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NUCLEAR REGULATORY COMMISSION

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NRC HEAF PHASE II INFORMATION SHARING WORKSHOP

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THURSDAY

APRIL 19, 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 8:34 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

AGENDA

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

(8:34 a.m.)

MR. SALLEY: Okay, good morning. We'll get started here with Day 2. I take it, I trust everyone rested well last night, watch my Penguins beat up on Nick's Flyers. Played well. That was a very enjoyable hockey game.

So, let's get started today. We had a busy day yesterday, we covered a lot of information. Again, I want to thank Mark Earley for the NFPAs presentation. A lot of that reference, there is a lot of work that Gabe is going to be doing, looking at stuff, like you, too, Nick.

And then Ashley in the presentation, Nick read the White Paper for everyone. I think that's very valuable, thank you.

And Bas, you'll give presentations to a fire protection engineer like me was very eye-opening about the electrical side. Much better handle on testing than on the body protection side but it was a great presentation. I learned a lot from it.

So, yesterday, like I said, it was a lot of information that we were exchanging. Day 2 on this workshop, we really want a lot of your participation and we want to have a lot of good active discussion today.

And again, it's forming how this project moves forward. We've got a good mix of people in here with utilities, the test labs. We got the NIST folks, FM, NFPA, some of the regulators. So I really want a good discussion.

Last evening when we were looking at this after the meeting, Nick, Gabe and I were kind of going over it. And we looked at the agenda, and what we thought for today, to make it a little productive and maybe a little quicker, was to flip the agenda around.

So if you look at your agenda, what we would like to do this morning is for the NRC request for test parameters, ranges and equipment selection, we'd like to start with that.

And I think with a lot of that discussion we can actually answer some of the questions and things that we got on the test parameter. So, again, that's where we'd like to start, for the people on the webinar, so that they know where we're at.

So with that, I'm going to turn it over to Gabe, Nick and Kenn Miller and we'll get the discussion going. So, Gabe, you got it?

MR. TAYLOR: So, just a couple of

administrative things before I get started is, again, we have the court reporter transcribing the meeting so we would like you to use the microphone so that both he can capture as well as the sure phone. With the speaker right there we can pick up the audiences communications a lot better for those on the webinar. So please use the phone, introduce yourself.

That's the microphone. And on this one you got to get pretty close, so you don't have to kiss it but almost. So, I'll just leave this back here in the back corner.

It's off. You have to hold those two buttons down, it will do a countdown, three, two, one and then it will go on. So it's off right now, you're not being recorded.

PARTICIPANT: Not hot mic you're saying?

MR. TAYLOR: No hot mic, just this one.

(Laughter)

MR. TAYLOR: Okay. So, as Mark said, we want to get into the test parameters. And really that's one thing we got feedback from Phase I, is a lot of people thought that we should be doing different things than what we did.

Part of that was, part of the real reasons of what we did was because of what international group wanted to. Given the importance of the aluminum impact, we need to have a little more control on what we're doing here on Phase II.

So we felt it was important to understand the parameters that we can change when we test. We get feedback from the audience on what those ranges for parameters should be, as well as the types of equipment that we should be testing.

So the test plan, as Nick mentioned yesterday, went out for public comment last year. And we have those comments. And we've resolved most of those comments, however, there are a few that we're looking for feedback. So he'll cover that this afternoon.

My point is that the test plan is still flexible, so it's not final. There is a lot of time for changes before we actually go to the testing.

So hopefully we get valuable feedback and make the changes and do the testing that we need to address the problem.

MR. MELLY: And again, we are doing this one with the OECD. And I believe we have ten-member countries who are going to be joining on.

So next week I will be also sharing a lot of the insights from this meeting with the international members to try and come to a resolution of the parameters, what we're going to be testing at, voltage current, duration, things like that.

MR. TAYLOR: And the NRC is the biggest player in this program so we have the biggest weight of directing the program where it needs to go. Obviously, if the country donates equipment or money, they're going to have some say.

But if we can influence them with a good background or a technical explanation of why it should be covered a certain way, I feel that that should make it easy on Nick when he goes and tries to negotiate the test plan and agreement on the international folks.

Next slide. So, what we really want to get out of this presentation, I kind of already went over it, but feedback, lots of discussions, all right. I'm not up here presenting like yesterday. We went probably over 200 slides yesterday giving you a lot of information.

Today we want to focus the discussion but really hear from the audience and get feedback to do what we need to do, as I mentioned earlier.

Understand the range of operating conditions. You know, all plants are very, aren't the same. There's a lot of variations out there.

So understanding the different parameters and configurations and the importance. So we'll look for feedback on that aspect.

And then also, getting into the equipment that we'll be testing. As I mentioned, there is likely going to be some equipment donation from the international participants, however, it's not going to be as extensive as it was in Phase I.

Right now we're looking at two countries that are going to donate equipment because they could not donate monetary funds to the program. So, all the other equipment we'll have to go out and procure.

So we're kind of working off a blank slate. We're looking for feedback from the audience on what equipment is typical, what aspects of the equipment are important for procurement.

Next slide. A few weeks ago we put out this document. And the real intent and purpose of the needs and objective of the document was to a very simplistic high level, identify what the hazard is.

You know, in general, common terms. As well as the second part of the document, identify parameters that we'd be interested in trying to understand the range for current, voltages, durations, that sort of thing.

