus bar stubs itself from the fault. But usually, very limited duration of protection scheme works.

So you'll see smoke damage and potentially the initiation of a small fire which may or may not self-extinguish.

The Class 2 that we're talking about are these ones that can have the pressure effects to the room. Possibly contingent with a fire as well.

However, the fire that would be associated with these Class 2 events, we wouldn't initially say that it's at the 98th percentile of the heat release rate curve at time T equals zero. So that's another differentiation that we'd want to do to the method.

Then these Class 3 fires are what you typically associate with how you're thinking of higher arching faults that make Appendix M methodology. And the -- and Supplement One to NUREG 6850 in the FAQs for bus ducts.

So these are the larger damaging events that have the ensuing fires. And the classical zone of influence of damage outside the cabinet.

And so, visually it helps to picture what these types of classifications look like.

MR. MILLER: And the last slide. Then the last definition, electrical enclosure thermal fire.

Thermal fire is an electrical enclosure fire in which the electrical unit does not significantly contribute to the heat release rate of the fire. Rather, the heat release rate is determined solely by the chemical energy released by combustion of the cabinet's contents, and classical fire dynamics.

MR. MELLY: And these would be the type of fires handled through the Helen Fire work and the Rachel Fire documentation.

MR. MILLER: So, again, our intent was to put these up on the board for you all to see. And I guess if there are any comments that you wanted to provide to us at this point.

Or, you know, a day to think about them. As we're doing stuff tomorrow, we can also revisit the definitions once you've had a chance to think about it.

But, that was the purpose of the presentation. Yes?

MR. RHODES: Yeah, I'm Bob Rhodes from Duke Energy. On your definitions, you need to put a clarifier on there.

Because I can read your first one there for the arc flash, and get down to an electrical failure on 108 or 122/40 to a 36/18 volt transformer inside a Hoffman box that nothing ever came out except a little whiff of smoke.

And by that definition, I'd have to call that an arc flash.

MR. MELLY: That's a good comment. We

currently do not have voltage electrical characteristics built into this.

But that maybe something that we want to do for threshold limits.

MR. RHODES: Voltage and power -- I'm sorry. Voltage and power release or something like that. Because I'm dealing with one of those right now.

I'm trying to decide if that's an IMPO reportable. And with that I'd have to classify it as at least an arc flash.

MR. MELLY: That's a good comment.

MR. TAYLOR: Yeah. And I think their original definition in 6850 is 440?

MR. MELLY: The original definition for HEAF 440, we have seen indication from OPE internationally that there was a higher arching fault as they classified it in a 380 voltage piece of equipment in Germany.

That is in the International Operating Experience topical report. That was also one of the larger comments from the international community, to try and investigate the threshold of how low we can go and actually create one of these events.

That becomes a little challenging just

because of the amount of resources you have to put in for one test. That performing lower and lower test voltages to get a threshold, eats up a lot of our budget for actual testing.

So, it's something that we're considering. But I don't know if it's necessarily going to be part of this next test phase.

MR. FUNK: Dan Funk, I have a question. Just a couple of points. On the two second that you had brought up, I think I could be wrong here, but that the basis of that was for IEEE applicable, IEEE standards, mainly C37.

That's the basis for everything. For the withstood rating of all the enclosures. So if you go beyond two seconds with high energy, basically you're out of warranty if you will.

MR. MELLY: We have --

MR. FUNK: And no guarantee that mechanically that the switch here is going to stay together. And then all bets are off.

MR. MILLER: Yeah. That's kind of getting to what we were -- what I was saying earlier about that, you know, in the protection world, two seconds is an eternity.

And I can see why IEEE would assume two

seconds is the upper bound.

MR. FUNK: And that's the second -- in cycles, a few cycles, five to ten cycles --

MR. MILLER: Right.

MR. FUNK: For your primary trips. So if you're at 120 cycles, something's really, really wrong.

MR. MILLER: so C37.

MR. FUNK: ANSI C37.

MR. MILLER: Yeah. Okay.

MR. FUNK: I would suggest getting familiar with those. They will probably be fairly helpful.

MR. MILLER: Yeah.

MR. FUNK: One other quickie on the threshold. It could be -- again, I was not on this committee, but the Arc Flash Committee, 1584 for IEEE, and I know going all the way back to the 1970s when they started requiring arc fault protection for large load centers.

MR. MILLER: Um-hum.

MR. FUNK: There was a tremendous amount of research that was done on the threshold for a sustained arc. And so instead of retesting, you might do a good literature search on that.

And I know there's some really, really good information out there.

MR. MELLY: That's a good comment. Any more questions?

MR. MILLER: There's one up here. He was next. This guy here was next. Mark was next.

MR. TAYLOR: Mark Earley, NFPA?

MR. EARLEY: Yeah, thank you. This is one aspect of our program that we're doing a little bit more work on.

Because we've done some tests at the lower end. And had situations where we couldn't sustain it.

And now we're just trying to explore the floor. And that is in the -- coming into the next phase of our program.

So, we weren't convinced that the material already out there in, was conclusive enough. Thank you.

MR. MILLER: By floor you mean voltage or energy?

MR. EARLEY: Yeah. The floor at which you could sustain an arc. And I recognize that, you know, there might be some qualifying conditions that make it sustainable. Thank you.

MR. MILLER: Um-hum. Oh, Ken Fleischer

had one.

MR. TAYLOR: Next comment from Kenneth Fleischer.

MR. FLEISCHER: Yes. This is Ken Fleischer from EPRI. I wanted to just leverage off of what Dan Funk said.

Actually, there are switch gear standards. They're two seconds. And circuit breakers are three seconds.

And I can trace back to some of the IEEE standards to help support that. That was actually in our official comments on the draft test plans. So they're also in there as well.

The second item too, in regards to the high energy arc flash definition, I offer up that for consideration when you talk about typically related to lack of protection or circuit protection failure, I recommend saying multiple circuit failure protection.

Because typically, when you start getting into seconds, it means both your primary and your backup probably failed.

MR. MILLER: Um, yeah.

MR. FLEISCHER: So, I would consider multiple. In fact it gets into other things about what are HEAF events.

Most of what I read appeared to be failed multiple barriers on multiple accounts. And failed protection, failed -- inadequate maintenance design flaws, and human operator events.

So, I would think that even maybe adding that as well considering multiple -- a failure of multiple barriers.

That's all I have.

MR. MILLER: thanks Ken. Anybody else?

MR. TAYLOR: Bob Daley, Region II.

MR. MILLER: Mr. Daley.

MR. DALEY: Mr. Miller.

MR. MILLER: Be good now.

MR. DALEY: I'm just looking at your -- you've got these -- you've got the different classification.

Then you go to the very last slide, which talks about electrical enclosure of thermal fire.

MR. MILLER: Yep.

MR. DALEY: Well, what do we -- what was your -- what was the purpose for including that? And what are we talking about?

Are you talking about like low, or very low energy and control circuits? Is that what we're talking about there?

Or are we talking about something else?

MR. MELLY: No. The --

MR. MILLER: I think this more about the fire then --

MR. MELLY: Yeah. The reason that we included this was just to be all encompassing for all of the ends that we're talking about. What can happen in an electrical enclosure.

And the regular thermal fire the way that we treat it through the fire growth, heat release rate profiles. We were trying to clean up and make sure we had a definition or all our treatments.

This one may or may not be necessary in the overall definition if we're going to focus in on the arching behavior.

MR. DALEY: Yeah. Because the only -- really, I mean, a lot of this has. But if you're talking about low energy control circuits and that, then you're probably talking primarily just, you know, talk about insulation type fires.

But when you start getting into anything that's got something with higher energy on it, you're getting into some combination of, you know, insulation and electrical. Even if it starts with the insulation.

MR. MELLY: Right.

MR. DALEY: You know, or a combination of both.

MR. MELLY: This was more trying to get to that image that was during Mark's presentation of the two potential paths for an electrical enclosure fire.

You have your thermal typical fire associated with Helen fire, Rachel fire, as well as the 6850 heat release profile treatment. Then you also have this separate risk driver, which is the high energy fault -- the faulting cases.

So this one may or may not be necessary. But to be all inclusive, we included it here.

MR. MILLER: Other comments at this point?

MR. TURNER: I have a comment on it.

MR. MILLER: Okay.

MR. TURNER: I'm Steve Turner. I do a lot of testing work. And we struggled with this a lot too. How bad can things get and how to classify it.

I think one of the things you guys might want to consider is you touch on a couple of things here like this. Let's go back to hazard analysis 101.

I'm trying to figure out how bad the hazard is with the potential. We can always relate it to energy. Right?

And ask for every height, how high is the brick off the floor? If you can relate these to energy somehow and you captured it some with the duration thing here.

This makes something happen. But as they're defined now, I can sort of see how to Bin it in this category once it has occurred.

If I'm trying to analyze my plant, I've got to think about the potential in some other way. These kinds of subjective, this has been, that's been, doesn't work.

So if you can relate it to energy, I think that would help. Because for example, it relates a little bit to Kenn's question. My energy is this by the time the primary circuit fails.

But the secondary circuit that's in two seconds. Now the energy is higher. And my HEAF is worse. But my frequency is a lot lower.

So if we can get back to where we're talking about energy, I think that helps a lot. And your one definition for high energy arching fault, you mentioned the duration.

But you could be having an arc maybe just because a contact didn't close. So my arch's over two inches. And my arc voltage is going to be so low that my energy is going to be pretty small.

And so duration itself doesn't capture it. What we found after testing, I'll need to drop back one.

The hard part about calculating what the energy is, is we all know how to do a short circuit calculations to figure out what our shorting current is. So current's easy.

The hard part is, it's harder to do the duration. And it's really hard to do the voltage. Because the voltage really depends on the gap or whatever decides to be arching.

And you can't predict that very easily. And you can find that even in the tests where we set it up a certain way. Predictably, I don't get the arc voltage I'm looking for.

So the arc energy calculation is hard to do. But even as random as arcs were, one of the things we found out in our Japanese tests, and I think they're leaning toward classifying what do we do about this?

When is this a problem is, when we ran a bunch of tests and what the point that we get internal fires in the ca -- inside the cabinet.

And we ran a whole bunch of tests with all sorts of configurations. And all sorts of currents and all sorts of supply voltages, and ended up being arc voltages too.

We pretty much found out if you didn't have at least 25 megajoules in the cabinet, you couldn't set the cables on fire.

Now so to them what they're doing, is they're going back and they say okay everybody, don't calculate your protective circuits. And if you get to 25 megajoules, you have to do something.

But if you're below 25 megajoules, we don't think you get the cabinet for fire on this. Kind of simplistic. More deterministic and not quite what we need for the PRA world.

But, you've got to give us something to calculate. These definitions I think are great once we look at the picture and say oh yeah, that's a Class 2 because this happened and that happened.

Well, I'm trying to put down predicting something in the PRA.

MR. MELLY: Yeah, but --

MR. TURNER: If you just go back to energy.

MR. MELLY: I think you're two presentations ahead of us right now.

MR. TURNER: Okay.

MR. MELLY: But we're going to be discussing how we are going to be potentially using the information of the test two and test one program to create a dynamic model based on the parameters, energy duration that configure to your plant.

That is absolutely where we're potentially going to go with this. However, for the definitions piece, I'm not sure about if we want to tie in the energy levels there.

We can look at that. However, this is more for binning the frequency once the event has already occurred. We were in that mind set.

But it maybe something we can look into whether an energy level can be directly tied in here.

MR. TURNER: If you're doing your binning kind of based on this and looking to experience base out there, you may not have enough duration data.

But, can you go back and calculate the energy for those events? And be able to put on these slides these were generally 25 megajoules to 40 megajoules in the --

MR. MELLY: Not from the operating experience data.

MR. TURNER: You can once you do your

experiments containment.

MR. MELLY: Right.

MR. TURNER: But I think -- I think you might end up having something a little fortuitous like we had on our internal cabinet fires. Like hey, 25 megajoules seemed to be the magic number to fit.

We've got enough data points now that they're actually regulated to that. But, I just feel like when we're doing actual analysis and having this sustaining effect that hazards 101 and say hey, what's the energy you're dealing with?

That's how you look at the severity of any hazard you have.

MR. MILLER: So you have an energy value for Class 1, Class 2, and Class 3.

MR. TURNER: Yeah.

MR. MILLER: Successfully higher.

MR. TURNER: Yeah. And then that way when people can -- that's actually something people can calculate, because I think you'll get enough data where even though it's very difficult to predict what the arc voltage will be, probably for certain sizeable equipment.

Say hey, it's medium voltage, you should be having 700 to 1200 volts that you could put in as a distribution if you wanted to.

And the duration you could relate back to the failures that we're taking about. You know, your primary system this fast. And now your secondary system acted that fast.

So, regardless of what the arc wanted to be in duration, you can just let it go. As long as you're protected from circuit response that everybody knows how to do.

Let that be your duration. Give the energy levels, put in these bins. That's why I was commenting on cancelling.

When you look at your secondary system, that might let it go three seconds. But that's a much lower frequency.

So you might still be on the good side of analyzing HEAFs. So, let's just go back to energy if we can.

I think it just makes me feel like it's more bounded in something quantitative then just these observations of well, that was a lot of energy, and it hurt this more than this. Or this door blew open.

If you relate it to energy I think that it won't override the standby. And things that people can kind of calculate.

MR. MELLY: Yeah. Thank you.

MR. TURNER: Ahead of time.

MR. MILLER: One of these presentations will be touching on that.

MR. TURNER: All right.

MR. MILLER: I think it's two presentations.

MR. TAYLOR: Any comments on the webinar?

MR. MELLY: Just speak louder.

MR. MILLER: So any other comments or input? Like I said, when we get into the other sessions, if something comes up on definitions, we can always take additional as you think, had a chance to think about it.

MR. MELLY: And for this specific topic, we have provided the full working list right now of what is in here. And I know that we have had previous calls with NFPA and IEEE. FM has also been included.

If we -- if you have any written comments or anything that you would like to provide on this Word document or a write up in either pdf or Word format, that would be greatly appreciated. And we would take those and try to work with those comments.

MR. MILLER: Let's see, I guess next we've got small-scale testing. That's next? Is that next?

MR. MELLY: Yeah. That's good.

MR. MILLER: Okay.

MR. TAYLOR: Okay. I'm going to stand up if that's all right. My name is Gabe Taylor. I'm in the Office of Research.

And what I want to go over here is the stuff that we're doing out at Sandia National Laboratories. And it's the small-scale testing program.

It's a little different than what we typically do in the fire research area where we do testing. On account of especially when we look at circuit analysis, we do small-scale and a lot of data all effectively.

And then we go too large-scale and make sure that the small-scale results match up with more realistic type of thermal environments and what not.

So, here it's a little different. And really, you know, why -- why are we looking at small-scales? It really comes into the aluminum aspects of these events.

The exothermic energy that we're getting from the aluminum, we want to better understand that. And one way that we can do that is by controlling the variables in the experiments that we are going to perform small-scale.

Large-scale is not saying we can't control experimental variables like voltage, current, or duration, those sorts of things. But when you look at the large-scale testing, we'll talk a little bit about this tomorrow, our instruments have to be in the right spot.

All right, so if your instruments on the front of the gear and the arc blows out the side and you don't have instruments there, well then you're missing what you really want to capture.

So when we go small-scale, we can really focus our instruments and get in closer to the arc. And characterize not necessarily the arc itself, but here we're more interested in the particles.

The aerosol and the different types of vapor and molten material that's coming out of the possible material. And the real reason why we're interested in that is we want to understand what is causing this extra energy from the -- when aluminum is involved in these types of events.

So, it's a little different from what we've been doing in the past where we're trying to -- we use scale experiments to try to get the same results.

Here, what we're doing is we're trying to work with the University of Maryland, Dr. Jose Trojero. And to develop a model that can predict or estimate the amount of energy coming off of these events from the aluminum reaction due to the particle morphology and size of the particles.

So what we're trying to learn from the experiments is listed on slide three. We're trying to understand particle sizes, the distribution of particle sizes.

How fast we're producing the particles at a certain rate. Composition, morphology, degrade of oxidization, as well as the trajectory.

One of the thoughts with the model was that as the -- as you get further and further away, the particles change. They coagulate. The morphology is different than when they're close into where the arc is.

And as they get out there's going to be less and less energy that they're going to contribute. So the trajectory is also important.

From this we're also going to take some mass loss measurements that may help identify how much mass is lost that can then be correlated to an energy release. Probably need a small-scale event.