So, really, the whole purpose of getting that document out there was to get the audience to look at it, look at their plants, help understand the range of equipment variations and bring that information here so we can have a thorough discussion on understanding those variations.

Okay, so if we look at the hazard, and I took this from a presentation that's referenced there, but it provides a general description of the arc events and the different types of effluence that comes out of it.

So, the things that we're interested in is obviously the thermal effects. So that's going to radiate energy out and potentially damage equipment from the thermal aspects.

Also, this says copper vapor but obviously aluminum vapor is the same issue. The conductor vapor that can go out much farther than the thermal aspects, as far as the damaging concern.

So the vapor that gets expelled from these events is going to be important to understand, both how far it can go out and the nature of that vapor. Can it cause damage or shorting to other electrical equipment that could cause functional failures and then impact the ability to shut down the plant or control the plant.

Also, another thermal aspect is the molten metal that gets expelled from the event. So you melt the aluminum, you melt the copper, it gets thrown out, how far does it go. That's basically another ignition source besides just the thermal energy from the arc.

As Nick showed you yesterday from the Turkey Point and the other events, pressure can also have an effect on the plant. Breaking down barriers, opening doors.

So, that defeats certain fire protective barriers. So understanding that is also an important aspect. And I think there's been a lot of work done in that area, but also something that we're interested in.

And similar to the molten metal but also somewhat different, the shrapnel. So non-melted material that gets ejected from the event and could cause physical damage to equipment in the surrounding area.

So, the goals of the program, we talked yesterday when I was going through the different matters, really we have a bounding method that's in

6850 and we wanted to see if we can refine that. Whether it's for aluminum or copper or anything else, we want to see if we can make it more realistic, more representative for the plants.

And then also, if we modify that base model, can we then take that model and modify it for aluminum, the effecting impacts of aluminum.

So that's really what we want to get out of this overall program. And the objectives that we need to complete to reach that goal are kind of listed here.

Some of these we won't be talking about today, but a lot of them we will. So the first bullet is really the important thing, understanding the test conditions, or making realistic test conditions based on plant configurations.

So understanding the electrical distribution. And we have Kenn Miller up here who is the electrical to help us along with that discussion.

And also understanding operating experience. A great operating experience in, because it provides valuable information. Specifically, when we talk about the duration aspects of some of these events.

We're going to go through some of the

parameters that we can change. And the way that we're going to go through it, is I'm basically going to take one parameter, provide some background information and have discussion. And we'll go through that, through the different parameters.

And at the end, because the parameters kind of play on one another, we had a general discussion of all the parameters we support. But again, it's a free for all, if you have questions just ask them as they come up.

On the collection and measurement, and also the developing application and measurement devices, we're not going to get into too much information on there.

If there are questions related to that, please bring them up. But we've been working on developing measurement devices, heat flux gauges and whatnot for quite some time.

There was Sandia report that got put out in 2014. I know the Japanese have been working on measurement devices and Tony Putorti and Scott from NIST have been working on that.

So I think we have what we need from that, but if you want to have some discussion, obviously we can it's just not going to be a focus of the lead presentation.

And then the last part, some more later on, AMIs and the data and using that to improve the models and revising the models, which are outside of the actual testing program but it's an important piece to consider how we're going to use the data.

Next slide. So, here's some of the test parameters that I've identified for discussion today. So the important ones are duration, voltage and current.

And as we talked about yesterday, voltage is not necessarily the system voltage that we're going to be concerned about but the arcing voltage. And we look at that, get into other things like bus bar spacing and closure configuration, the impact, the actual arc voltage.

Grounding configurations and X over R ratios are also going to be important to understand for the types of available fault current that you can have in the system, as well as your DC time constant for the ACs asymmetric portion of the current profile.

And one thing I want to talk a little bit about also is the arc initiation phase, phase angle. So when you initiate the arc, again, on a asymmetric aspect of the current profile, it may have some impacts on the pressure from these events to run the testing.

And then the last one I want to talk about is arc location. For testing realistic equipment, where should we initiate that arc.

So, should it be back in the bus bar section, should it be up by the breaker slabs or somewhere in between. And that's something where we need some, a lot of the discussion because when we get into the measurement aspect, we want to make sure that we can capture the energy coming out of the equipment. And we're going to be limited by the number of instruments that we can put out.

So we can't like have a slab power all over, we have to kind of position them where we think the arc is going to come out of the cabinet. So knowing the equipment and how the magnetics effect arc, travel and movement and then being able to position equipment where we can measure those, those energies, is going to be important. So we'll spend some time on that.

Next slide. Okay, so thermal energy. That's an important piece for the thermal aspects of the zone of influence.

If you look at the IEEE type calculations and the NFPA tables, the calculations really rely on both arc voltage, arc current, duration as well as the heat transfer coefficient as a simplified assumption, or a simplified model to characterize the energy. So, we'll start off talking about those variable first.

Next slide. And also, what I've done here is taken our test matrix. And we can come back to this slide as needed.

But this is currently how we have it broken, broken down. This is just showing the electrical enclosures with the cabinet. Experiments that we have tested.

We have two spares at the bottom which we haven't decided what to do. Those could be, possible used for pressure or they could be used for additional replicates or something else.

And we haven't decided what to do with the spare tests right now. But basically, if you look to going toward the right material, we split it up evenly between copper and aluminum.

Voltages levels. We have half of them being low voltage, 480, and the other half being medium voltage. Either 4160 or 6.9.

The 4160 are likely going to be the equipment that's donated from Korea. They've already identified what equipment, and it's right between here and the breakers. So unless they can be tested, unless the enclosure is rated for a higher voltage, it's likely that equipment will be tested at that range. And then the rest is at 6.9.

Current. This is going to be a little different from what you see in the previous test plan, and I'll get into currents in some later slides, why we've selected these, but we're looking for feedback.

15 and 25 for low voltage and 25 and 35 kA, that's thousands of amps, for medium voltage. And then the durations range from anywhere from two, four, eight seconds for the enclosures. One, three and five are actually for the bus bars.

Gaps. You can see that column is empty, so we'll have some discussion there because, from what I found, there is no standard that says this is what the gap should be for low voltage or medium voltage, it's basically up to the manufacturer to design their equipment to meet the performance requirements and various standards.

So, if there is any information to

support a specific gap, for the enclosures, we're more interested in learning that.

And then a lot of the energy, I think we want to put the energy in there before we go test them and understand what it is, but there is numerous ways to calculate that. And it's dependent on, highly dependent on what your arc voltage is. So I didn't fill that one in right now.

MR. MELLY: Question.

MR. TAYLOR: Yes.

MR. VERHOEVEN: Good morning, Bas Verhoeven from KEMA. I was just looking at this table and normally at low voltage panels the short circuit current are much, much higher.

An earlier rate of 18, 19 kiloamps, especially in the industrial area. While in the medium voltage, the currents are a little bit lower in the value that is here.

So how come you don't have higher short circuit currents at low voltage amps?

MR. TAYLOR: So, I can get into that, but if we can go forward a few slides, the current will be done.

Okay. So, back up a little bit. All right, go, okay, go forward. All right, so on 5.4, we don't have all the plants information that we need to identify what the arcing, all the fault currents are. You know, that's going to be specifically classified as a need to, system needs and whatnot.

But what we do have is some information on transformer powers, impedance to the transformer and the system voltage. So you can do an impendent bus type calculation, which is what I have done here for some of the plant.

Do you see the sample is pretty small? Only 18 for low voltage. Basically, what I did is, for plants that I could find that information, I took one or two buses and ran that calculation. And then this is just a composite.

So, with a low sample number, I wouldn't say this is highly representative but it's the best that I can do to come up with kind of understanding where the fault currents are.

So what, on the low voltage side what this is showing is just a histogram of, the blue would be your voltage fault current and then the orange would be your arcing fault current, based on the calculation IEEE 1584.

So based on the orange arcing fault current, we picked basically a mean value of the

14.5. So that's where we got 15, and then 25 was somewhat higher.

Obviously, the way that I did it, I didn't include any motor contributions or anything else. And that's implicit, but it's what I had to work with.

So, you are seeing some multiple currents that are much higher. But typically, when you go from medium voltage to low voltage, at least from the plants that I saw limited by the power of those transformers being, maybe on the high end, 2 megavolt amps, ratings of those transformers.

I don't know what the experience is here but typically that's current on the higher end of those transformers.

MR. MELLY: And that's exactly the type of information that we were looking to collect is, with plant experience, what are your fault current levels for these low voltage pieces of equipment, medium voltage pieces of equipment.

MR. VERHOEVEN: Yes. Also, to give a comment. When we test the buses that we get from KEMA, and we test low voltage circuit breakers, normally the current value is, for normal circuit breaker testing, are in the values of 60 kiloamps, 18, sometimes even 100 to 30 kA for industrial circuit breakers.

And I can't imagine that this is an industrial implication.

MR. FUNK: I guess my input would be, this is probably not unrealistic. And I do agree most 480 volt systems, or even 600 volt systems, the standard rating would typically be 42 kA, 65 and 85. That would be a tide test.

But nuclear plants are a somewhat unique from a broad perspective of all industry in that they're medium voltage to low voltage step down transformers tend to be small. Typically ranging from 750 kVA to 1.5 MVA. It's pretty normal.

So, I think that maybe explains the difference that you're looking at it.

PARTICIPANT: Okay.

MR. FUNK: Which means the gear typically will be subjected to fault currents. Hopefully, considerably below their rating.

Maybe Shannon or some other utility folks can weigh in on that.

MR. TAYLOR: Yes, I can speak to --

MR. FUNK: There will of course be exceptions, but I think Gabe's approach is not unrealistic.

PARTICIPANT: Yes.

MR. FUNK: Yes, let's go over here real quick. Shannon Lovvorn from TVA.

MR. LOVVORN: Yes, Shannon Lovvorn, TVA. I would agree that the median looks about right to me. Our low voltage fault currents range around the 16,000 amps or maybe some 18 or some lower.

The switchgear is typically feed off of like a 1000 kVA transformer for us. So that's, I think for us, I think you're in the right range.

MR. MILLER: I guess the other factor that can affect that too is, I'm thinking about the plant I was at, I think our 480 volt system was solidly grounded as opposed to the 4 kV and 13 kV. So that can tend to drive the fault currents up on the lower voltages. And I can't remember what our numbers were but --

MR. LOVVORN: Yes, we're on, our 480 volts are delta ungrounded.