So, how are we going to do this? Sandia National Laboratories has a lightening simulator where they've been looking into different types of electrical discharges.

And they have a lot of toys out there that are very high speed sophisticated that can characterize the materials and the particles. So, we're going to collect high speed videography, up to five hundred -- or five million frames per second.

We probably won't need that type of capability. But one million frames, maybe two hundred thousand frames per second with neutral density type filters so we can actually see the particles that are coming off of the arc and off the bus bars.

And then they come right after their super computers and come up with the trajectory speeds for the different particles.

We'll also have a proof of concept type of program with this small-scale. Is out there.

And I'll show you later one, but there's black carbon tape and silicon aerial gels that will be used to capture the particles. And once they capture the particles they can then take it to their type of spectroscopy and scan electron microscope tools to then analyze the particles.

So what we want to do here is test out those processes, those post-test analytics to see if they work. If they can characterize the particles.

If they do, then we want to employ it when we go up to do the full-scale testing. To capture that -- those particles and make sure it's the one to one comparison.

To help support the model that we hope to have from the University of Maryland. Next slide.

So here it is a picture of the experimental stuff as well as the illustration that was in the test plan. I'll get to the test plan in a few slides.

But basically from the photo you can see two vertical bus bars there. So, the arc will occur near the top.

Because they're vertical, the thermal will quickly shoot, you know, off and away. So, the arc will be initiated there by a thin film -- or a thin filament, it's basically a shoring wire that we use in the full scale. But a thin filament here.

And then they have cameras at different angles. So you can see a camera there. There's one looking down. Here's one looking in this direction.

So on three axes there's high speed

cameras. And then what's not shown here is where they'll do the particle collection.

They usually get it pretty close to the bus bars. They ran some shakedown tests, we like to call them, just to make sure that they can capture the particles, their systems are working and get the information that we really want to do before we go and actually do the tests.

The testing's not the expensive piece. That we may can do probably 20 or 30 tests a day. The expensive piece is the post-test analysis for the material and their high tech equipment and post-processing. Next slide.

So now we talk about some of the experimental variables. We can -- now I have a test matrix later on that I want to spend a little bit of time on, getting your feedback on.

But, we can get a wide range of voltages. Right now we're proposing those voltages, 48kV and then some medium voltage, .48kV up to 10kV. And currents at any range from .35kA up to 29kA.

One thing that we're limited on is duration. So unlike the two plus seconds that we probably be in authority at the KEMA facility, here we're limited to milliseconds, is what they can do.

And they're also making some modifications to their power system to be able to get a tenth of a second duration. So, it is quite limited on what the duration is.

But, those durations, even with the 40 milliseconds, it's long enough to create the plasma. And to emboss on aluminum from the bus bars.

And from their analytics they can then look at the particles and tell whether it's the filament or the actual bus bar that they're analyzing on the particle side.

Bus bar material, we want to -- the focus of this is on aluminum. But we want to also include copper to get some comparisons.

Here's the current text matrix. And this is what you've seen in the test plan. I basically went over these on the previous slide.

But again, about 20 tests in total. Varying voltage current, time and materials. Has everybody been able to see this before? Are you familiar with this?

So, here we can just get into this right now. Going for a little bit due back and after the meeting, or even tomorrow, you guys are welcome.

But certain things that, you know, kind of came in towards the end of the development, the test point is looking at DC.

Now on the DC case they're limited only 300 amps. Basically what kind of, you know, welding type apparatus to perform that.

If you look at the Op E, there's not much, if any, information on DC arcs. I'm not saying that they can't happen or they aren't significant when they do happen that that lasts awhile.

So you know the question that I'm basically posing is, is it worth our time looking at DC? And if it's not, can we reposition some of those tests to get more replicates in other areas?

MR. VERHOEVEN: Hello, Bas Verhoeven from KEMA. You talk about on durations of four milliseconds. And how do I prepare that? Because you call around as an AC.

Good. But in this time frame it is just some kind of DC like current?

MR. TAYLOR: Right. Yes It is a DC current. So these are -- these voltages are scale.

So basically on the wave form you're not getting any so at least for these short durations.

MR. VERHOEVEN: And how is Sandia making this change of current? Is a bus for a conductor running things?

MR. TAYLOR: So they have an MD set. And they have a conductor and capacitors set up to provide the source.

Question from EPRI?

MR. FLEISCHER: Yeah. Ken Fleischer here. This maybe just more of an observation on the table.

It looks like items 8, 12 and 16 don't -- doesn't say which one's an AC or a DC test. The columns are empty.

MR. TAYLOR: Yeah. That's a good point. We'll get that fixed. So, it should have been AC in there.

But as far as, you know, these tests here, does anybody in the room at least see a need for performing them?

MR. FLEISCHER: For performing DC?

MR. TAYLOR: Correct.

MR. FLEISCHER: It has been a very long time, but I worked with an IEEE professor out of Rome, Italy where DC arching faults can have severe damages.

And telephone substations that rely heavily on batteries have been known to completely burn down buildings from arching faults. But they may be of a different nature.

So from an -- if we're in experimental space and exploratory, it may be worth trying those to see what we get.

MR. TAYLOR: Okay. And again, you know, this isn't a scaled program. So it may be worthwhile just on -- from the particulate aspect to see there is a major difference between the two.

MR. FLEISCHER: Right. The thing I forgot to clarify. With a DC arching fault, the reason why they can be so catastrophic is you don't have the zero crossing as you do in AC current.

So therefore, you don't have that momentary extinguishing and restriking the arc. In DC they can persist.

MR. FUNK: Yes. This is Dan Funk. I just want to second what Ken said.

I think from -- or it's pretty soft testing. You know, the desert retesting we have pretty good evidence that the DC can be pretty damaging.

The other thing is, nuclear plants have very large batteries. So the available fault arc can be extremely high.

And you just work the energy numbers like Steve was pointing to. You know, 10 thousand amps of

DC with no zero crossing, and once we have those, a tremendous amount of energy.

So, I think it's a good test to run. The fact that you're limited to three hundred amps, I'm not sure about that. That may not be great.

MR. TAYLOR: Okay. So I'm not hearing any feedback to get rid of those tests. Any other opinions in the room?

MR. MILLER: We just had -- we don't have any OP B on DC events, right?

MR. TAYLOR: None that I'm aware of.

MR. MILLER: So Nick's the OP B man on HEAF. So, he's shaking his head no. We don't have any OP B for HEAF in plants.

But, you know, that doesn't mean it can't happen or that it would be catastrophic.

MR. TAYLOR: I agree with that to some levels.

MR. FLEISCHER: There was years ago an AT&T -- I'm trying to think of when it was. Maybe about in the mid 90s there was an AT&T. It's not nuclear.

MR. TAYLOR: Right.

MR. FLEISCHER: But it was an AT&T switching substation that had a tremendous amount of batteries that burned down from a DC arcing fault that would not -- that was -- that did not self-extinguish.

If I can remember or find that OE, I'll see if I can bring it up.

MR. TAYLOR: I guess the other thing that I wanted to mention, and I don't think I have a slide on it, is that -- could we go back to the diagram of the set up? Right there.

So these were kind of the shakedown tests. And you see the bus bars. They're fairly big.

I can't remember the size they used here. But you know, you're basically looking at a centimeter, by four or five centimeters, a rectangular bus bar.

The one thing that they identified was that when they tried to go and do the Raman spectroscopy to look at how much material had been lost or eaten away from the busses, they were having some difficulty.

So one of the things that they wanted to do, and it's in the test plan. But there are some errors with the test plan associated with it.

Is basically scale down the bus bars to make them smaller. And by doing that they should be able to get better measurements of the mass loss.

So what they proposed and the test when it went out, is to do a one millimeter by three millimeter bus bar. So that's pretty small.

And you know, I questioned them. You know, is that so small that it's just going to deflect away? Or, you know, blow apart and then you don't have anything to go and measure anyway, because you're picking pieces up and, you know.

So we're still working on that. They're going to actually run a few more shakedown tests to see if that is the case.

But again, we're trying to scale down the bus bars such that we get a better, more accurate measurement. So I know Ashley brought that up. And Jeff Wagner from Southern Company brought that up as well.

The other thing is that arcing -- in the test plan there's an error in the arching wire. It said we used six American wire gauge. We're actually using a filament.

So a filament is like 10 to the minus 6 millimeters. Like it's really thin wire. It's what we use in these experiments.

It's a copper filament. So, again, on the post-test analysis we'll be able to make the difference between a copper filament and aluminum bus versus -- and vice versa for when you have the copper bus for the particle analysis.

Keep going. Go back to that test plan.

So again, if there's any comments or feedback, we have three medium voltage that we're testing. I don't really see too much 10kV at least in the US plants.

International plants, I think there's more. But you know, obviously we have 12, 13kV plants out. Again, we're looking for some feedback here.

If you want to give it to me now that's fine. If later after the meeting, send me an email.

The time line, which I'll get too later, we're looking to do these tests sometime in late June. This bar count.

So, we need that feedback fairly, fairly soon. Also scale currents. Any feedback on that one too.

Shannon Lovvorn from TVA.

MR. LOVVORN: Yeah. This is Shannon Lavvorn with TVA. And I was just curious, do you guys think that you're going to be to try to project different voltages from this data?

Well, one thing that comes to mind is like isophase bus, for example, you know, it's most plants will be higher than 10kV. And sometimes with the aluminum bus and trying to model isophase bus faults, not exactly sure if we can project what this looks like for those who are being thought and put in that.

MR. TAYLOR: That's a good comment. I don't have the answer to it.

MR. LOVVORN: Okay.

MR. TAYLOR: We can take that back to Sandia and see. Obviously the guys that work in the lightening simulator have a lot more experience at modeling.

And the extrapolation, it might be possible. I just don't have a good answer for you.

MR. MELLY: That's also something that we're looking for in the larger test program. If we can do extrapolation across both of this incurrence that we are -- have selected to test at.

And that's why we're trying to get a range of currents and voltages in the test program. In hopes that maybe we can do extrapolation beyond it.

MR. CAVEDO: So, we spend a lot of money on 125 OTC coordination, evaluations, and I was wondering from the electrical folks, because that's not my background, but how difficult is it to have these higher current and volt allowed plant on 25 volt DC system?

Because it seems like it would be much less likely then at some AT&T station where they don't have to do all the detailed evaluations. Is that something where it's just not practical to happen in a nuclear power plant?

Maybe we don't need to do this? Maybe we could do testing in other areas that's more important?

MR. TAYLOR: Anybody want to answer that?

MR. FLEISCHER: Ken Fleischer from EPRI. Yeah, historically I haven't seen a lot of arcing faults in DC systems.

Usually they've been more three phase bolted for three phrase. They've been more like a bolted or a low resistance fault.

But if we're in an exploratory space right now, this would be the time to get it. We finally, or if we want to go back to it, we'd have to re-contract the facility, rewrite the test plan and all that.

But the thing is that when you do have an arcing fault in a DC system, they're very nasty. So, I'm not sure if I'm answering your question though.

(Off-microphone comments)

MR. FLEISCHER: Some -- there are -- the newer DC systems do. Older DC systems may still only have one fuse.

MR. MELLY: And since we are in DC, everyone can look at the metro failures and problems that we continuously have on our DC system.

MR. FLEISCHER: Yeah. No, no, you're right. You're right. The single fuse are typically in the 120 volt control power transformer fuses.

But yeah. Yeah, usually there's two fuses.

MR. MILLER: Usually it's two.

MR. FLEISCHER: Yeah. Usually it's two.

MR. DALEY: Yeah, I don't -- I guess that you'd almost have to look and see if they've done some OA and see if they've actually had these type of events.

I know Kenn Miller. I work with Kenn a lot. We did a -- there's a NUREG and what's the number on it? We gave it a number.

MR. MILLER: 6778

MR. DALEY: 6778, what we did. Because we found out that the -- through a plant event that the DC system was not coordinated properly.

And there was a lot of assumptions as far as how -- what the maximum current you would see like at the actual charger.

So we went through at Brookhaven and did a lot of short circuit testing. And you know, so we got amperages, we got, you know, time to trip the clear the -- yeah, clear the fault.

But I kind of agree with what you were saying. I mean, if we -- if it's not that difficult to do, why not do it?

So when the event actually comes up, we can actually, I mean, we could actually -- we have something. Right?

But I mean, if it's really a big problem, then I think you'd almost just have to look and see how many events we've had. If we've had no events, then we just go from there.

MR. MELLY: That may bring up another question. Is that the current large-scale, full-scale HEAF program does not have any DC systems for planned arcing.

Whereas we can do this. And this is currently going to investigate the particle size things and everything that Gabe went over as outputs of this test program.

We have nothing in the large-scale program, whereas it could be an option to add it in.

And again, we'll have larger discussions tomorrow.

But, it may, if we feel like it's worthwhile to do, we may want to do a few.

MR. DALEY: It was not easy. As a matter of fact I remember it wasn't really easy to get batteries and to get everything, the equipment and all.

MR. MELLY: We will have -- I believe KEMA can speak to it a little bit. But they have the capability of doing a DC system.

So, we can run the test without getting the battery banks and things like that.

MR. DALEY: We don't -- yeah, we don't use those.

MR. MELLY: Right.

MR. MILLER: Yeah. I guess to answer your question, Bob, we had batteries and charges set up for some other types of testing events. And we already had the infrastructure in place to do this additional fault test.

I guess the other thing too is that going back too again, to the nature of a DC event versus an AC event. And again, with the small-scale we're looking at the physics of what goes on in the fault.

It would be interesting to see, I would

think, the difference being able to compare AC and DC. So again, I too would make the case that doing some DC, I think, is worthwhile.

Plus, along with all the energy it's -- again, at a nuclear plant, they do have very large batteries with many amp hours of capacity. So their potential to drive an energy event is huge.

MR. FLEISCHER: Yeah. I used to do DC short circuit ops. I've seen them go as high as 17, 18 thousand amps.

But again, we're talking -- that's a low resistant fault. We're talking arcing faults which have a characteristic in nature much different than a low repeating fault.

MR. MILLER: But the energy is there.

MR. FLEISCHER: Yeah. That's going to come back.

MR. TAYLOR: I think we'll go ahead and go on the next slide. Again, looking for feedback on any changes.

I haven't heard any yet. But if you do, please get in touch with me.

Measurements, we went over this a little bit. Videography, taking the high speed imaging. And then they can put that in their computer system and actually track particles. You're already seen some of that from the shakedown test.

Aerogels to collection, again, proof of concept. If it works here we'll probably do it full scale.

And then from those collection techniques there are a bunch of different post-processing analysis tools that they can use to characterize what the aerosol is. So, I'm not going to get into all of those.

But you see here, well it's small, but the photograph to the left is basically showing you what's the arc. For one experiment on the shakedown test.

And from that they can all use it. So, one thing I found interesting with that is that they can then look at that, put it in their system -- in their tool, and they can look at the soot deflector.

And because it has a characteristic similar to graphite, they can actually -- they say they can predict what temperatures that the bus bar has reached from the residual carbon on the bus bars.

You can go to the next slide now. And then using our scanning electron microscopy, they can then get into see what type of diameters.

They can look at oxidation levels. They

can look at was it a vapor, was it a molten material?

Because of the characteristics of this, they're seeing a lot of molten material in the particles. So, it melted and it re-solidified.

So again, you know, surface area oxidation, trying to understand what contributes to that extra energy from the aluminum type of events. Next slide.

Just touch briefly on the modeling. Again, we're trying to collaborate with the University of Maryland, College Park, Dr. Jose Trojero to develop a fundamental energy model.

And some of the -- we met with him about 18 months ago. You know, the things that he needed were really the particle characteristics that we're trying to get from this experimental program.

So really, he has a model he's developing. And we're -- this is the input that's going into the model to help further develop that approach to characterizing it.

And then towards the end here. You know, there's advantages and limitations to everything that we do.

Because it's small-scale we can get close to the arc. And we can characterize the particles very close.

From that cost, it's a pretty cheap experimental program from a, you know, the other types of experiments that we've run in the past. You know, it's probably less than one percent of what we spend on HEAF in general.

So far a lot of different tools they can use. They take the measurements and we control the variables a little better.

Limitations. The biggest limitation is duration. You know, milliseconds compared to what we're trying to do full-scale, you know, it's much shorter.

And also, we're only using a single phase. So, you're going to get one or the other. In a three phrase system, we get multiple arcs starting in the same path.

Touch on the Federal Register Notice. We put the draft test plan out for public comment 30 days.