MR. MILLER: Ungrounded, okay.

MR. FLEISCHER: Ken Fleischer from EPRI. So, since I anticipated a workshop, I brought several nuclear utility diagrams and I've already spot check, I've seen 750 kVA up to about 1.5 MPA. We can --

MR. MILLER: For transformer size?

MR. FLEISCHER: For transformers for a 4 kVA to a 480.

MR. MILLER: Yes.

MR. FLEISCHER: I can continue to look at them and we can maybe adjust those number ranges but that seems to be right spot on with what Dan Funk was just saying.

But, I did bring drawings so that we can, if we need to fact check something that may be available on a one line, just let me know and I can do that here.

MR. TAYLOR: Okay, thank you. While we're here, let's just go to the next slide to show the medium voltage.

And I did it for 4160 because if you look at the times, I mean, that's about 85 percent, somewhere around there, have 40, or excuse me, 4160 volt gear. And maybe about only a third of the plants have 6.9 kV here.

So 4160 is much more common in plants for medium voltage on distribution. So I put it up that way just to see if there's any difference between the two.

Again, the sample size is not that great but similar to what I did for the low voltage. And just a histogram showing voltage fault and arcing fault.

One thing that is different here is that you saw a much bigger shift from voltage to arcing fault in the low voltage. And that's primarily contributed to the IEEE method.

There is a calculation for low voltage and a calculation for medium voltage. And that approach is based on a statistical analysis, or a regression analysis, of the data that they had to develop those models.

So, because this is a histogram, you're still getting a reduction from your voltage to your arcing fault, but it's not enough, at least for this case, to make it drop bins. And my bins are 10,000 amp width for the bins.

So you can see I didn't put the mean and median for the voltage and the arcing fault. And you see the arcing fault currents does reduce but not by as much as you saw in the low voltage.

The low voltage is almost half of the, the arcing fault current was almost one half of the voltage fault current.

So, again, not that many samples. I took one, maybe two buses, two buses. And I took two if I saw a difference in the power rating of the different transformers, whether it was a startup or a rad or whatever the transformer was.

Typically there wasn't too much difference. So in those cases I only take one sample. But that's for the 4160.

Next slide. This is for 6.9 kV. So again, slightly higher but not by really that much. Right around 30 kA on the mean. And there is some change here, just it jumped in when you went from voltage to arcing.

So, when we looked at what we wanted to test for this, 25 and 35 is what we picked. We wanted 25 to be, we wanted one point on the medium voltage to be in line with one point on the low voltage side.

So 25 is the common voltage between the two, or common term, sorry, 25 kA current between the two. And then we picked one higher, which is 35 in this case.

Again, this doesn't take into account motor contributions but, again, it is a non-conservative assumption but then, again, it doesn't take into your opinions on your source. Which is the opposite.

So, another factor of the real system response, somewhat undetermined. It really depends on what motors you have running, what your system in HEAF test for your power source.

Where is the handheld? Sorry about that.

But with the information that I had available, this is at least one way we can get a basis or at least a discussion here and get feedback from that.

So I know it looks like Kenn is looking through some diagrams, if you guys want to look around while I kind of go back and talk about that, at least you know now where we're coming from on the current problem.

So if there's not any questions, I'm going to go back to where I left off. We'll hit this again.

(Off microphone comment)

MR. TAYLOR: Nick, can you go back?

MR. MELLY: Back to --

MR. TAYLOR: Wherever I left off. I guess the HEAF plan --

MR. MELLY: Here, yes.

MR. TAYLOR: Yes. So again, 1525 low

voltage, 2535 for medium voltage. And then the durations, we need to spend some time talking about this. Some of the limits are based on what available energies from KEMA and other ones are based on OpE for these types of events.

Obviously, if the breakers work that's a sign your talking cycles and not seconds. And if they worked on designed you wouldn't have the HEAF.

And there's also been a lot of research done from NFPA and IEEE and others, on the shorter end. So it's another reason why we're focused on the longer durations. We have slides on that as well.

One thing before we go, EPRI's report on review, the testing in the OpE, as well as the other report on the mean, it did identify that there is not that many events in low voltage, and right now we have it split 50/50 between medium and low voltage.

So I think one thing that's up for discussion is, should we reduce the focus on low voltage and still run some test on low voltage but expand the number of tests that we do at medium voltage since it seems, from the information that we've been reviewing that there is more medium voltage type events occurring in the plant that have a safety significance, or a potential safety significance.

So, I want to just think about it right now, but I want to come back to that because, as I said, this is fluid, we can make changes now. But once we get an agreement signed with the international group, we're then limited to what we can change.

Because the test plan actually goes into the agreement and it gets signed. And to make changes to that, from then you have to get all the countries agreement.

MR. MELLY: Seventy-five percent of the project group.

MR. TAYLOR: Okay. You got to get 75 percent of the project group to agree to that change.

So, right now the majority of the testing is in that project. There are some, actually, Nick, can you go to the website? Pull up the website with your test plan.

MR. MELLY: Which website do we have it on?

MR. TAYLOR: Just go to, it's already pulled up unless you closed it.

MR. MELLY: Here we go.

MR. TAYLOR: So, the test matrix that I

showed, it just takes Nick's test plan and puts it in this form. But you can see the blue and the orange, the blue cases are what's going to be sponsored with the international group, and the orange cases are the ones that the NRC are going to have to fill in on their own. Just from a financial standpoint.

We couldn't get enough interests for contributions for an international group to cover everything. And because, as Nick mentioned yesterday, aluminum is more of a U.S. interest than most international countries, they elected not to focus on aluminum as much.

So, I guess, just for your awareness, that's where this came from. And we do have a little more flexibility on some of the tests. You can go back.

MR. DALEY: Hey, Gabe?

MR. TAYLOR: Yes.

MR. DALEY: I just got to ask a question, maybe it's premature, but where are you seeing the aluminum? Where are we seeing that?

Are we seeing it in both 480 and 4160 or are we seeing it primarily in one application as opposed to another and are we seeing it in newer plants via older plants?

And the reason I'm asking is, because the separation issues that older plants are much different than newer plants, so I'm really kind of curious what you want to look at, from both an aluminum and a copper.

MR. MELLY: So I can take a shot at answering that. Based on the NEI survey, we can't tell whether it is in older plants or newer plants because the plants were anonymous. Just numbered as they were given to us.

MR. DALEY: Okay.

MR. MELLY: However, in terms of the pieces of equipment that we've seen in them, it's all over the board. I was expecting to see it more in the low voltage equipment based on the OpE that we've seen, however, it was in many pieces of medium voltage equipment.

And in many plants, it's used primarily as the enclosure material for the bus ducts throughout the entire plant.

So, from the NEI server that we did receive, we saw more aluminum than we expected. However, only 52 plants were involved in that survey.

MR. MILLER: Did they break it down like aluminum used as bus work versus just enclosures or

--

MR. MELLY: Yes, they did. For, in terms of the bus ducts that they used, they gave us whether it was the conductor material within the bus duct or the housing.

In terms of the electrical cabinets, if aluminum was involved in any piece with the closure, conduct or for the cradle units themselves, that was also included.

But in terms of vintage of plant, we don't have that information. No.

MR. DALEY: Yes. I'm just trying to think, I'm really getting ahead of ourselves, but I'm trying to think, where is this going to go, right, and the effects on different plants when you got certain plants that have separation for all the 4160, really good separation.

Some plants have minimal, you will have 40, you might have 4160 switchgears separated by rooms by you might have some of the other division kind of roaming through that. And then there is some of them where you got 4160 that are in the same room and you're separated by distance, right?

MR. MELLY: Yes.

MR. DALEY: So you're really dealing with three different factions there. So, in the 4160, I mean, to me it's just a clearly, from a fault perspective in how the fault is going to affect things, it seems to be the, it seems to be more important.

And the other thing, now this conductive property, the conductive vapor in that, that would probably just be talked a little bit more about because that could affect everything.

MR. MELLY: And, Bob, I think we may be giving you a call when we start the pilot plant discussion for the selection of plants when we get to that stage, because these are the exact things that may come up in that discussion of how we select which plants we're going to try to evaluate the risk impact of this, where is this going.

MR. DALEY: Covering a broad spectrum of types.

MR. MELLY: Yes.

MR. TAYLOR: While I have it up here, also on the bus duct testing, the majority of it is aluminum. So you can see the NRC is picking up a lot of that cost. So feedback on that has been very important for us to make sure that we get the right bus ducts configuration and whatnot.

And so we have, Slide 8 will into this, but right now, for your awareness is, we're breaking it down by bus material and by enclosure material. So copper bus fuel enclosure, copper bus aluminum enclosure, aluminum bus steel enclosure and then aluminum bus and aluminum enclosure.

So, I think we feel that those are up in the plans, but obviously if there's one of those cases isn't it, we would want to test it. So feedback when we get to those slides, on that aspect and the importance of the testing matrix.

Can you go to Slide 10? So, what I just showed turned into a table form. We had a couple spares that we could do. You know, possibly do a longer duration. Again, it's flexible.

But everything at 4160, no changes in the current. So that could be something that we could change, we could use multiple currents. And it's just a variation of bus and duct material.

Again, gap spacing, I don't have any of that information. So I'm not sure there are standards out there that says it should be five, 17 years apart, whatever it is. So feedback on that.

Design specs. Again, it's solely representative of --

MR. MELLY: And the one thing that we also need to discuss when we're talking about the bus ducts, is whether the conductive material is insulated or not insulated. That can have effect on where they place the arc and how we place the arc.

Because we are dealing with a limited segment of bus ducts that we can put in the test enclosure itself, we need to be able to determine how to hold the arc in place. If it has the insulated material on the conductors themselves, we've seen in testing that has been done for the Cooper event that we can hold the arc in place.

However, if there is no conductive, there's no insulation material, we may be just creating a rail gun and having all of the energy go out directly one end of the arc travel down towards the end of the bus.

So that's why the test plan currently had a hard break in the conductive material to try and hold the arc in place. However, we'd like to know whether your plants have the insulated material on the outside, inside the plant and kind of get a feel for how that is across the fleet.

MR. TAYLOR: And no bus bars have been procured yet so we're open on what the configuration is. Question from Mark Salley?

MR. SALLEY: Yes. This is a good place as any to jump in here, but going back to this original testing we did with the internationals and the GENESIS on how this all came together, we knew one of the biggest expenses was going to be procure nuclear grade equipment to basically destroy it in the testing.