The draft comment period closed April 4. There's a Docket ID, NRC-2018-0040. You go to regulations.gov you can find that information. The direction notice has a plan.

There's already comments received. We did receive two comments. On April 2 we got comments in from an engineer at Beaver Valley .

And then on April 3 we got a request from NEI to extend it an additional 45 days. We haven't received anything from our admin or Federal Register Notice Office on the extension.

So, because of limitations on our contract, it can't be extended anymore. And also budgetary constraints.

What we plan on doing is we don't want to shut you off. So we're going to basically add another 30 days.

So if you can get me any comments on the test plan by May 4, next month, I'll go ahead and add those comments to the Adams. I'll make it publically available.

And then we'll treat them just like we treat any other comment that would have come in on the Federal Register Notice. So again, my email is up there.

And anything you have, you want us to address, please send it to me by that date. And then that gives us the team, the NRC and the Sandia team enough time to thoroughly review the comments, access them, make changes as needed.

And then start the testing at the end of June. And then the test plan -- our contract ends at the end of September. So there's a lot of back and forth and report generation.

And because we couldn't -- we tried to extend it, and we couldn't extend the contract anymore that's kind of our hard stop on this.

So again, basically a total of 60 day public comment period. Get your comments to me if you haven't done so so far.

And that's it for me. So are there any questions on the small-scale testing? Anything on the webinar?

MR. MELLY: We have one question.

MR. LOVVORN: Shannon Lovvorn with TVA again. Looking over the test plan, I saw a discussion of some of the testing being phase to ground. And obviously the voltages we're talking about here are phase to phase.

So, is it because of the test set up you're going to do a say a 480 volt test, a 480 volt phase to ground? Is that how you're doing the test?

Or is it just -- sometimes I'd read, you know, voltages and phase to phase voltages. And then I'd read, you know, phase to ground testing discussion.

I got a little confused in the test plan.

MR. TAYLOR: So the question is, is it a phase to phase or -- is it a line volt or a phase to phase volt?

MR. LOVVORN: Yeah. Well, is it -- yeah, I guess I'm trying to understand why we're talking about phase to phase voltages and phase ground testing.

And is it just simply the test setup that's driving that? Or --

MR. TAYLOR: So it is -- that's a good question. It is the test setup. So the voltages that we have here will be the voltages across the two processes.

So basically a phase to phase voltage. And not a phase down, or a line voltage. Okay.

Any other questions? Any other on background? Bob Rhodes from Duke?

MR. RHODES: Yeah. This is Bob Rhodes from Duke. Is your 480 volt test plan going to bound the plants that have 600 volt weather control centers?

MR. TAYLOR: I'm not sure it will bound it. You know, it does provide some data point at low voltage.

MR. MELLY: Yeah. That's going to be another question for extrapolation.

MR. RHODES: Can you extrapolate on that?

MR. TAYLOR: I think I'll have to take that one back. I'm not sure. So, we can add that to that.

MR. TURNER: What they're talking about here is the supply voltage. That really makes a difference in what amps are the plasma and melting things is the arc voltage.

And that's generally set by the gap. So whether you get it at 480 or 600, it probably isn't going to change the arc voltage very much.

And I don't know what their predicted arc voltage is. But that's really where you get the energy from.

The same with the medium voltage tests. You'll probably get close -- if you don't change the gap, you're going to get about the same arc voltage on those tests.

MR. TAYLOR: Okay.

MR. TURNER: You really look at the gaps is what you're looking at.

MR. MELLY: Right. And for the full-scale testing where we did low voltage, 480 volt tests, our arc voltage was on average around 380 volts.

For a medium voltage, our average was right around 830 volts for the arc voltage itself.

MR. TAYLOR: Yeah. So that, I mean, that brings another good point. And I have some slides to get to what Mr. Turner's brought upon arc voltage and separation distance, at least from our phase one testing.

But, and I don't want to go too long, because I'm already over my time. But, you know, maybe that's another variable. Gap space.

Because right now, I don't think, they plan on changing their gap spacing. So your arc voltage is going to be what it is.

So, given that, you know, it might not even be worth adjusting your medium voltage. Right? It might be more worth where you have low voltage testing, you have a medium voltage set point, and then you do some variation in your gap spacing.

So, good feedback. Okay. I think we need to move onto the next one.

Okay. I don't think this one's going to take too long. Basically, you know, trying to look at where we want to go with this. And why we're doing all these -- this testing.

You have to look at -- I say PRA modeling, but what I really want to get at on this is the HEAF modeling.

You know, what -- when I talk about HEAF modeling, zone of influence is really what we're concerned with right now.

So how -- how are you going to go and improve upon the current method for the ZOI that we currently have in 1650 to make it more realistic? To maybe be more representative of the plants' configurations.

So we need to just do a quick review of the existing models. In 1650 you have two models. You have the one that's in Volume Two, which looks at the electrical enclosure.

And basically anything within the zone of influence, which is one and a half meters in the vertical direction, or five feet. And then .9 meters or three feet in the horizontal direction.

You assume it's both damaged. Physically damaged and it's also functionally failed.

And then you've got the fire that occurs after that. So you assume ignition and then you follow the typical, you know, classical fire modeling approach that's in Appendix E and G of 1650, Volume

Two. Next slide.

In Supplement One of 1650 we also have segmented bus duct HEAF event. And in that you basically assume that you have a failure.

You have the sphere that goes around the bus duct that's one and a half feet. I think that's -- is that a radius? I'd have to double check.

MR. MELLY: Yes. It is.

MR. TAYLOR: You have a sphere. And then you also have this cone of death that has been referred to.

And it's basically a cone with a 30 degree down cone, or 15 from the vertical. And it goes down until your diameter is, you know, you hit the ground and your diameter is 20 feet or a total drop of 37 feet below the fault if you have that much room in your configuring.

So those are the two ways that we model ZOI right now. It is -- the next slide, it's bounding. It's conservative. It's based off of, you know, what they've seen from operating experience.

And with the aluminum, you know, the question that comes to mind is, does aluminum fit this model? Or is it something larger then this model?

And even if you exclude aluminum, you

know, let's assume we exclude aluminum, you know, this doesn't capture all the variability that's in the plant.

You know, you have a HEAF event, it doesn't mean you're going to get this much damage. And a lot of other events you look at, you don't have that much damage.

Or you don't have some of the other assumptions that go into the modeling of a fire occurring. So, what we're trying to do here is advance or improve the models to make them more realistic. Next slide.

So, kind of the way that we've broken it down, is potential pass forward. Is that we've been sticking with the current approach and just refine it to include aluminum, you know, bounding worst case. That's one way that we could do.

Another thing that we could do is we could start looking at what variables impact the heat and the ZOI. Whether it's power energy volts, or voltage current, the protection scheme that's being used for the circuit material, safety class, what not.

I listed all the variables that could potentially influence the categorization of the equipment. But, for each of those categories then you'd have your own type of ZOI determination.

And again, this would be somewhat similar to what was -- is currently modeled. You know, it would have that, you know, physical dimension around the equipment.

But based on the influencing plan or what category it is, you have different ZOI dimensions. So that's kind of the second, you know, way that we could break it down.

And the third way that I've listed there, it's similar to what they do in the arc flash calculations in IEEE 1584. Where basically you have system information on duration, voltage current, and cap weight and incident energy.

And because that standard's worried about human safety or physical protection, personal protection, anything, you know, below 1.2 collars per centimeters squared, I think that's the units, you don't need protection. And anything above that, you do, to alleviate second degree burns.

So, something like that, you know, could be extrapolated to what we need here. You know, some -- we'd probably follow something similar to what's in IEEE or even the Lee approach that came out of the 80s.

And I think that's achievable. The one thing that we still have to do on the back end then, is what's your target fragility?

When are your cables going to be damaged? When are you, I don't know, your pump or whatever other equipment that's important to plant safety, when is that going to be damaged?

And we do have current thresholds for damage. But again, we're talking here about something that's a high intensity, short duration.

And we're using the temperature thresholds for possible fire, heat transfer. Do those match up? Are there ways that we can use that information to develop a target fragility for these HEAF type of events?

That's something that we're looking at what possible solutions or methods to try to characterize that. But, we're not there yet.

So that's one of the -- one of the aspects there for the dynamic ZOI.

MR. MELLY: And for the larger scale test program, you'll see when we discuss how we plan on instrumenting, as well as what information we're going to collect, how we are heading down that path of trying to create this dynamic zone of influence model.

Where you can take the idea that that Steve was discussing earlier, of going more scenario specific. Of, I know what my voltage level is. I know what my current is. I know my circuit protection, my secondary circuit protection.

And I can postulate how long this arc will hold in for. And what type of energy will be released.

And trying to be eventually leading to link that up to a scenario-specific zone of influence.

MR. TAYLOR: And I guess the other question is, and I have a slide later, but you know, how much time and effort do you want to put into applying the method or even developing the method?

You know, if you can get away with a bounding approach, then, you know, doesn't that work for your plant? If you can't, you might want to sharpen the pencil and have this approach available.

You know, if that doesn't work you might even be able to use something like this. So, you know, picking where we want to go.

We haven't said this is the route we're going. We want to understand where we can do with it. And make sure that we are collecting information that will support any event.

MR. MELLY: Yeah. And it's important to realize that in the larger scheme of how we plan on doing things in that if we are testing one piece of equipment in the next test program at two seconds or four seconds, we're doing it within mind that the possibility to get to this dynamic zone of influence.

Rather than just slapping this is the worst case that we saw. At an eight second duration arc you have to then use this for every bounding case in your analysis.

That's not our intention with the longer duration events and the test program.

MR. TAYLOR: Yeah. And just to add on the dynamic piece. Steve Turner brought it up earlier.

Is that if you look at both of these, this is -- I modified it slightly just to make it more anonymous. But this is the lead equation.

This is that accurately. And basically you've got similar terms. You have voltage. You have current. You have time and you have distance.

And down here you have the same thing. You have time, distance, current, and they use the gap spacing to estimate their arc voltage.

So, you know, those are the parameters we know that's important. And we're capturing those in our testing.

We're trying to work with everybody here in the room as well as other stakeholders to make the testing realistic to support this. Next slide.

So, just getting into, you know, kind of the pros and cons, worst case, the bounding current model worst case. One size fits all.

Your damaging the right components in the ZOI. And you assume you have your peak heat release rate as soon as you have hertz.

So, if you don't think that is conservative, I must have missed something. Or Nick missed something when we talked about it earlier.

Although this is -- would be one of the more simpler models of the approach. You need the least amount of information to apply it.

It's not really that realistic. The majority of the cases out there, at least from the operating experience that we've reviewed, if we look at, you know, a lot of the events like the Brunswick event or the Turkey Point event, you know, it really doesn't match what this model's doing.

So, you know, not much realism there. And however from both the application as well as the development costs, it would probably be the cheapest approach. Next slide.

The refined bounding ZOI. Again, you have to break down equipment types, power, all the different variables and understand how those affect your ZOI.

So, you know, looking at the testing that we're doing, as well as the testing that's been done in the past, we have to collect a lot of information to help us develop those ZOIs.

Because of, you know, you're basically getting more information, you can make it more realistic. However, as far as more information from -- to apply the methods to your PRA, and also your time to develop it.

And then the last piece is the most complex, most costly to develop. But it also could potentially provide the most realistic results.

I mentioned the fragility of being one part of the equation that we're still working on. We don't have a clear path forward for addressing that.

I'm not saying that it can't be. But I don't want an obstacle we'll have to attack. And you have a more physics of failure type relation to the model.

So, it's not just the worst case. So,

pretty self-explanatory. Next slide.

So what do we need? You know, the NRC is here concerned with this. Plant safety, reasonable.

You know, realism versus cost and time. That's what we're really weighing here. You know, we can't -- we want to wait and come up with a ZOI and spend all this time and effort if the bounding one is going to meet our needs.

So, we want to make sure we're aware of what we can do. We're collecting data to meet the needs of those categories.

And you guys are going to help us with at least or the middle one. Especially making that one realistic on equipment types, powers, you know, maximum currents or realistic currents, all currents.

So, that's really where we'll weigh in here in trying to figure out in the end what we'll develop.

Any question about the modeling?

(No response)

MR. TAYLOR: It's not to say that there's not other ones out there. But, these are just what we're looking at right now.

And if there are others, that would be -- we'd be interested in learning more about those.

MR. TURNER: If I could just make a comment on the state of the art of these models, reflecting on the other models he was talking about.

He's right. It's really expensive. There's a lot of stuff out there that he hasn't covered yet that the NRC could probably leverage off of. There's been a lot of development. CFP models for example.

Not that we would expect utilities to go do CFP models of all their campus while their flux is two feet away.

But there are two factions in the IEEE publications that are out there, the published works. A great number of them relate to the IEEE 1584 in protecting people.

But there's a whole other school that does nothing but computational fluid dynamic modeling. And matching it to high energy arcing models.

Or developing fairly simple energy balance models, which have the level of ability. A bunch of manufacturers in Europe got together and put together a pretty good model that all are actually duplicating what we see in these experiments, the high energy experiments.

The problem with most of those models is they all are just maybe a 14th of a second or half a second. They don't go for longer durations.

But, I've been modeling with Japan now on longer durations and matching it up to data. So there are CFP models out there that may help you predict these things.

And I think we share that stuff with EPRI. So they'll be able to leverage off of that. And that's in addition to even the empirical models you see.

And both factions in IEEE work just fine. It's just a different direction that each one of them have.

But just -- we're using hands as fluent. And we're not even using the plasma physics model. And we're coming up with some pretty good results.

So, the state of the art of the modeling is actually pretty far along. And it is being shared with the NRC. So they can leverage off of that.

MR. TAYLOR: I guess the last thing I wanted to mention, and it's a very important point, is that a lot of this modeling is looking at the thermal aspects.

So, you know, the heat fluxes and the energy fluxes that you are receiving at a certain distance away from the arc. As Nick mentioned from the experiments, you saw the conduct of byproducts. That cloud of material.

It's not like in any conductivity issues associated with that. It's also -- and it's also not looking at pressure, although there are models out there that can estimate pressure.

And another thing that it's really not looking into, and it's an important piece, and we might only be able to capture it through uncertainty, is the actual characterization of the arc.

There's a lot of parameters that affect the arc. So, you know, we're not really looking into that too much right now that support these, any type of model development.

We're trying to make it applicable without having to, you know, consult with CFP type -- I was not saying that those aren't valuable.

I think if, you know, from some other work that we've done, we may be able to leverage some of the CFP work to support what we're doing here.

But again, you know, I don't think I would expect the NRC to say -- or do CFP type analysis to come up with the supporting PRA. That's just my opinion.

Any questions from the room? Tony Putorti from NIST?

MR. PUTORTI: So, Mr. Turner talked about one side of the modeling. So, if you think about the concept of the HEAF or the phenomenon making the threat, making the thermal environment that threatens other pieces of equipment, and you think about the vulnerability, you could model both sides.

So he talked a little bit about trying to model the generation of a thermal environment. But, we can also use models to take a look at how those thermal environments, what affects they have on the targets.

And so there's been modeling and other types of modeling you can do to take a look at what the result is to the target. And some of that's already been done, with cables, for example, and in other areas.

MR. TAYLOR: Yeah. So, I think that's getting into more of a -- at least from the zone of influence or fragility side of assessing the nuclear.

MR. PUTORTI: I will put them both together.

MR. TAYLOR: Right. Well, yeah. So like we're not just looking at the source term and saying okay, this is how big the events can be. We want to tie it together to the actual targets.

Any questions in the room? Again, this is kind of just high level. There's a lot of good research out there on a whole variety of things related to this event.

But, if you look at the IEEE 1584, they provide a lot of good information. But there's other publications as well that get into the nuances of it.

Anything on the webinar? No questions on the webinar? So I think we're a little --

MR. MELLY: A little behind. But we can take a break.

MR. TAYLOR: No, we're ahead still. About ten minutes, right?

MR. MELLY: Yeah. We are.

MR. TAYLOR: All right. So, let's go ahead and take a break until 3:15. We'll get back on schedule then.

So we're on break. Thanks.

(Whereupon, the above-entitled matter went off the record at 2:51 p.m. and resumed at 3:16 p.m.)

MR. TAYLOR: All right, we will go ahead and start. If everybody could take their seat. It should be on now. Is the webinar running?

MR. SALLEY: Okay, so we have the webinar back up, and we'll get ready. Like I said, this afternoon is about a lot of information we want to share with you and exchange, and we're lucky to have three guests to present with us.

The first one will be Mark Earley with the NFPA, and Mark is the Chief Electrical Engineer there. So he's going to present us some work they're doing with the NFPA. It's interesting that we've been working a little bit through some webinars trying to share some information. It's been very profitable for the NRC and also for the NFPA, and we want to continue that exchange moving forward after this workshop.

We're also going to have Ashley Lindeman from EPRI with the EPRI perspective, a presentation after Mark. And then we've got Bas from KEMA from the Netherlands, and he's going to give us some information that they got from KEMA. Okay? So with that, I'll turn it over to Mark, and you can take it.

MR. EARLEY: Thank you. It's great to be here. Starting off with a new generic slide that we have that shows our new theme, which is, it's a big world, let's protect it together. However, I also included this one, because this first slide is uniquely unreadable. But it's a nice slide.

I'm going to be presenting the report in place of Dr. Wei-Jen Lee who is responsible for a lot of the scientific part. He is a Professor at University of Texas at Arlington.

So who are we? The National Fire Protection Association is a global non-profit organization established in 1896 devoted to eliminating death, injury, property and economic loss due to fire, electrical, and related hazards. We are the worlds' leading advocate of fire prevention, and we are the sponsor of Fire Prevention Week.

We are primarily a publisher of codes and standards, and we publish more than 300 consensus codes and standards that are all about minimizing possibility and the effects of fire and other risks. We have a membership of about 50,000 from around the world.

The National Electrical Code was also founded in 1896. It did not become an NFPA standard until 1911. But from its very beginnings in 1896, we have included representation from around the industry, including IEEE and the utility industry has been with us for a very long time.

The first edition was published a little over a year later in 1897. We are currently working on the 55th edition of the NEC. We've been published on a three-year cycle for 65 years.

When OSHA was first formed, the first electrical standard that it adopted was the 1971 National Electrical Code. That presented some issues for them, because the National Electrical Code has a lot of installation requirements in it that have nothing to do with safety in the workplace. They are, for example, requirements for residential electrical construction.

So, OSHA, along with IEEE, asked NFPA to consolidate its electrical requirements into a new standalone document. The original concept was that they wanted something that was timeless and adoptable by them. And what we found over time is that nothing's timeless. That as experience is gained, standards need to evolve to stay up to date.

So the result of this was NFPA70E, the title of which was Electrical Safety Requirements for Employee Workplaces, which is a title you can't recite after you've had a few drinks. It has now been renamed as Electrical Safety in the Workplace. It has, however, become far more known as 70E than it is by its name.

And that kind of puts it in the company of most of the other NFPA documents, other than the NEC. The NEC is known by its name, or by its acronym of NEC, and rarely ever referred to as NFPA70 outside the walls of NFPA.

NFPA70E evolved into four parts. The biggest part is now gone. The biggest part was just a regurgitation of electrical installation requirements, but most specifically those that are related to worker safety.

The entire standard is important, but most of what you need to know for most installations and most work is in chapter one. The arc flash phenomenon has been in NFPA70E since about the 2004 edition. And right around that time, IEEE formed a working group.

Actually, it dated back a little bit earlier than that, but they formed a working group to provide a method to quantify the phenomenon. And this working group developed IEEE 1584.

What we know about arc flash phenomenon is that over time, we've been noticing, or had noticed, an increase in the number of arc-flash related incidents. When NFPA70E was first developed, it was all about electric shock. If you look out there in the international community at IEC, most of what they do is about electric shock in the 60479 series of standards under TC64.

And actually, calling those IEEE standards --- excuse me, those IEC documents standards is actually a misnomer. They are actually technical specifications. They are not standards, because they have not gained the required consensus in the international community to be classified as standards. But they are none the less widely recognized.

So what we've found happens with arc flash incidents is they produce burn injuries, they produce injuries from ejected materials, they produce in some cases arc blasts with an accompanying pressure wave, an intense amount of light, and rather intense sound, as well as toxic metal dust.

And I found it interesting watching the videos of the tests this morning, they were very impressive, and you would get a sense of how loud they are. But when you're in the booth next door and these tests are going off, even though you know you're going to hear it, you're rather shocked at just how loud that event is. And they are very convincing of just how much of a problem it is.

The IEEE standard was initially designed around a series of about 300 tests that were valid over somewhat limited range, and over time, it became necessary to extrapolate that out. And when one is doing that, one wonders just how valid that extrapolation is. So they were developed based on some statistical relationships and seemed to work well within that limited range.

But there were differences of opinion between the members of the IEEE committee and the NFPA committee on how to protect workers. So both committees became concerned about the technical basis for the analysis, and they both decided to pursue arc flash research projects. Each committee recognized that this was going to cost a lot of money, and that they did not want to do it on a shoestring.

The first round of the tests, the 300, was certainly done on a shoestring budget. NFPA was going to pursue this project through our Fire Protection Research Foundation, and IEEE was going to do things a little differently by forming their own task group to do it.

After a while, we both recognized that we were going to be knocking on the same doors, asking the same people to contribute to this project. It was unlikely we would get any sponsor who would support both projects. We also recognized how important it was going to be to get industry buy-in and industry would not be well-served by competing arc flash projects.

So the IEEE staff person contacted me and asked whether or not we would be interested in collaborating with them. We concluded that we were both well-recognized in the industry for a number of things, us for the National Electrical Code and NFPA70E and IEEE for a whole series of electrical and electronic standards and the code that affects the utility industry, the National Electrical Safety Code.

For both of us, it's all about protecting people, and we recognized the conflicting viewpoints of committee members. And some of those were very strongly-held positions. We chose a totally neutral party in this to chair this research test planning committee, Mike Callanan, who is Executive Director of NJATC, which is now the Electrical Training Alliance.

What that is, is it is a training organization that is jointly owned by the National Electrical Contractors Association and the International Brotherhood of Electrical Workers. These members, with their strongly conflicting views, were told to check your guns at the door. The membership represented a number of different constituencies from IEEE and NFPA committees.

And we developed a pretty comprehensive research plan, which formed the basis of the research project. I believe the research plan was about 128 pages long. And we had unanimous consensus for the research plan.

Chances are you don't recognize many of those names, but we had here IEEE people, Underwriters Laboratories, DuPont, Snyder Electric, more DuPont. We had Ferraz Shawmut, which is now Mersen. We had various American Chemistry Council members, and a few different folks from the utility industry. So a very broad group of people put this thing together.

So the primary goal was to work together collaboratively so that we could capitalize on all these various industry groups working together and also, all these industry groups willing to punch holes in it if they found them.

We're very pleased to get the sponsors that we got. Platinum sponsors contributed $500,000.00 a piece, and the one at the top is a Canadian utility, Bruce Power, and we had Cooper Bussmann, which is now Eaton, Ferraz Shawmut, which is Mersen. Wait, there's one missing. Oh, okay, yeah, Eaton came in separately merged with Cooper Bussmann later, so they are in effect a $1 million contributor.

And Underwriters Laboratories, and a variety of gold contributors and silver contributors. And one of the things that we talked about earlier that was a big contribution from Bruce Power was they had done some DC research. And so that is forming the basis of some of the later research that we're planning on doing.

So, okay. When did all this stuff happen? The formation of the collaboration up through the fundraising started between 2003 for the challenges to the status quo up to 2006 for the fundraising stage. And for the fundraising stage, we were fortunate to have two people who were Vice Presidents of their companies who were just uniquely positioned to go out and meet with CEOs of organizations to ask them for a lot of money.

It's one of those things that a lot of us just, it's not in our psyche. I'm not likely to be able to ask anybody for $500,000.00.

The initial research phase had a couple of PhDs working on it, Dr. Tammy Gammon and Dr. PK Sen. Dr. Tammy Gammon is an independent consultant and PK Sen is a Professor at the Colorado School of Mines.

For the testing period, we had Dr. Wei-Jen Lee from University of Texas at Austin, and he has worked with some various PhD candidates who did some of their thesis based on this work.

Between 2013 and 2016, we have had the model intensely reviewed by the 1584 committee. So this has had quite a bit of a scrutiny. And so we've met the criteria of the test procedures and protocols committee. We hired a test manager. We contracted a research manager. We've actually used a couple of different laboratories.

And we conducted over 2,000 tests. And they were all based on the RTPC task group work, and we conducted low-voltage and medium-voltage tests. So the test range was from 208 volts up to 14.3kV.

So the initial cost projections were $6.5 million. We did not raise that much money, and so we found a way to get most of it done a whole lot less expensively. We estimated a fair number of laboratory days. We got some used equipment for some of the actual equipment tests.

And some of the --- and so we did focus on the whole range of tests. We planned on LV, MV, AC tests, and some DC tests. The good news was we had that contribution information from Bruce Power, which is helpful. But we are planning the DC tests at our next stage.

So we estimated some personnel costs. We had we figured about 520 actual lab days, and we came up with estimates based on how much money we were likely to have in the program and what we would be able to accomplish with that.

And so the good news is we've been able to accomplish most of what we set out to do. So I know this is another one of those pie charts, but this is the range of tests. At the low end, 208 volts, we ran 67 tests. At 480 volts, which by the way is the most common voltage where electricians are injured, at that level, we ran 369 tests. Up at the top end, 14.3, we ran 274 tests.

We ran tests in a couple of different configurations. They were vertical tests with the vertical electrodes in a cubic box, vertical electrodes in a cubic box with a bottom insulated barrier, vertical electrodes in open air, horizontal electrodes in a cubic box, and horizontal electrodes in open air.

And as far as publishing the researching, well, there's been a number of papers published over time, mostly in IEEE's industry applications transactions. So we published on the visible light intensity viewed from human eyes, and of course, when you're concerned about the hazard to eyes, you're concerned about the potential of being blinded by the light, but also the shrapnel is a huge hazard.

And despite all the requirements for safety glasses in the workplace, we frequently see people not wearing them. But with a real intense blast, safety glasses could be easily punctured.

So we've published on that, the magnetohydro. I will pronounce it. 3D magnetohydrodynamic modeling of DC arcs in power systems. DC arc model based on arc simulation. Arc flash pressure measurement system design.

And in talking about system design, one of the interesting things about this is when you consider that you're measuring the effects of a big electrical incident, you essentially have lightning in an enclosure.

And so it creates some unique problems of trying to make sure that you can measure the phenomenon you're trying to measure without the outside interference from this little thunderstorm that's taking place in the box. And so Professor Lee and his team had to come up with some unique ways of measuring that phenomenon and filtering out all of the interference.

So again, the list continues. I won't read all of these off, because you all have a copy of this presentation. But we generated a lot of information, and there is a summary of the DC work to date. But we know this is an area that we have more work yet to do in.

And this is the committee that we have today. So we have some of the same organizations represented. There's actually only two people on this list from the original committee, but continuing to move that forward. And now we want to do a comprehensive DC arc flash model.

We believe we're seeing some things telling us that we may be able to establish some correlation between the AC tests and the DC tests, but there are some factors to consider with DC. The source can make a real difference. Rectified DC and DC from a battery in terms of its, one of the fuse people classified it as its stiffness, can be a factor.

With rectified DC, you may wind up destroying the rectifiers. And certainly, when you're doing any of these tests, there's a lot of hazard to equipment, and you usually wind up damaging quite a bit of it along the way. And as in the case of KEMA, the test cells as well.

So, that's a factor. The voltage and current ranges are a big factor. And sometimes, the voltage and current ranges are limited by what the laboratory can provide, and sometimes by what they're willing to sacrifice because of the potential damage to equipment.

Gaps between electrodes and materials certainly make a big different, as has been discussed earlier today. So the hypothesis that we're working on is that the incident energy is proportional to the arc energy during the arc flash event for DC, and it's possible to establish a relationship and use the AC arc flash model for DC incident energy and arcing current estimation.

So we want to do some initial scouting tests based on about three to four days of testing and see --- or I could have just asked Siri. And that was mine. I don't have it set up to do that. Oh, it actually came up with a website, okay.

Okay, so the proposed approaches are to, according to the test configurations, perform some computer simulations to obtain the estimated arcing current, arcing voltage, and arc energy and see what we can do about comparing the simulation between the two models and see if we can get reasonable results to determine whether or not there is a good relationship between the two.

If the proposed study does yield positive results, we'll design some additional laboratory testing and perform some more DC simulations. So if we can get some good lab work, it will certainly expand our ability to do modeling, which is a whole lot less expensive than actual lab time.

So, where are we? We developed ten AC models that we've been able to integrate into one using five electrode configurations. We've done low-voltage and medium-voltage AC tests. We have some test results already and are looking at doing a few more tests at the 208 volt level to see where the floor of the model is.

Initially, when we ran some of the lower tests, we would report them as failures, and later on, it was decided, well, no, maybe those weren't failures. What that was, was we were feeling around for the floor. And so we have those results, and we're going to be doing some further analysis to determine where that floor is.

We developed instrumentation for measurement of the thermal effects, the light effects, the pressure and sound effects, and came up with a portable instrumentation unit. And as I indicated, there are a number of IEEE papers, so there is a myriad of research that is available.

So, mission of the collaboration was to develop one model to ensure worker safety. I think we've been successful with that. We have a working AC model. Our next goal is to explore that lower boundary, and the next step is a correlation of the DC model with the AC model.

That's it.

MR. TAYLOR: Any questions in the room? Dan Funk?

MR. FUNK: Are we -- I see this is working. I guess it is. Obviously the reason we're here today is because of the unexpected result of aluminum conductor, and as Mark and Gabe and Nick and the other folks familiar with their test program relayed, copper behaved in a way that they feel confident enough to characterize, but this aluminum situation right now tagged as aluminum oxidation is problematic. And that's obviously where a lot of the focus is going to be for their test program in the future.

What I struggled with, and I think some of us that have bene looking into this, is 1584 and 70E don't make a distinction between the conductor. And as you put it, you ran over 2,000 tests. Is there some concept that you could help us with as to how you didn't see any difference between the conductors in all your tests, or if you did, how they were dealt with?

MR. EARLEY: Most of our tests were actually conducted with copper. We do know that copper does splatter as well. In fact, we have a photograph in the report of an arc flash involving copper electrodes where you can see the pieces spreading out.

Now, in discussion with the folks in the fuse and circuit breaker industry, they are in fact very well aware of the aluminum issue and where it can go. I am less schooled with that, so I would have to direct that question to Dr. Lee. But we are aware of how aluminum can behave.

MR. FUNK: Thank you.

MR. EARLEY: You're welcome.

MR. TURNER: Okay, I have a comment on aluminum. There's not as much mystery about why aluminum behaves the way that it does. As a matter of fact, we first saw the effect, we knew when we inspected. I don't want to get too much into just metal chemistry, but if you look at something called the Born-Haber cycle, this is a number that's produced or how much energy does it take to go from a mole or gram of a bust bar to melt it, vaporize it, and oxidize it, what's the resulting energy? And for oxidizing aluminum, that number is somewhere in the range of 30 kilojoules per gram. And for copper, it's about four.

So we very well expect it from the chemistry. I actually talked to Jim Billups a bit about have you seen this aluminum oxidation, and he felt they hadn't run enough tests. But if you read some of the IEEE reports, and it's all good work, some of the aluminum tests support it.

They did come out and say, wow, that was a little better than we thought, so we might need to look at that more. So I think there is an awareness, and I think that they're considering it, but they just want to be careful about how they approach it. But there's no mystery about what the phenomenon is in terms of basic physics.

MR. FUNK: Yeah, no, I agree. I mean, and that's in all the papers. My point is, it doesn't show through the standards. Right. So my point is it doesn't show up in the standards after spending $6.5 million. So it seems like you've got a discontinuity of it didn't make the front page, and now this is all we're going to focus on. That's my point.

MR. TURNER: And that's what I said. I called his colleague Jim Billups and said, are you guys looking at aluminum, and he said we're thinking about it. So I think we'll hear more of that.

MR. FUNK: Understood. But they do good work. It's great work.

MR. EARLEY: Yeah, just a point, our budget, our goal was $6.5 million. We got a little over $3.5 million, and so we had to scale back some of our expectations, because there was only so much we could do, and you know, just like we had the discussion here today about DC testing, there's a lot of debate right now as to how much more we should do in that are as opposed to making sure that we have that AC floor well established, because know that the AC floor is a real issue for us from a practical standpoint.

DC tends to be less of an immediate problem, but on the industrial side, it's becoming more of a problem because of all of the green energy systems out there with lots of energy storage coming online, and of course, what do PV panels generate? They generate DC.