And when we had the original agreement with the countries, the concept that we went in with was, hey, find a plant in your country where they're putting in some new switchgear, they're upgrading, updating something, get that old equipment. It's going to be scrapped anyhow, so let us use it for the testing and that will be a whole cost saver.

So that's why you saw a lot of that equipment in there, for example, Korea were the first ones that were on it, and those original cabinets we did were from Korea.

Again, Gabe and I through Zion Solutions were able to procure the duct that was tested, the bus duct from Zion.

But when I, I guess the plea or the question I'm throwing out here is, we have some plants that will be going into decommissioning, and as you guys are doing upgrades to the plant, we'd be open to say equipment donations that you could or if you'd want to put into this program. So, again, keep that in, we can work through EPRI, and equipment that you would maybe be doing an upgrade, would be scrapped out, could be used or for plant safety commission, we'd welcome that equipment.

MR. TAYLOR: Thanks, Mark.

MR. SHUDAK: Tom Shudak with NPPD. So the comment I keep hearing coming up is, what we have as our plan configuration, will it be one that has insulated aluminum buses.

So, we really don't know what's out there. We have an anonymous survey out there. You keep bringing up the point, we need to know that information, not all plants are represented here in this room.

Is there another effort to gather that information from industry to make sure we get the testing right, as far as that configuration?

MR. TAYLOR: I will let Mark Salley answer that question.

MR. SALLEY: You know, as far as going through that information, we've kind of backed off there. And we would look to NEI, as we did with the original one. Or to EPRI or EPRI and NEI together working in that.

So, again, that's where we would look for that to come from.

MR. TAYLOR: And not that it's that important, but process wise, what process these could be used to get that information. And really, I don't think where we're suited by, I'm not sure that we get the support to go out and issue a 50, for a type letter or a temporary TI for the inspectors to go out and look for it.

So we're really trying to leverage EPRI or NEI to help us understand what's out there.

MR. SALLEY: And again, that's the purpose of today's meeting and having your attendance here, is to learn what's out there and what we should be testing. So, again, that's a big part of today.

We've done similar things with cables. If you remember years ago, looking at cables, what was the typical thermoset cable out there. We did the biggest bang for the industry, our data, and it was raw asbestos fire wall III. I think that was in like 80 percent of the plants.

So, again, those were the things we learned so that our research is applicable. So, again, that's a key point of you all being here at this meeting here today is to help us guide how we do this testing.

MR. TAYLOR: And I guess the other option would have been a bulletin but, you know, those are, take at least a year. And then trying to keep this within the GI program being timely response is also something that we're trying to work with.

Question in the back with TVA.

MS. WETZEL: So when do you anticipate the agreement to be signed and the test to be locked in where we can't provide input?

MR. MELLY: The agreement right now is currently held up with lawyers. There is some viability issues in signing with that many countries and the NRC internal ability to accept testing, liability and indemnification clauses within an agreement.

We were hoping to have the agreement fully signed in hand towards the end of summer. August time period. That is when the test plan will be included on it.

Small changes can be made but they will need to be discussed with the entire group. And small changes I consider to be, if we decide to put insulation on the bus bar materials.

After, if we receive more information, we would have a meeting with the international members. And it's a very collaborative working group that we have established for this testing program.

We usually do not run into any controversial issues where we can't breach consensus agreement. So I don't see it as a huge stopping point to make changes as we move forward.

Like we say, I mean, testing, we have the spares in there because we're bound to have other cases where we just see something we do not expect. So, I don't think it's going to be a hard stop.

That said, we still are under an agreement. But the end of August is what we're shooting for to have the agreements signed by the member countries.

MR. TAYLOR: Okay, thanks, Nick. Can we go to the next slide then.

Okay, so for the first parameter, one of the most important, in my mind, well, arc holders is very important too, but one of the also more difficult ones to predict from the HEAF standpoint, is the arc duration.

So, one thing that we wanted to

understand was, your clearing times for your protection systems. And if you look at the needs and objectives document that went out, we tried to break that down to understand what was more current for a typical case and then when you're needing a breaker or your protective equipment fails to clear on the first clearance protector, device point.

Such that the fault would travel upstream and then you have a second protective device to clear and what the clearing times for that are. For both voltage fault as well as arcing type conditions. So that's one aspect of the duration that we're interested in.

The other aspect that might have more weight is actually the operating experience that we've seen. The IN has information on the aluminum events. And I think there has been presentations that have discussed the duration of other events in the duration.

So, because those are really, those types of events are really what the frequency is being contributed to for the Bin 16 type events, we're looking into a lot more on that.

But we wanted to understand if the systems worked as designed, what are those starting times for voltage and arcing fault currents.

So next slide. Just to reinstate what we're planning on right now, and this is flexible, low voltage four and eight seconds, medium voltage two and four seconds. We can go longer on the low voltage because of the system, the energy that we have at KEMA.

And then the bus bar is one, three, four, potentially up to five seconds at medium voltage. But most of the majority is medium voltage bus bar. Testing right now is one to three seconds in duration.

So, some information --

MR. MILLER: We have a question.