So that's certainly an issue. All the UPS systems out there in the field are certainly an issue for DC. But right now, it's become less of a priority, again, because we didn't get $6.5 million, so we had to do what we could.

MR. TAYLOR: Question in the back.

MR. EARLEY: Yes?

MR. LEJA: I was just curious, I was looking at the summary of the test. How did you guys develop the gap range population?

MR. EARLEY: How did they develop the gap range population? I think that's another one I would have to direct back to Dr. Lee.

MR. LEJA: Okay, thank you.

MR. EARLEY: Thank you.

MR. TURNER: Okay, thank you. All right, thank you. Ashley?

MS. LINDEMAN: Okay, I'm going to give a little bit of the EPRI perspective on the HEAF issue. I wanted to start off with EPRI published two white papers on the subject, and the objective of the white papers was to characterize the testing, the operating experience, and some of the designs in nuclear power plants. And really, just put everything in one or two spots to characterize the state of the arc.

So there's two papers. The first one is focused on the testing observed to date as well as the operating experience with a focus of United States events. The second paper is really focused on the electrical distribution system and how these systems are designed to tolerate a fault.

So it was a collaboration not only within EPRI. We used Tom Short who is in the power, delivery, and utilization sector. He works heavily with the arc flash work for personnel protection, but we also used Penn Engineering and Ken Fischer and Dan Funk have played in their contributions to the paper.

So, due to the importance of the subject, EPRI normally doesn't make their research available to the public, but in certain circumstances, we do. So if you go to EPRI.Com, you can download the paper. So you just need to memorize a really long number. So it's 3002011922 and 1923. So these white papers form the basis for my presentation, and feel free to download and read the gaps.

MR. MELLY: And in a few minutes, we will have all of the presentations available in ADAMS. That will be the ML number associated with all of the slides that have been presented today and tomorrow. Gabe's working on that right now.

MS. LINDEMAN: Okay. So one thing that we haven't talked a lot about is the different types of electrical and distribution systems. Something that we really haven't talked about is where we have seen some of the more severe HEAF experience. So what we've found is that the main generator can feed a fault for several seconds.

And in a lot of instances, this is where we've seen the long duration faults. So Ken and Jim and his team, they went through a variety of station diagrams and identified seven common power distribution configurations and ranked their importance most vulnerable to lease vulnerable to generator-fed HEAF risk. And we'll talk a little bit specifically what a generator-fed HEAF is in a few slides.

But out of the 19 sites we reviewed, we found 14 of the 19 have low risks, designs five through seven. So these were sites that either employ a generator breaker, have good electrical separation, or feed off-site power from the station transformer.

So this is what I mean when we talk about the unit-connected design. This is specifically the power system downstream from the main generator. So it includes the main generator, the step-up transformers, and the breakers in the switchyard, the auxiliary transformer, and then the connection to the medium-voltage switchgear.

In this case, it's the class for the safety division, but another station systems that it could be in the non-class. So faults in this system are this scheme. If there's a stuck auxiliary transformer, there may be a longer duration fault or, you know, any other location.

So, from our experience, this is where we found the longest duration events from experience.

So, as I foreshadowed, we looked at about 30 events, and we found that the most severe ones had a very common theme, and that was the main generator played a role in extending the duration of the fault. So in this case, we found that the faults can last several seconds, and as we talked about earlier, normally we think about things in cycles, which are very quick, and now we're talking about routines that last several seconds.

We did find a few instances where the plants had a generator breaker thus they can isolate the energy source from the fault during the generator coast down. So that was a way to mitigate some of the main generator-fed HEAF risks.

Some of the good news is --- maybe not good news --- is each HEAF event is obviously a sever event, but the ones that we've observed in the United States that are generator-fed HEAFs impacted only non-class equipment and non-class 1E locations, and they all occurred in the medium-voltage range. So typically, limited to turbine building and areas like that.

We did find that a fire occurred in all the instances. Of the 30 events, there was nine generator-fed HEAFs. Fires in all of them. In eight of nine events, we found that the equipment extended beyond the equipment origin, which in Fire PRA, that's really what we're interested in, is when the equipment can cause damage to other targets. And again, the events caused significant damage and were challenging.

So, the next paper really focused on looking at the event review. What did the data tell us? So we have a lot of well-documented fire event history at U.S. nuclear power plants. I maintain what's called the Fire Events Database, and it's a collection of fire events occurring within the U.S. industry.

So, I review a span 1980 to 2017, and it was roughly 32 events. So what we found is that the HEAF events represent around two percent of the fires within the U.S. nuclear power plant fleet, and you know, this is not just the LER fires. It's the potentially challenging and greater.

So we found that the HEAF experience within the United States does not follow some of the trends from the international data, which may have a different reporting threshold.

We found that no flavor of a HEAF was identical. We found a wide variety in the severity of events. Not all of the events resulted in a fire, and most of the events damaged only the equipment itself.

We did identify some key factors, and I'll go over those in a minute. But similar to the thread of the presentations early, we do believe that there is refinements to be made in both the frequency and the zone of influence based on the data that we reviewed.

So this is some of the statistics we tried to look at the information that was available on the events and characterize them. So, the first thing we did was look at if the equipment that initiated the HEAF occurred in a class or safety-related or non-class equipment. And what we found is that most of the events were in the non-class or non-safety-related system.

There was one or two events in the class system. And then there was an unusual event, and that was a switchgear that was both class and not-class. But anyway, 91 percent were in the non-class system.

We also found that 84 percent of the events were in the medium-voltage range. So our takeaway is the HEAFs that we see are primarily non-safety-related medium-voltage concern.

So what about zone of influence and damage? So we found that most of the events, two-thirds, did not impact equipment beyond the equipment of origin, and similarly, not all the events resulted in a fire. Two-thirds of the events did result in a fire.

We also found that no one equipment type dominates the events that we've seen. It is quite divided between busses and switchgear and circuit breakers. So not one general prevalent trend of equipment type.

We did find that a lot of the HEAF events did involve preventable shortcomings. In other words, the HEAF could have been prevented. So, human error, maintenance, design, installation, construction. Those were all ways that we could have mitigated.

I know Ken has brought up multiple fail barriers, and in a lot of instances, it wasn't just one thing that went wrong. There was a series of events that led to the severity of the event.

And circling back, we did find that one-third of the events were associated with this unit-connected design. So I think that's significant, and we discussed that it probably deserves its own special attention and treatment in the PRA.

I don't want to spend too much time talking about the testing, but I think it's important to characterize that the tests that were run, over-current protection, which is typically there in the plant was not in place for the test.

So kind of what has been characterized in the test is pretty much the most severe and violent that we can see. And in the real world, we over, we design that over-current protection or some type of protection will work, and the fault energies will be considerably lower.

And if I had to summarize the tests that have been done to date, the low-voltage testing, I think we found the arcs didn't always sustain. Tests with durations of two seconds usually didn't result in fires, and that may line up with how the equipment is rated and some of the IEEE standards. I think Steve Turner said 25 megajoules was the threshold for a fire. Yeah, I think we kind of agreed when we looked at the tests, that that seemed to be the threshold.

When we look in the medium-voltage testing insights, the threshold was higher. I think the equipment at the medium-voltage range is more rugged. And once initiated, the arcs sustained themselves for a longer period of time.

We did observe a wide variety of damage in these tests. There was external ruptures and breaches between compartments, and I think the NRC has demonstrated that in some of the pictures that they showed this morning.

So the involvement of aluminum on this is a primary reason why we're here, and I think the testing to date has identified that as a significant contributor to the total energy release. I just wanted to stress that it wasn't always observed.

I think there was more than the two tests that had aluminum, and I think in the new reg, that was with the Japanese. At first, I think they tried to take a cut of estimating the arc energy from oxidation, and we compared it to the arc.

And in the most severe tests, the release from the oxidation was 2.6 times the estimated energy released from the arc. So that was the most severe, but we found it range from 0.34 to 2.6, so the high oxidation scenarios were less common.

This was brought up in the last presentation, but you know, why haven't we seen this involvement of aluminum before? We have all these, we have 1584, C37, 70E. I didn't want to answer your question, Mark, but some of the theories that we came up is, right, there may not have been aluminum tested.

The testing that's been conducted to date outside of the nuclear industry typically tests of shorter durations, so there's less melting of the conductors. And that was kind of our best guess of why this hasn't become a major factor.

But really one of the open questions is that the threshold at which this oxidation of aluminum occurs is really undefined. I'm not sure if we have a rhyme or reason, is there a duration or a voltage or an energy where this gets much worse? And to me, that was a big open question that we had. So maybe hopefully you guys can figure it out, because it just didn't seem like it occurred in everything that we saw.

MR. GARDOCKI: In your database, did you discriminate or were you able to discriminate events that involved aluminum or no?

MS. LINDEMAN: So that wasn't one of the factors we looked at. I think upon reading the event reports, we noticed there was some mention of aluminum, but it wasn't something that we specifically looked for. So getting into Fire PRA.

We definitely suggested and we've worked with the NRC to really redefine --- maybe not redefine, but refine the ignition frequencies and the scenario definition of what we will term a HEAF, which has been 16.a, 16.b, 16.1, and 16.2.

And based on the data review, we believe that there is subgroups and split factions to do a better job of characterizing the risks. Right now, we pretty much have low-voltage and medium-voltage which is existing. And we also have bus ducts, but we believe that adding in the safety classification, that seemed to be a significant finding from our white papers.

We also feel that there was also room for split fractions on the extent of damage, if there was a fire or not. And again, special treatment for a vulnerability such as the unit-connected design where protection may be absent or unprotected zones.

So we also did a sensitivity study to see how the impact of a larger zone of influence from aluminum might impact the PRA results. Obviously I think as Nick said, it's definitely plant and scenario configuration dependent. Obviously if you have a well-separated plant with two different switchgear rooms and good electrical separation, I think the numbers will come out to a lower impact.

So the sample plant that we used had that safety-related switchgear in separate rooms, and what we found was the impact was minimal, which is in stark contrast to the numbers that we saw. We ran it with a lot of similar assumptions. We assume that the oxidation failure resulted in a hot gas layer. And for those not familiar, a hot gas layer essentially damages everything in the room.

So that's what we did. I think we did credit suppression and everything, but anyway, we found that the impact was certainly less than 1E-4. But obviously scenario and plant dependent.

So one thing I don't think we really talked about is I think we do want to work on understanding why these events happen, because I'm not sure if the answer is, well, the ZOI is 7.3 feet. It seems that we want to make sure we have a strong PM program and we're not deferring that maintenance, because really, I think it's better to prevent the events than to find out what the ZOI is.

These events are not only a safety concern but may be an economic consideration of a large event that could keep a plant offline for months, in addition to the nuclear safety aspects that we frequently worry about.

But the testing highlighted the importance of making sure the protection schemes are optimized. We do, if we have electrical abnormalities, we would want to rapidly detect and clear the fault such that it doesn't get to the severity of a HEAF.

Proper maintenance is prevention. The white paper ending in 23 identifies several maintenance practices. Refurbishment, testing, and lock-downs to ensure that the equipment is operating properly.

So that is kind of a summary of what we've been doing. Our white papers are really a cut at characterizing the issue and not to do any PRA type numbers, although we can kind of see that as definitely an area that we can work on.

MR. TAYLOR: A question from Bob Daley, NRC.

MR. DALEY: It looks like there's a lot of really good stuff, and I haven't looked at the documents, but I'm going to make sure I read them, because I like Dan's fluid writing style. But I do have one question. You talk about HEAF events represent approximately two percent of fires within the U.S. nuclear power fleet. Is that two percent of all fires, or two percent of challenging fires?

MS. LINDEMAN: All fires. Well, so the fires that court towards frequency, so the potentially challenging and challenging. So all those events.

MR. DALEY: So it's not all.

MS. LINDEMAN: Yeah.

MR. DALEY: It's just 4:17:01. And the 4:17:03.

MS. LINDEMAN: Yes.

MR. JOGLAR: A quick clarification. It would be very rare to find one of these fires to be not challenged.

MS. LINDEMAN: What we were saying, well, I think Bob was asking -- so, if you looked at 2169 --

MR. DALEY: I agree.

MS. LINDEMAN: Yes.

MR. DALEY: That's why I was asking the question.

The second, you have another thing in there that said wide variety and severity of events. And it goes, "Not all HEAFs result in post-event fire. Most HEAF events damage only the equipment suffering the failure."

Were we able to extract, just based upon plant that this happened at, whether the cable would be thermoset or thermoplastic?

MS. LINDEMAN: No, we don't have that clarity of data. And I should mention, when we drew the box around the HEAF events, we tried to include everything that had kind of the arc blast event. So, things like the Palo Verde event, the Turkey Point, we added those in just because, as Nick and Gabe said, we actually really don't have any definitions of what's a Bin 15 fire or what's a Bin 16 fire. And we felt that if we were doing this data review, it would be to our advantage to put those all in and deal with them, and see if there's similar characteristics. So, we did include those.

MR. SALLEY: Yes, this is Mark Salley, while I'm here.

Actually, on your slide you had the PRA

and the risk, I think a couple of slides back. There you go, PRA treatment.

MS. LINDEMAN: This one?

MR. SALLEY: Yes. That was some of the stuff that Nick talked about earlier with the pilots. Is there, I guess, something like a question you could take back to EPRI? If there is some way we can work with you on that to support the generic issue for Stan, moving forward with that, I think that would kind of meet your pilots and it would kind of get us where we need to be, if we can work with you on that. So, if you would please take that back, Ashley?

MS. LINDEMAN: Yes, I'll figure out whether it's Victoria or me.

MR. SALLEY: Yes, that would be great.

MS. LINDEMAN: But I think we can certainly help you out with the study.

MR. SALLEY: And, Stan, that would kind of be what you're looking for to move us forward?

MR. GARDOCKI: Well, for generic issues, we're trying to figure out across the board the impact. And I know every plant has different configurations. I saw your limited scope was safeguards were in different rooms. So, that kind of like zeroes out applicability to what we're looking at where that would go across either two trains or impact a certain train as the initiator, and then, the single fire would take out other important equipment --

MS. LINDEMAN: Yes.

MR. GARDOCKI: -- if we go that far with it.

MR. MELLY: Right. So, I think it's important, when we do eventually decide what our pilot plants are going to be, is that we have this discussion as to what are we picking that can cover the range of possible plant designs as well as what we're looking for. So, I think it will require a follow-up meeting with EPRI, and potentially the industry as well, as to how we're selecting and what pilot plants can cover the range of these possible very plant-specific questions.

MR. PELLIZZARI: Francesco Pellizzari, EPM.

In doing the assessment, did you consider these HEAF events when they occurred, what operational state the plant was in where there would be a shutdown or a power operation?

MS. LINDEMAN: We may have considered that.

Dan, I don't know if it became a factor, but --

MR. FUNK: Yes, I think most of them were at power.

MS. LINDEMAN: I think most of them were at power, though.

MR. PELLIZZARI: And then, another question, it appears you're leading to a distinction between 1E and non-1E switchgear buses. Is it possible that the distinction you see might be due to the normal loading of some of the buses as opposed to true dedicated Class 1E buses? They might be get particularly heavily loaded during power-ups.

MS. LINDEMAN: We discussed this a little bit. I think it's the care and maintenance and some of the operational practices. I'm not sure if Ken or Dan has anything to add. But we did discuss that.

MR. SHUDAK: Tom Shudak from NPPD.

I'm curious on some of your data support, numerous subgroups. It's not up there. I was wondering if you looked at insulated or uninsulated buses. Do you see any correlation there?

MS. LINDEMAN: I don't think we looked at that.

MR. FUNK: No. Again, the LER data wasn't ideal. We could get back into the 1980s and the early

1990s. So, we were going from what data we had available. And, of course, for a project like this, you want more than what you generally wind up having to work with. As part of the second phase, I think we looked at, tried to do a drilldown on some of these features, as we get smarter on what's driving the equations.

It's a good comment.

MR. FLEISCHER: Ken Fleischer from EPRI.

I wanted to try to answer what I heard as a part of maybe that question on the Class 1E buses being maybe lightly loaded or the configuration.

Can we go back to slide 4 for just a moment?

Although that's really intended to be very simplified diagram, that's not the most common diagram. As you can see, coming right out of the auxiliary transformer and the station transformers, you go immediately to a Class IE division bus. That's not typical of those plants. Most plants, there's what we call the intermediate non-Class 1E bus and, then, it goes to a Class 1E bus. There's also other non-Class 1E buses that are maybe bifurcated and dedicated to balance plant equipment. But, typically, there is an intermediate non-Class 1E bus division before you get there.

So, when the paper gets into the seven, what I call, scenarios, if I have an H-E-A-F or a HEAF in zone 1 or 2, under those different seven circumstances, we walk through how the protection system is designed to work and what the ultimate outcome is going to be.

The more common designs are an intermediate bus, and almost 50 percent of them don't even operate operationally off of the unit auxiliary transformer. They're dedicated to offsite power at all times.

So, we still evaluated those HEAFs, but they were not generator-fed. I don't know if that sheds any light on this.

MR. MILLER: Yes, you said "generator-fed". The classification was only those that didn't have generator breakers. If it had a generator breaker, that doesn't mitigate that.

MR. FLEISCHER: The generator breaker will mitigate that because that operates in cycles.

MR. MILLER: Right.

MR. FLEISCHER: And it will immediately isolate the generator from both the unit auxiliary transformer and the main power train.

MR. MILLER: Those were not -- eventually, you would save on those and generate a breaker --

MR. FLEISCHER: Yes. Okay, yes. But what we also get into those scenarios are the multiple barriers that fail. So not only do you have the initiating event, which the HEAF, but now I also postulate stop breaker. A lot of these designs have a bus transfer system, as you can see. I show the breakers normally closed, normally open. If I have a HEAF in either fault zone 1 or fault zone 2, particularly fault zone 2, and that breaker is slow to respond or gets stuck, I will transfer over to the station power or station transformers. And in this case I just have one.

What will happen is that let's say division 1 fails and that breaker sticks. Division 2 has a successful bus transfer, but it is going to backfeed into that fault. Now I lose both divisions to the diesels. So, that's kind of the thing that you've got to worry about. And a lot of the HEAFs that occurred were during bus transfers, so they were complicated by that.

In fact, we leveraged off of the NRC paper. If you're familiar with the Monshon (phonetic) paper, you actually covered similar -- I think there was a Monshon event and you covered five or six other scenarios with that. So, that was a good paper, and we leveraged off of that. If you need, I can get you the ML number. But we got a lot of our research out of that.

If you read the paper, particularly if you avoid the paper on anything else, read the seven scenarios. I think as I walk you through them in those scenarios you will see how each HEAF is treated differently by a different configuration protection to system design.

MR. TAYLOR: Any other questions? Yes?

MR. CAVEDO: I just had a comment. I don't see how that could have caused the loss of the two divisions. That doesn't make any sense. The diesels aren't going to come back on until the feeder breakers are open there. There's an interlock there. So, I don't see that it could have the fault propagate to both divisions. Now you could have damage that goes across the proximity, but not through the breakers.

MR. FLEISCHER: There are two bus transfer schemes up there for each division. If I have a fault in zone 2 and that breaker sticks, the one that says "normally closed," okay, and that normally-open breaker now closes as part of the bus transfer design, I have now connected that to the station power transformer. I'm now feeding that fault with that station power transformer.

MR. CAVEDO: Then, that other normally-open breaker pops open and it must be energized. So, then, the diesel cuts off. You don't lose --

MR. FLEISCHER: It can. It can become a race at that point, and you may or may not. And I think that's the way we wrote it, "may or may not". We cover different scenarios in different -- I covered different scenarios and different fault scenarios. There are several of them in there. But you could ultimately go to both diesels.

MR. CAVEDO: Not without that other normally-open breaker there.

MR. FLEISCHER: Well, actually, that was, in the Monshon paper, there was an actual event where that did occur.

MR. CAVEDO: Where the breaker failed?

MR. FLEISCHER: Where the breaker failed.

MR. CAVEDO: So, it is possible --

MR. FLEISCHER: Yes.

MR. CAVEDO: -- but it is not likely.

MR. FLEISCHER: Yes, it is not likely, but it happened once.

MR. MELLY: Then again, in frequency space, one event is one event.

MR. CAVEDO: Yes, one event is one event.

MR. MELLY: It's handled in frequency.

MR. TAYLOR: Any other questions or comments for Ashley in the room?

(No response.)

So, I'm going to check the webinar real quick.

It doesn't look like there's any questions.

So, I did have one quick question.

MS. LINDEMAN: Okay.

MR. TAYLOR: Nick did a lot of work when he put together the information notice, Notice 17-04, which was the one that Tom talked about, identifying operating experience or test data on aluminum aspects. We tried to do justice to come up with durations for those events. So, on the second paper that you had, were you able to find any additional or new information on durations that we didn't already identify? Was there any feedback on that aspect?

MS. LINDEMAN: So, we didn't focus so much on the event review of duration. But what we did characterize is how the protection schemes performed. So, I'm not sure if that provides you the duration answer, but at least insights on what scheme actually did and if there was failures in the primary or the backup.

MR. TAYLOR: Okay.

MR. MELLY: This is very interesting work in looking at this and how these faults persist for a long time with unit-connected designs. We also do see the situations like Fort Calhoun where the fault persisted for 42 seconds and was postulated to have released 80 megajoules of energy during that period of time on the root-cause analysis. It was a very low-current event, but it was stuck in and had to be manually turned off by the operators themselves by switching a breaker. So, there are several cases where it doesn't require that many levels of failures in order to have these events hold in for long durations.

MS. LINDEMAN: So, I think that event as also an instance where there are multiple fail barriers.

MR. MELLY: There was one.

MS. LINDEMAN: There was more than one, yes.

(Laughter.)

I mean, I think there was design deficiency and there was more than one thing that --

MR. MELLY: It was 42 seconds.

MS. LINDEMAN: Yes.

MR. TAYLOR: Okay. Thank you. Thank you, Ashley.

Bas, I think you're up.

MR. EARLEY: Just one more question? Thank you.

I was asked a question about what was the basis for the gap spacing in the tests that were run. And the gap spacing was based on the product standards for equipment of a certain voltage category and the basic impulse level required. And there was a specified minimum and maximum spacing for that.

MR. CIELO: I just want to do a real quick introduction for Bas. He's actually visiting the U.S. between travel to India last week and Dubai this next week. Yes. So, he is our Global Director of Business Development and Innovation for KEMA Laboratories. KEMA Laboratories -- he's going to tell you a lot about -- is a division of DNV GL.

We don't design, build, or operate anything other than our test labs. But we test for every manufacturer on the planet between our three laboratories. So, we see, basically, all the equipment that you have and any other industry has.

We've got decades -- we've been around since the early 1900s. And Bas ran the High Power Test Lab, the largest high power test lab in the world. He ran it in the Netherlands for a number of years.

He's also a member of the IEC, the Dutch IEC Standard Committee, and he's one of the managing directors of the Short Circuit Test Lab, or liaison, STL, which is kind of a confederation of short-circuit test laboratories all over the world that not only work to the standards, but develop test protocols to have common results from these labs.

So, I just wanted to do a quick introduction. He's here from the Netherlands. He's going to present a lot of data. There's a lot of information here. It's a little bit of a long presentation, but, hopefully, I think you'll get something out of it.

So, thanks.

MR. VERHOEVEN: Yes, Frank, thank you very much.

First of all, it is my pleasure being here talking to you. And, also, the information I got from all the discussions this morning and the afternoon so far is really interesting.

I would like now to bring you a little bit more a global approach. There are some global things that I see happening or in our work we see happening in the world.

Like you said, I do travel a lot. So, I have a lot of frequent miles for my family. But, at the same time, I talk very often to utilities. Just last week, I was in India talking to the utility and the former Secretary of the Indian Ministry of Energy, talking about power system reliability, power system performance, and all that kind of stuff. We'll do the same next week in Oman, Qatar, and, then, Dubai. Week four on that, it will be in London.

So, I have quite a bit of a background of knowing what was happening in the world. There are a few items that are generic, and I will address these and, also, on other things with some data, what was happening over there. Hopefully, it will give you some additional information in your scheme of discussion.

So, what I would like to do, very shortly, is just an introduction of KEMA, KEMA Laboratories, let's say our mother company. Then, we'll talk a little bit about certification, a global approach. I think all the world is dealing with the word "certification," independent testing and certification. It's slightly different than it is normally done here in the U.S. So, maybe there are some things to learn there.

Then, we will talk a little bit about statistics on testing and certification of the components, circuit breakers, cables, and instruments as well as transformers, and so forth. And in that statistical data, because we have a time spent of 20 to 30 years, there are some lessons. And then, we will take some summaries and takeaways.

So, KEMA Laboratories, the name KEMA is very well-known in the utilities all over the world. It was established originally in 1927 when we started building the High Voltage Laboratory and, later on, it became the Short Circuit Laboratories. In 2012, we were, let's say, acquired by DNV GL, and that's a Norwegian-based company. Actually, it is a foundation, fully independent. And that is dealing basically to save lives, property, and the environment. So, we do not serve any -- there are printouts of my presentation? Can we share it --

thank you -- for people who want to make notes? So, everything that we do, we do not produce anything. Only we provide services to ensure the safety of life, property, and the environment.

Basically, it's what we call an industry consolidation. So, let's say the mother company is DNV by itself, a Norwegian foundation, over 150 years old. We grouped with Germanischer Lloyd, also a company active in the field of the maritime sector and the gas and oil sector and safety-related matters. So, the company KEMA, the Dutch company KEMA, was integrated in the system as well.

And we have here some background. KEMA has been in the gas world. So, a lot of our people knowing about gas, gas behavior, wind field areas, and also within the piping industry.

So, again, a lot of disciplines over here. Like I said, 150 years old. With our maritime background, we are in over 100 countries globally, mainly at the main ports, and 100,000 customers, 12.5 thousand employees.

These are our business areas. Maritime sector, basically, the ships, and they can be normal ships, special ships, special laying ships, or containers, or whatever, to ensure that the ships are up to the class.

Oil and gas, that is basically to safeguard lives and the property in the environment of rigs in the sea or on gas rigs in the sea. I think here, with the discussion I've overheard this morning and this afternoon, it is here we can make a connection between the experience and the knowledge we have -- oil and gas, where we have a lot of people available and they have the expertise and the calculation methodologies to see how, let's say, if you have a gas explosion on a rig, how it is being protected with safety barriers, and so forth, in that field. I think when you talk about long-term durations and propagation of heat and fire, there could be a connection. So, that's an invitation to you all to work on that.

And also, we have in this field of play special laboratories in the UK where they are able to have real gas, real high-pressure gas, gas explosions, and to study these also.

So, I think that is already, Frank, included in the proposal. That is something to look at because there is a lot of information available there that we need to combine.

So, energy is there. Business assurance

is taking care of the management, accreditations, and so forth, that we talk about.

Let's jump to KEMA, KEMA Laboratories. There are, basically, three of them. The main laboratory, one laboratory, you could say, here in Arnhem. This is the Netherlands. It's on the German border. You could say it's the same as Amsterdam, but, then, a one-hour drive to the east.

This is the largest laboratory for short-circuit testing and dielectrical testing in the world in terms of power. No laboratory is bigger in terms of how we perform. And you can see from actual size, it's a very large facility. Total estimate is maybe even 600 million euros to make this happening.

This part over here is the short-circuit part where we test the circuit for short-circuit performance. The generators, the switchyard, the test facilities and test base, and here on the top we have the High Voltage Laboratory, and so forth, dielectrical testing.

As you can see over here, we are located to the River Rhine and with our own harbor, where we are able to dock ships in with large power transformers, so the big ones up to 800-kilo class power transformers, the real big ones, so stationary transformers, where we can test these transformers for their ability to withstand short circuit passing through the transformer. Every power network has several short circuits in a year, and these short circuits pass through all the components, including the power transformers. And then, we determine how well this transformer behaves for those currents passing through.

So, that's the largest one. We have two more or less comparables, one in Chalfont -- that has been referred to by this board already -- where we have here the test cells where we did the execution of the test in the last years. So, one of these was, let's say, it can be vaporized by the dose particles, generator hull, and the train passing by that was referred to this morning. Comparable laboratory like that we have in Prague, in the Czech Republic.

How does a High Power Laboratory look like? Because the short-circuit testing, whether it's for an for a durable arc or an explosion arc or the physical performance test of the circuit breaker, you need to have a huge amount of energy. And that amount of energy is basically you cannot get it from the network without having the network going up and down a little.

Especially when we talk about here in our facilities, like I showed here, we are able to test circuit breakers on their functional performance to, let's say, switch of the short circuit current and failure, at the same time having 800 kilovolts or even 1,000 kilovolts as the feeding network. If you do quickly the math, the number of power that you need for that is huge. You cannot take it from that way.

So, what we do, we do it differently. Basically, we have here short-circuit generators, and these generators, we bring them up because they are using the power network energy. But we accumulate the energy in rotating energy in the rotor. So, each generator has a rotor with a mass of 55 tons of steel spinning at 3,000 RPM, or if we have to do the test at 60 hertz, it will spin at 3,600. And that's basically an energy storage. By the time we do this, we energize the rotor winding here in the generator hull, and the energy comes back out again as this electrical energy.

So, that's basically how we generate the power, our step-up transformers to perform this to any level that we need. Or we can connect even the generators from their 10-kilovolt supply in parallel for testing the certification of generator circuit breakers.

Switch our test base, several test bases over here. The harbor is there, in there for the test certification.

Here is how such a generator looks like, and this is a generator. It's about 10 meters long and diameter, overall diameter of about 4 meters. This generator can make a short-circuit power of 2,500 MVA.

For that power class, this generator is very small, because we do not have the limitation of the thermal properties. We run this generator. We speed it up, of course, but the actual short-circuit test normally takes about, let's say, max 1 second. So, we don't have an issue with the thermal continuous operation mode. That's why we can get really energy out of this generator of 2.5 kilovolts.

Then, have a look at the power rating. We installed six of those generators, which can be better now. So, basically, our continuous power rating we can make is 15 gigavolt or better. Basically, that is sufficient to power the whole of the Netherlands for about 180 seconds. You get a feeling of what kind of numbers we're talking about. These are big numbers.

Our laboratory in Chalfont that I've

already referred to, we have two generators, a bigger one and a little bit smaller one, T-1 and T-2. They can't be parallel. So, the maximum power we have in the Chalfont is 2.2 MVA, or a thousand MVA available. We have two generators that can be parallel.

That means that, if you are running tests or you need the ultimate power and our Chalfont plant is not available, there is this lab in the Netherlands that is six times the size of Chalfont. The question is, is that needed? Most likely, the power rating that can be supplied by Chalfont is sufficient for your kind of testing certifications. But, if you run into limitations, don't worry, there is a backup, a big one.

What is important, and that's why I added it over here, that's laboratories that people use normally have to have, let's say, a decent accreditation. And normal accreditation is the ISO 9000 series. I think everybody's familiar with it. But there is a special one that is 17-025, so that IEC 17-025, which is a generic certification scheme for laboratories, any current laboratory. It can be a short-circuit lab. It can be a high-voltage lab, but also a lab for the testing of clothing or blood samples, or whatever. So, it is a generic management organization for laboratories.

If you make use of a laboratory, ensure that it is certified by 17-025 for sure, and that's also the connection here with the NRC, I believe, that there is a simplified method of using laboratories as long as they have that form of 17-025 accreditation.

Many the laboratories in our field of play, where you look around the world in the power sector laboratories, most of the laboratories are manufacturer-based laboratories. So, they use it for their own testing and certification. These are typically not certified by 17-025. They're just run by themselves. The commercial, good, independent operation laboratories, of course, all have the 17-025. So, also, our three laboratories at all locations are accredited to that system.

And basically that means in the end that you are connected to basically the methodology as pre-described in ILAC. That is the informational organization for accreditation of laboratories.

So, let's look a little bit about the global approach of certification. Basically, the certification is what we call a means of mitigation of risk. And there are, of course, several ways how to mitigate risks. And so, the global approach that I see happening in the world over and over again is basically a two-step approach.

First of all, you have to assure that the design of your power network or your powerhouse, or whatever, basically, the conceptual design is okay, that you have selected the proper voltage classes, the proper single circuit or double circuits, having managed work and managed tools, or whatever. That's basically the design that will give you the function that you need. And you need to balance that with the criticality of the component and on the system.

Again, I expect for a nuclear power station the reliability issues are even at the higher level than a normal substation in the queue. So, that's one.

The second, if you have designed the system, and you go to build it, you have to buy in components. You have to ensure that these components are up to the task, that they will be able to withstand the voltages, the currents, and that the circuit breaker will open when it is supposed to open, and so forth and so forth.