MR. LEJA: Thank you. So, one thing that comes to my mind is, if you go back a slide, for the 480 volts, or low voltage switchgear, we're saying four and eight seconds. And I can't think of where the eight seconds come from.

The only incident that comes to my mind is Fort Calhoun. And that situation you had a bad design, so misaligned status.

And also, you had zone select interface jumpers that were not being disabled. So you lost all protection in the incident.

Other than that, I've never seen a coordination diagram where you would actually have eight seconds before the second level protection would pick it up. So maybe two, three seconds, maybe even four seconds at some plants. I haven't seen it.

But eight seconds seems very excessive. And I don't think anybody really supports it. So for the realism scenario that we try and represent, I really don't think it's representative.

And in any statistical analysis, when you have an event like Fort Calhoun where it's so off the wall, you know, everything else is four to eight seconds, maybe 12 seconds and you have an event that's 42 seconds, you were to remove it because it's anomaly, right?

So I'm thinking, if we're trying to be real and trying to really represent what's out there, I don't think there's anything there that supports eight seconds. And that's just my opinion but I don't know how anybody else feels about it. Thank you.

MR. FUNK: Yes, along that similar that Gabe gave, we've talked about this, and Nick and I too, that for a properly designing system, we really wouldn't anticipate exceeding the two second range even with your backup protection under most conditions. But again it is, as he just mentioned, statistically based because there is no way to know exactly what the fault current is.

And so, coordination folks work under the concept of a range of available currents. You get your voltage for your theoretical max all the way down to an overload condition and we're just not good enough to predict exactly what's going to happen for every scenario.

So, what strikes me with the testing that's been done so far is it's performed on a basis that your primary and secondary protection will either fail the function properly or were improperly designed to begin with, based on normal considerations.

Is there any value in performing some tests that, number one, is through primary protection work property or the primary protection failed and the secondary protection was relied upon?

In other words, you would limit the duration approximately two seconds. I mean, you could work a range on that but that kind of concept.

Or is there, the problem with that is, well, you don't get necessarily great results as far as maximum information gained on equipment suffering catastrophic failure, I agree with that. And with limited equipment, you want to maximize that.

I think that my concern, to sum it up is, every test we've run and projection for future testing is we assume loss of both primary and secondary protection, which has happened. I'm not going to say it hasn't, but it's just the unusual case versus the normal case.

MR. TAYLOR: Kenn had a question --

MR. MELLY: Before we get there I wanted to touch on the eight seconds question. We do have international experience where we do have one low voltage event that occurred in Germany that lasted the 8.5 seconds.

We do understand that these are anomaly events but the frequency is fairly low on these events, which brings you into the model. We're looking for more information on that event in particular.

And we do know that the low voltage events, we've been discussing it is, they are rare because you have to defeat so many levels of protection to get one of these long events. So we see that in the frequency in that when we had done the split for the low voltage versus medium voltage equipment, you see more of these higher arcing faults in the medium voltage because you don't have to fail these many levels of protection.

One of the reasons for testing at the eight second range for the low voltage equipment, is because it does give us the larger energy profile. We've seen in the operating history for Robinson, for instance, we have had the ten second to 11 second range of duration for that medium voltage case.

And we cannot replicate that at the KEMA facility. We're limited by the duration that we can go for medium voltage 3.5, four seconds, kind of stretching our generator there.

So there were several reasons why we went to eight seconds, but that's why we're here today. We want to discuss the selective values and take note of, we do understand that eight seconds may be fairly excessive for the low voltage cases, however, we have seen these off the wall events in operating history.

MR. DALEY: Do you want me to, I'm going to put on my regulatory hat here to respond to, Dan. I think you're right, Dan, I think we have to, yes, you have to be realistic with it.

I just look at this whole encompassing

thing and I see where the major effects on it. You know, we go back to one of the first slide presentations we had and it talked about fire protection and it talked about single failure, right?

Okay, but you're talking, when you talk about those two things you're talking two different events, right? Fire protection you don't assume that something is just going to fail.

So, I think the idea that doing a realistic, some type of realistic arcing failure for fire events seems to make a lot of sense, because in the end, I think that's where it will be from a regulatory perspective.

Now, the single failure, you assume a single failure so having something, having a fault, this type of fault with a breaker, or at the breaker, is kind of, it's kind of an all-encompassing event so then you get into the situation, okay, I can go this long with it and how does that effect other divisions, right, if there --

And like I said, I'll go back to what I was saying earlier, you're dealing with a lot of older plants in that regard because, later vintage plants. I'm a BWR guy so I think BWR-5, BWR-6 just ain't, you're not going to get there.

So, that's kind of my thought. So, I agree with you, Dan, I think you should have a lot more realistic ones but you should probably put some bigger ones in there too.

And for the conductive stuff, for when we actually get to the point where we do the conductive cloud, the cloud of death --

(Laughter)

MR. DALEY: -- then we probably need some longer durations in there.

MR. SALLEY: Yes, Dan, and if I could just put one thing up, we have the fire forum last week where I gave a presentation on this and a couple guys grabbed me afterwards and said, hey, could you just bring one thing up in the meeting, and I said sure.

And one of the things they told me, or they thought was a vulnerability to look at, is when they're switching over to standby generators, that that would be a time when we could see these longer durations. They just asked that I bring that up, so.

Again, I don't know if it is or not, but that was something I thought about.