So, what is important? A good design. Secondly, make use of components that have proven to be suitable for it.

And maybe a little bit of difference in understanding between the U.S. and the rest of the world or other bigger parts of the world. Many utilities in the world want to see the proof upfront at the development process. And by saying, well, the manufacturer says, well, yeah, this is one design; it will work definitely, it's on the specs. So, when it is off, you can sue me, or whatever.

Well, people or utilities in the world -- especially next week I will be speaking to SUN, SUN-ELECTRIC Company, that simply said, every component that will go to tender must have at the tendering phase already the certified, independently-certified performance check. That means an independent laboratory, like KEMA or some other companies, have tested those components to a standard. Most of the time, it is IEC-based.

And that's basically what you see happening quite often, that in the global market, where you say, okay, when I'm tendering, I am going to demonstrate with the type of documents, that it is tested in an independent laboratory, not in the country of origin. That's how the global play is more or less conducted. And that independent laboratory can be an STL member.

So, what is the STL? STL is a voluntary group of laboratories that operate globally, where they said, okay, many of the standards that are out there, whether it is IEEE, ANSI, or the IEC, sometimes these documents are still political documents. That means that they are not -- let's say the working committee was not able to design really, okay, these are the tests that have to be done, or there are options. And every political solution in the test standard, basically, it can be shown that you have a clause for a certain performance criteria and that you may choose between test 1, 2, or 3. That means the committee could not decide what the real test should be because the stakes of the people was too high.

All STL was doing, the short-circuit testing result, is basically doing a harmonization of the implementation of the standards. So, if IEC standards, basically, are given options, STL will say to the testing laboratories, we will always go for option 1 or 2, and this and this is the way how to be executed. That means that the members of STL will always perform the best in-depth specific guide.

Basically, it's looking at IEC. So, that is that IEC standard, although sometimes I know even in the IEEE and the ANSI there may be different approaches, but we do see that both those standards are becoming more and more closer. So, a lot of IEEE standards that are there on a day-to-day will take over sometimes even 100 percent IEC. I think that's a good development.

So, who are STL members? There are currently quite a few. But, basically, all these are what's now shown on the graph, I understand. There is a membership here, STL, the source of the test liaison, "NA," this North America, that's a group of laboratories there. KEMA Laboratories is over here, and we are, of course, members, even a founding member of the STL. But you can see our general approach and, also, you can see here our laboratory, that it is part of the STL.

That means that they work and operate, they have to work and operate exactly in accordance to the STL guides. And when you talk about STL, not any laboratory can become an STL member, because you have to prove that you are up to the task, that you're knowledgeable, that you have been maintaining that knowledge for a longer time. That's one of the criteria of the laboratory. That's why the number of laboratories that you see is limited.

When you look at the STLNA, so the American version, it's comprised of several laboratories, manufacturers' laboratories, but also independent laboratories. I mean, Eaton is there. Cooper is there. LAPEM in Mexico is also part of this group. S&C is there, Eaton, and then Gelfem (phonetic) is there as well. So, it is important to delegate, and the influence of STL is becoming much more important globally.

So, how do many of the utilities look at certification? They said, like I said just before, they need to at least ask for an independent certificate upfront in the tendering process. In the IEC, and I think also in the IEEE, or many in the IEEE standards, there's a section which is called five test or design test. And basically, that comprises the set of tests that components should be tested to, and when these tests are done, basically, it will say, hey, this component is up to its stuff; it can be used by itself.

And this is a prospect that many utilities demand that full type test to be executed upfront or even during the delivery, depending on the methodology. That is typically how it is done. That means that the majority of the work we see in our labs in the Netherlands are always certification tests. When the manufacturer is ready with the design, he thinks, okay, I'm done, I'm ready, let's go to the independent test and hope that I will receive it, and with that, I can release it and do my marketing, and so forth.

Also, a thing that came across with some discussions I had with American manufacturers as well is that the liability of the component is not transferred by certification. Although we, as KEMA Lab, said, okay, this circuit breaker is up to the task, it fulfills the requirements as stated in the IEC, I will not be responsible for that circuit breaker. That remains with the manufacturer, of course.

Also, a thing that's often discussed, modeling in place test. The feeling is such that modeling are important tools for the design of components, very important tools. And it can be rules of thumb. It can be numerical calculations or finite elements, or whatever kind of calculations or models. But always a model is just a simple presentation of the real-life situation.

And especially in those areas when you are in a phased transition from solid to plasma, your arc, that is where modeling becomes extremely difficult. Modeling is extremely difficult. There are models for the arcing parts. There are models for the stationary solar part, for the transition between those two, and the phenomena, especially when you talk about zero crossing of a current, when you go very quickly from a plasma state, hopefully, through a solid state, and then, if you have a retrigger to a plasma state again, that kind of modeling is extremely impossible. And computers, even the big super-computers, are not able to calculate that kind of stuff.

Also, to prove that little bit, CIGRE designed several years ago and said, okay, I'm going to make a circuit breaker in a certain design, and that design was given to several manufacturers, Real Global, Abrandt (phonetic), and manufacturers. They were asked, hey, calculate this circuit breaker when it will seem like the goal breaker. And a simple electrical breakdown on AC voltage, the most simple thing you can imagine.

So, every one of those manufacturers start to calculating, and the super-breaker was also built and tested. And then, all the results were compared. It showed that there was a very big scattering of the results. We had a physical result of the test was, let's say, 100 percent, and there were calculations weighed.

And why? Basically, it is also very simple. Why? Modeling is so difficult to represent the real-life situations. The majority of the cases when something, let's say, has a breakdown or a dysfunctionality, it is because of slight imperfections in the materials.

If you have a pencil, you can calculate if I squeeze it and put it under pressure. You can calculate the stresses in the wooden pencil, but you never can calculate where it will snap, on my left thumb, right thumb, or in the middle. Because it will snap at the point where it has a small imperfection. And I push with my fingertip in the wood, or an imperfection will do it. That is something that you cannot calculate.

Then, let's go to some experience about reliability numbers and statistics and failure rates. This graph that I got from Eaton here in the U.S. -- and if you Google out Eaton's blackouts record, that's a study being done by Eaton, and they calculate the number of outages that is happening in the U.S. What's the root cause of that? They do it year on year.

So, this is the 2016 graph; '17 is being calculated, will be published, hopefully, in a month's time or so.

But this is a very interesting picture. Basically, it shows that in the U.S. there are, in 2016, almost 2,900 outages in that year. That means the outages today. And they are trying to find out, hey, what is the root-cause analysis of that failure? It appears to be -- and this is basically, of course, the data that is looking at the transmission and distribution networks -- it means also the median voltage lines throughout the city and the countryside. So, it is the exposed system, medium voltage and the lower and higher voltage.

So, 33 percent of the outages was caused by weather incidents, a storm hitting over, snapping a pole, or that kind of stuff. And 4 percent was animals, the deers and the raccoons that climb into the poles and there may be short circuits. Cars hitting the poles and the pole snaps and breaks the line. About 5 percent was planned. So, when you have the radio feeder and go into an area -- and they had to do some prepare; it was a planned outage. Because the people were in the way, it could not be switched over.

More importantly is this number here, 24 percent. Twenty-four percent of the outages in the West here is basically arrangement by faulty equipment or human error, the mistakes made to maintenance, or whatever. But that basically means that the circuit breaker who receives the trip amount will not trip. Twenty-four percent.

I'm talking about reliability of components where you just put components in the network without knowing that these are of decent quality. You're demanding something from the network. And I think the discussions here was, yeah, yeah, that can be so, that we have circuit breaker that doesn't trip or we have multiple layers of handlers. Well, yes, it's 24 percent. And I think that's quite a high number. I think that number that can be influenced by the utility assuring that what you put in your network is of proven technology, that it's up to the standards, up to the task that it is designed for.

Then, when you look at that 24 percent, historically, over the years, then you see this graph. Basically, this is not percentwise, but an actual look. So, in 2008, it was about 650 outages caused by faulty equipment, and that is going up to now just over 900 incidents.

That means that more is happening. And a few reasons are here on the left. One of the main reasons is by interconnecting of power networks to stiffen the network, to make it stronger, so that the short circuit performs better and the voltage fluctuation in the networks are slower. And you have better, let's say, availability in terms of -- but it also means an increase of short-circuit performance, of short-circuit currents, can go from maybe 20-30 kilograms up to 40, 60, and there are already power-nets working in the new world with short circuits' current values of close to 90 kilograms, 9, zero; 9, zero. That's a big one. That means that all of these stresses are put on the components and are sitting there. So, you see an increase of those parts.

I talked about CIGRE. I will refer to CIGRE a little bit more. That's why I put this slide on, because I do not know if everybody is aware of CIGRE, because that's an international organization from 1921, which basically it's voluntarily an academic environment where they do a lot of studies, a lot of imports, and working groups, in the power sector. So, technology outlooks, but also a lot of statistical data is there from how the power-nets are performing.

Also, people from the U.S. are, I think, a member of CIGRE. But I definitely would advise you to please have a look. And there's quite some information freely available. A little information is available. For some, you have to become a member. So, you can sign up, become a member yourself or find somebody in the U.S. who is a member, and then, get that data.

One of the three datas that came out from the Working Group A2-37 was to perform a reliability study. That's basically looking at power transformers, the bigger ones, all over the world, and how do they function. What is the overall experience in terms of reliability?

And here you see the graph that was coming out. Here in the white/blue blocks, basically, the step-up transformers. And depending on the voltage class, that means that in the step-up transformers 1.3 percent failure rate per year. And the step-up transformers, of course, are the most critical component in a power station, where it jumps up to power. So, if you have an issue in the step-up transformer, your unit is out for, let's say, a year or half-a-year, or a considerable amount of time. The normal power transformers that are at substations always have a little bit lower tendency to have issues.

But that means one out of two of the transformers has an issue in its performance. That's quite a high number, obviously. So, things happen, and we don't expect it, or things that were not, real importantly, does happen.

This report, by the way, it's a long search, but this report is freely available. I can be downloaded by anybody.

Another graph from the report is basically looking at, hey, what are the root-cause the analysis of the failure of power transformers? Basically, it was 11.6 percent of the cases the failure was caused by an exterior fault, and this, the next general short circuit. The short circuit passing through the transforming, shaking the windings, and a lot of force on the windings, and that was basically the root cause of the failure of the transformers.

So, design issues, a big chunk on aging, of course, here. And after time, power transformers are often 20, 30, 40 years old, or longer, and then, the aging becomes an issue. But well before aging, the external short circuit kicks in in this case.

And that was a study we found from EPRI on the performance of power transformers, a reliability study. And also there, inadequate short-circuit strength was the major cause of failure.

The funny part is, if you look at how many utilities are demanding short-circuit testing of distribution of power transformers, that's relatively low. They all think, well, my network is good; there's no issues for me, or that the manufacturer says, no, no, I don't want this test because it's too risky. That's a very, very odd situation there, what I see globally, but it is changing.

Here again from CIGRE, an overview, 13.08, and the number of faults that are happening in power systems. Because many people in our own industry say, aw, short circuits hardly even occur, at least not in my network; it's not an issue. But, if you look at it from a global basis, basically, depending on the voltage class, you have two to three short circuits in the line. That means, if you have an extended power network, you do have issues, things happening in the power network that will have an effect on the overall performance. So, that can happen.

Before I start on this part, this is the part of the experience we have in the last 20 to 30 years with time testing of components. What is important is to understand the following: that is data when the manufacturer comes to our laboratories for a time test. It means the full time test as it's in the system for that specific component. Mostly, it's to set a different course. That needs to be short-circuit performance, dielectric performance, temperature-wise, and sometimes also mechanical or circuitry.

The manufacturers that come to us have, let's say, completed their R&D phase. They are ready with the design. They don't come to us for R&D tests because we are too expensive. So, when they come to us, they are ready with the design and say, hey, this transformer or this circuit breaker is of high standard, high quality. Okay, yes, please come and miss the circuit breaker or miss the transformer.

And then, we will start with the time test sequence. And then, we don't basically look -- when there is one of the tests in that sequence of tests fails, then we call it initial failure. That means, although the manufacturer thought it is okay, it did not at some point during the certification process. Of course, he can do redesign and come back, and then, maybe hopefully for him, it will be successful. But we only count the first time and we see if there is an initial failure rate or if this is successful.

Before I show an overview, I would just like to ask the question, out of, let's say, the 100 percent, out of all of the components that we started time testing, how many is your rough feeling of samples have that initial failure rate problem? How well is this sector in this case doing? Or do you think that the initial failure rate is 5 percent, 10 percent? So, five components out of the whole group are not going well? Or is it a little bit more, 20 percent, 30, 50?

MR. FLEISCHER: Are you talking prototype or production?

MR. VERHOEVEN: The real one, the real production type.

MR. FLEISCHER: Oh, the real production types?

MR. VERHOEVEN: No, no, no, no, not R&D, no.

MR. FLEISCHER: Ten percent?

MR. VERHOEVEN: Twenty-five. So, all the components, the experience we have -- and it doesn't matter when you talk about circuit breakers, power transformers, cables, enginators, or medium-voltage panels or low-voltage power panels, they all hover around the 25 percent.

And if you compare that with another industry, we're not so good. If you compare it to the car industry or the computer industry, or some other industries, this number normally in all industries is around 3 to 5 percent. We are, as a sector, 25.

Then, the question is, how come? Are we not smart enough as people? No, I think we are educated persons. We have a lot of smart people. No, I think one of the reasons -- and I will give you some more proof later on -- but, basically, this 25 percent, it is happening that these components that we are using in our power networks, and whether it was a circuit breaker or a panel or a transformer, or whatever, these are what I would call high-tech components. It has to be built in good condition. It has to be designed in good condition. Because they are up to the task, and that is a strong task. A circuit breaker normally has sit in the closed position waiting for the trip command. Maybe it has to wait five years for that. It has to come, and within 2 mini-cycles it has to open. That's a very special product that we are designing in our sector, and that is basically reflecting the number of 25 percent.

Let's look at some statistical data. So, large power transformers, 20 MVA or larger, we started testing these transformers in '96 up to last year. Basically, this is the trend. So, the total number of these big transformers we test and the individual year-on-year performance. And you see that in this case our average is 22 percent. So, one out of four transformers fails to meet for short-circuit performance. That exhibits how that will look like.

But we mention that you order power transformers and you don't test for short-circuit performance, you could say. If this is true for the whole population of transformers, if you have four power stations, one of the power stations is at risk. If that's completely true, I don't know, but roughly to get your mindset a little bit in this way.

Also, you see an increase in the number of tests we performed over the last power transformer. That is showing of the world, and these are utilities basically in India, China, or in Europe it's France and the Netherlands, that are more and more and more asking for short-circuit performing testing.

MR. TURNER: Is some of it because the standards are requiring testing at 100 percent of expectations whereas in a real application it may only be running at 60 percent of that? Is some of it because the standards have --

MR. VERHOEVEN: No. I will go through the standards.

MR. TURNER: So, what you're saying there, in effect, if I build something, I can put four of these things in there. When I try to commission the plant, one of them is going to go down. That's just not the experience people will have.

MR. VERHOEVEN: No?

MR. TURNER: So, where's the disconnect? Are the standards too tough or people just aren't running it near the standard limits, or something of that nature?

MR. VERHOEVEN: It's complex. It is very complex to answer that question very directly, but I think a lot of data on the physical performance of networks does not come together. And that's why I put this graph here for power performance. These numbers are quite higher than people expect. So, a lot of data or information on things that are happening out there is not, let's say, accumulated to today's experience.

This is a time test on the short-circuit performance of a transformer. It goes very fast.

Where there is a secondary short circuit, together in here we feed in, and here you see what is happening due to the mechanical forces inside the power transformers that are creating a short wave in the transformer and starting vibrating of the -- then, you start to vibrate. And basically, a leak inside the transformer is pooling in the transformer on the enginator, and you have the snapping moment in the engine as it breaks. In normal life, it would be a big fire.

The other one, it is also a transformer. This will have, due to the short-circuit movements inside of the core, and then, the windings, there's a short wave in the well. The safety valve breaks open, and here even the oil catches on fire due to evaporation of the oil. Since we are able to disconnect the transformer very quickly from our feeding generator, we don't have an issue here.

MR. TAYLOR: Do you want your next slide?

MR. VERHOEVEN: Yes. So, what is happening there -- and, also, this is in Exhibit 4 -- the power transformers, to explain a little bit more what's happening and why this is so crucial, this kind of testing. It just also popped to my mind, this is also maybe applicable to the things that you were talking about, those sparks that are seeing short-circuit curves. It's basically mechanical forces out there, and this is the basic force of the curves. And two curves, depending on the propulsion actions happening inside, the winding order, parallel conductors in the bus box.

Especially when you talk about this as global, the distance between the crossbar is becoming smaller and smaller, and the forces go up. Since it's a short-circuit test, it's clear of the current. So, it goes up very fast.

The issue in the exhibit of what can happen, so this is normal rate of currents, and this is basically a short-circuit current going to the stationary in back. And this is the DC offset. Especially in networks that are getting close to a generator failure, the DC component becomes quite high. And you can have, let's say, between a normal curve condition and short circuits, it goes up to a factor 10 times or a little bit more.

But, if you looked into the forces, it goes up and, then, it doubles in size because it goes up. It means that the peak goes in the force maybe up to 400 per unit in force in total. And that's a tremendous amount of force.

And what is even more critical, that is not a steady-state force. That is a pulsation, constantly hammering with each going up and down. And actually, what is happening, the frequency also changes during the decay of the DC component. So, it goes from 150, slow, to a 50 or 60 hertz, the vibration.

And this can create a huge amount of -- you can see in the exhibit where the inner lining of the control and the outer lining of this, there was a leak going out where the complete winding was basically rotated. So, this length normally should have been straight from the inner lining. And here, you can see it was twisted. And that twist basically will end up in the short circuit.

The force was on the left, and the righthand picture shows the forces on the inner lining of the transformer due to the electromechanical forces that wants to make the inner lining smaller in diameter. And then, it build this out here in the linings.

On this slide, on the left -- we'll play a movie -- this is what you see is a winding. It actually is a line core that we tested for short-circuit performance. You can see, when we applied the short circuit, you see that the core will start vibrating. And that's the pulsating force of the current passing through.

You will also observe that the motion decays over time. And carefully look also to this part where you see some of the support was just moving out. Yes?

You see the pulsating force. The frequency is changing, and there is no support of this going out.

That means that over time -- maybe in the first time it remains okay -- but the second time it's gone. So, maybe the half unit or when the next short circuit comes, it will create an effect. And also, it can be possible, like I said, for burst bars, high-energy burst bars, where they are chemically supported, but where the forces are also there, you have to pulsate your forces. Then, the suspension engine may snap or will start cracking. At some point of time, it will evolve from, say, a normal fault to, at a completely different location, a secondary fault.

Things to look at: yes, I was a little bit surprised by it when I first was introduced to this high-energy arc fault. I was really shocked, as I said, at those 6 seconds or 40 seconds of what has happened, extremely high in time.

So, while the displacement is over here, let's move on a little bit. I will go to the standards. If you look at 444, that's volume transformers and that's developing the standard. It is that it allows in the IEC -- you have to, let's say, demonstrate the ability for short-circuit performance by either a test or by calculation. That's also applicable in the IEEE standard C75, which also allows calculation of mechanical forces.

Well, ladies and gentlemen, these kinds of forces that was just shown in the movies cannot be calculated. What can be calculated are static forces inside the core. There's usually an ideal treatment of the core, perfectly symmetrical, and all kinds of, let's say, transpositions in the core cannot be calculated. Leaks from the winding to the online depth changer or to the enginators cannot be calculated, impossible.

That means that the standard is changing, and not only for power control, it's also for arc reports. They are saying, hey, you cannot calculate; you must perform the test. So, the IEC and the IEEE will change -- most likely, it will be done in 2019 -- where the option of testing is ruled out.

Let's look at another component, distribution transformers. So, up to 2000 kVA across. Where you see power class, the initial failure rating, on average, is 25 percent. And here, for the bigger transformers, 2000 kVA or larger, there you see an observation that the failure rate doubles the size of the normal sized transformers.

When you go back to the manufacturer and ask, "Hey, how come; is this about double bit stops?", basically, it's, yes, it turns out their production is here in the moments, in the skills. For 2000 kVA transformers, they don't make that many of them. So, there are much more design flaws in there or there's much more, let's say, effect of people making it are having less knowledge in making it. So, you immediately see a high increase in the number of initial failure rate. So, that's an interesting observation, I would say.

Cast resin transformers, most of the time these transformers are used in high-rise building due to their fire properties, where you don't want to put oil or an oil-filled transformer in a high-rise building due to the fire things. So, you put in a cast resin, and they are a little bit more expensive, but, basically, it is assumed that there's no oil.

So, there is no issue with fire.

And one of the tests is a volt, and if this cast resin transformer is heated by a secondary fire, will it catch fire and start to accumulate extra fire damaging to the part? Or can itself ignite when it is heated up? That's what we call the fire protection clause in IEC.

And strangely, from the prior transformers we test for the fire properties, half of them is not meeting specs. And it seems a simple thing. And you buy those transformers for their fire properties. You put it in high-rise buildings.

And what happens? Our experience, 50 fails. It means that there's a special component. You can't name it. You cannot use it any kind of resin for making this transformer. You need to have special resin that has the right properties for fire; also, the right properties for the thermal things that are happening inside the core, but also the electrical fire. So, it is not that easy as it seems.

The cables, medium voltage and high voltage. So, medium voltage, between 1 kV and up to 36 kilovolts. Cables, medium-voltage cables, 11 percent of the cables has initial failure rates. So, that's unacceptable, as you know. But, if you look at high-voltage cable, it's 26.

And also here, how come? Because the cable manufacturing problem is basically the same for a medium-voltage cable or for a high-voltage cable. The same making equipment is what you need.

But what we see happening -- and we've talked to many cable manufacturers in the world -- basically, the result was somebody has an idea. Okay, I'm going to start to build a cable manufacturing plant in country XYZ. They call one of the German, or Finnish cable extruder manufacturers. You order such, and you will get it. Within one year, you are a cable manufacturer.

And then, these people are there and producing cable, selling cable. Then, they find, oh, the margins, my financial margins are not extremely well. I want to earn more money. And then, they look, hey, the high-voltage cable sector. So, 66 or 32, or 50 kV and 500 cables are very more lucrative in designing. So, they call the supplier of the manufacturer and get some additional components, put it on, and the next day they are a high-voltage cable manufacturer. But they are still in the technology, in their methodology of working and quality surveillance, and feeling this process, they are still a medium-voltage cable manufacturer. That's why this number is more than double. Very practical, simple, and maybe just, yeah, it's understandable. But this is really what was happening out there.

Fifty percent of the medium-voltage cable terminations fail. That's the heat shrink technology, a very simple, easy-to-use technology. If you use the right materials and the right components, it is very good. But what you see happening -- and that's why this 53 percent -- these termination kits, and you see an exhibit of these kinds of the termination types, if you don't take the right materials, it will start to decay due to the electrical field that is over the tube. So, you need to have a special tube that can withstand electrical stress, and that sort of stuff.

That means it is a little bit more expensive. So, a lot of push on the market to show a step that there's a lot of, let's say, not suitable materials out there that show this high level of fill rates.

If you look at, for the cables, medium-voltage and high-voltage cables, here is data year on year. In the graph, these are the results. The blue square, the performance year on year for medium-voltage cables and here for high-voltage cables. And the yellow triangles are the accessories, meaning for high voltage year on year. And the lines are basically the trendlines from these data points.

And what you see, that the trendlines are flat or even erode, although everybody would expect that the trendlines should grow. We have better materials. We have better design rules. We have better experience. We have better production facilities. We know more. So, all, let's say, the competence and the technologies that have become available over the years are not put into the components. Otherwise, these trendlines would go down, go into the 5 percent, which is maybe more a normal value. No, it's flat, and it stays flat. Actually, it's even going up.

Then, the question becomes, how come? How come is it that the trendlines are flat or, let's say, do not go down significantly while we have better performance of materials, we know to calculate, we have the experience, we have the improved production facilities, dah-de-dah, dah-de-dah? And there's only one answer to that question, ladies and gentlemen. Who knows?

So, everything that we learned and gained is not going into performance improvement. Otherwise, the lines would go down. It's all that knowledge and experience is put into one thing only, into cost reduction.

MR. PUTORTI: How many different cables are within each year's dataset? In other words, some years there's zero; some years 100 percent fail.

MR. VERHOEVEN: Yes. The total dataset is 900 samples.

MR. PUTORTI: I meant for a year.

MR. VERHOEVEN: That will be --

MR. PUTORTI: For most years, like maybe one cable was tested?

MR. VERHOEVEN: No, no, no, no, it's always at least 10-50. So, statistically, this data is okay, although the correlation for the trendlines is a little bit down. It's scattered. That's why you see the scattering. That's why I call it the trendline. The trendline is basically -- it is not in the statistical correctness of this data.

Because I wanted to learn what the result was, and just because there were many factors, and basically, like I said, everything that we learned and gained and improved so far is put into that one single thing. It's cost reduction. It's simple.

And I think even I was talking to the

Indian people last week, and they said, yes, it is becoming even worse. And the problem of purchasing departments is becoming so strong, and the amount, they are very open because they have to do an open tendering. So, the specifications, let's say the technical specifications have to become more simple and easy, because you have to go into an open international tendering.

So, in the past you could say, if you would order a medium-voltage cable, you described the cable and the technical requirements. Nowadays purchasing departments says to their own technical people, what's the most simple way of describing a medium-voltage cable? Well, simply it's photographs. You have in kV three-phase proper conductor of 250-millimeter scrap. That's sufficient to order a medium-voltage cable, but it has nothing to do with the technical requirement and, thus, performance.

But sometimes it is said with a provision, if you compare this with Windows, now we have Windows 10 for power-computers. If we would transfer this, what we have done in our sector with this craft, and to make that a comparison to Windows, we still, as a sector, are using Windows 3.1 and the same stuff that was put in the computer 20 years ago.

And they I say in an open discussion to the industry, are we doing well as an industry? Or should we be ashamed a little bit as an industry? I think the latter is possibly it.

Let's move on for time's sake. Circuit breakers, really the real course in the sector is to disconnect the short circuits. Within the IEC, there are many, many different duties a circuit breaker has to comply to. So, it has to be capable of switching in short faults, long faults, capacity switching, log-to-log switching, inductive switching. So, a lot of different tasks that the circuit breaker may see, and all these tasks have a specific duty.

And here you see in the graph the performance of the average of circuit breakers. Where we have over 4, over 50 tests, you see the numbers even go up very high, depending on the type of duty. So, also, on average is the 20-25 percent.

And this is the one we are relying on in a protection system. This has to clear the fault in the end. After the typical response from the protection system, the circuit breaker has to trip.

Then, let's move on a little bit to closely what I've seen within the sector on a global scale with regards to the internal arc test of medium-voltage panels. I would say what I have seen in my experience is that most of the utilities see a growing importance of this test for the safety of their own. Too many, let's say, people have been doing switching actually in substations all over the world and too many have died. So, the utilities are more taking up their, let's say, responsibility to ensure that their assets are, let's say, sufficiently protective for their people.

But, if you look at the IEC, but also I know for internal protection with safety-related matters, it's quite often it is the current value and the duration. Quite often, in the standards you see duration of .1 second, .2, or .5, and in extreme cases 1 in time, because they expect, if you go to 1 or 2 seconds, basically, the second or third stage of the protection must have cleared fully.

But I hear in the discussion today here in this room a different kind of discussion. So, I think this is for sure something that we have to study and look at. What's the origin that you come to these incredibly long times?

How do these components -- first of all, we do test them for the performance of the internal arc, assuming that there is a guy standing in front of it and that the guy should not, let's say, be hit by fumes or gases. Maybe he still dies of a heart attack or of the sound, but that's something different.

Also, here we are learning the statistical data of how many of those cabinets fail to meet the internal arcing test. I can't show you a graph yet because we are still data-crunching here, but it looks that it is, again, in the famous 25 percent. So, 25, one out of the four cabinets that is being sold on the market basically has a rating or at least you are buying with the hope that it will protect, but it doesn't.

So, how do you test it? Depending on what's put in here, you have those racks a short distance from the panel. These indicators, there's specific cloth, how basically you do the test, and these clothes should not have burn marks. You put it on the sides where people could operate.

Here you have the test that is running. It is difficult to see, but now it is starting. And then, you see the exhaust. Over here's the pedals, and going through the exhaust of the whole gases and the smoke coming out, protecting the people that are basically here.

We have another one. You see the opening of the shutter. Did you see it going in the beginning? You see the shutter opening. The shutter is opening, but this is a complete failure, of course. So, the cabinet was not able to divert, let's say, the fumes through the lid that was opening as an exhaust escape. But it has fully blown out the doors here.

Another one, also, a lot of fire, I think, but the guy that was standing here not affected by the arc. Of course, surrounding materials can be, let's say, for the personal safety, it is not very good.

Yes, what we see happening here with the statistics, 25 percent, and I was referring, also, to the cost pressure in the market. What we are starting to observe, that the cabinet builders are basically trying to reduce the cost of the cabinets. Thinner materials, hinges lighter, simpler designs. But, basically, they are just increasing the risk of having a real big issue with the internal arc. So, there the cost pressure is eating up this space already.

And also, more pressure reflection, seeing these tests which have arcing times of maybe 1 half a second, but I think most of it is .2. You see a lot of fume and fire in this case the more you talk about seconds. I cannot imagine the panel that can withhold internally 30 KA for that amount of time. It has to be like tank think; you can't pay for it. There is also no design there. So, you have to find a way to make sure that the gases can go out in a safe place, and that the cabinet by itself is sufficiently strong and capable of doing that.

Another thing that struck me was what I recall, and during the discussions this morning it came to my mind, I know of one case where a utility somewhere in Asia had also an issue with these kinds of faults. Basically, what they put into the panels was, you could say, sort of a crowbar system. So, it was a switch sitting at the terminal. Basically, when it saw an arc, bang, it shot an arc, both three-phase short circuit and the panel. So that you have a strong short circuit, protection will pick it up, and the result, you have an arc in the panel. And that arc, we see that; we test it. Yes, it's a crowbar.

So, these components are on the market, and we have tested those on their effectiveness. So, how quick can they pick up and how sensitive or insensitive they are? But it might be something to look at, although it, of course, is just introducing a risk of failure as well. So, yes, it was done.

Some other components, here, disconnect the circuit breakers, switches. Again, the failure is

25 percent. Arcing norms and arcing times, again, the same numbers.

Basically, to close down this presentation for this more global overview, the 25 percent is what we see for all the components. All the increase in technical skill and processing, everything is put basically in one thing, the cost reduction.

Where I have the idea of, are we doing well as an industry, utilities, manufacturers, and then, users? Modeling calculation is extremely difficult, especially when you are talking about phased transitions from a solid state to a more plasma state, difficult transitions. And we believe that in the end it is the test, the real test, that shows we have compliant entities and specifications.

And by that, I would like to conclude. So, just three minutes over time. Maybe we can have some questions?

MR. TAYLOR: Any questions in the room? On the webinar?

All right. So, in the last few minutes here, we will open up the lines for public comment. Can you unmute everybody?

One second while we unmute those on the phone line.

If there are any comments, raise those now. So, the questions can be from this presentation or anything else that was brought up during the workshop today. So, feel free to ask questions, for those on the phone line.

And while we wait to hear from the phone line, if there's anybody in the room for any of the presentations?

Okay. So, not hearing any, Mark, do you want to make the closing?

MR. SALLEY: So, it was a long day, a lot of information, a lot to think about.

Bas, thank you very much for traveling over. A great presentation.

A busy day tomorrow, a lot of discussion. So, again, let's figure 8:00, 8:30, getting through Security, getting up here. And again, tomorrow we'll look for a lot of, hoping for a lot of interaction and a lot of discussion in the path we move forward.

So, with that, we will call it a day.

MR. TAYLOR: I've got one last thing.

MR. SALLEY: One last thing?

MR. TAYLOR: So, for those on the line and for those in the room, the slides will be made publicly available. I've put the ADAMS session number up here on the tablet. So, if you're not here tomorrow, please feel free to look up that ML number. They won't become public until like Friday. So, if you go home tonight, you're not going to see that ML number be brought up, but this is the ML number. For those on the phone line, it's ML 18108A210. And we will also make note of that in our meeting summary that we put to document this meeting. So, again, the ML number is, the session number is ML 18108A, as in apple, 210.

So, with that, we will see everybody tomorrow. Thank you.

(Whereupon, at 5:50 p.m., the above-entitled matter went off the record.)