MR. FLEISCHER: Ken Fleischer with EPRI. So, there is a technical explanation, theoretically, as to how you can get to eight seconds and beyond.

It's governed in more of our White Papers, and none of the OE, there is not sufficient data in the OE to confirm any of these events occurred.

But, with the available fault current in a three-phased voltage fault with protection being an instantaneous element and an overload element, you should trip instantaneously.

Now, if you get to the point with an arcing fault and the current is below the instantaneous setting, now the instantaneous setting cannot see that so a couple things can happen. Now you have to start writing up the time curve until you hit your inverse, overload element.

Which could take anywhere from one second up to 15 minutes, depending on where you arrive that curve. Similarly, even if that breaker failed, your next upstream breaker, that current, again, cannot be seen by the short-term instantaneous, or short-time delay or short-time delay element, again, waiting for a thermal element to pick it up.

And so that's why I can see these occur. However, the OE just doesn't have the sufficient data to confirm it so that's why these were that long.

But I do still support that we should really scrub our OE, understand the best we can and develop realistic tests.

MR. LEJA: So, just a response to that. It is true that it could take from one to 15 seconds depending on where you are in the thermal region.

But, again, for sake of realism, I looked at coordination plots with the fault currents that they're simulating and I couldn't get there. I couldn't get to four seconds. I'm saying, yes, you could get from one to 15 seconds.

So yes, you could get there in one to 15 seconds, however, the fault currents that we're simulating is just not realistic. So, again, it's the realism scenario, you know.

MR. FLEISCHER: Yes, and I agree.

MR. LEJA: And another thing about Fort Calhoun is, if we take that into consideration and say, you know, this piece of equipment was mis-designed and this install and we're testing it because it could happen, then what's stopping us from taking the protection in the turbine and having the turbine explode and say, hey, this could happen as well. So I don't want to go that far.

I think we will get a lot more out of it if we had it at two and four seconds. The reason I am saying two seconds is because that's kind of what the gear is rated for so I think we'll get agreement and people will be very interested in those results.

And also, also because if you look at relay coordination, I was actually looking at that last night as well, could we get there, could, because normally when we do relay coordination you just want to, you just want to have things coordinated, you don't really worry about this arc fault arc kind of stuff.

But if I was worried about it and somebody gave me a project and told me to redo the relay so that we do get down to some reasonable amount of separation.

So let's say we want to get down to those two seconds, we could get there. If you're talking about higher than that, I mean, get down to like three seconds I mean, I don't know if it's going to happen, so, I think we could get down to two seconds and that's why I think it would make more sense to do it at two and four seconds versus four and eight.

Because I'm having issues articulating myself but maybe I'll get better. Thank you.

MR. TAYLOR: Any other comments to our

conversation, but do we have a response or --

MR. MELLY: It was a suggestion we go to two to four because the currents that would be associated with having a fault that sticks in for that longer duration, 15 seconds, are not the fault currents that we are proposing for our test program, they're the ones that are riding more like the Fort Calhoun and the 5 kA range.

MR. TAYLOR: Okay. So basically from your coordination curves you looked at, for these durations, this is what the fault current would have to be to get that duration. Is that kind of summarizing what I missed?

MR. MELLY: At the fault current that you are receiving you wouldn't --

MR. LEJA: The duration would be much shorter and much less.

MR. TAYLOR: It would be much less of course. Which would be much less than four seconds. Which is not realistic compared to what, I don't know.

MR. FUNK: Yes, I would agree with that but I do, the equipment, I think there is some force to suggest that testing between one and two seconds also has value, which would assume loss of your primary trip function which, in a lot of cases would be differential trips which are measured in a few cycles and they're reliant on maybe a less sensitive or a current relay back for something along those lines.

So I think that adds to this realism that I know that I have been looking for. One to two second range I think stays within the rating of the equipment and it provides maybe a realistic data point.

These other cases we're talking about are the created events. So, not to belabor the point, but I think there is value in seeing what we would expect to happen. What's more closer to the median than the extremes. Thanks.

MR. MELLY: I think the, well, the reason that the one to two seconds were even lower, the .5 seconds that's recommended in the guide or the metal clad switchgear.

And the reason that's not showing up in the current test program is because those events are not what I would consider to be part of this higher in the arc fault damage zone bin.

MR. FUNK: Okay.

MR. MELLY: These are the ones that are

going to go into Bin 15, where you just have the internal cabinet damage creating an internal fire rather than breaching the cabinet and have externals under the influence of damage.

MR. FUNK: They won't be a HEAF.

MR. MELLY: They won't be considered a HEAF and that's not going, that's what I do not intend to be in the HEAF frequency bin.

So that's more in line with what happened at Turkey Point where you have the 32 second, or 32 cycle event, .5 second event.

Also, the Cooper event was right on the threshold. That was a one second event. And these are the events that they're questionable, they're not HEAF events because you do have damage but you don't have the type of damage that we're looking to get towards modeling.

If I had endless amounts of resources, I would love to put in the one to two second range so we have those events as well.

However, we're talking about the destruction of a piece of equipment, extreme refurbishment, a full day in the test lab and the full apparatus of test equipment and measurement. Which is why we were focusing more to get what we see in line with the Bin 16 bin.

MR. LEJA: And I agree with that. I agree .1 second, .5 second testing would be a waste of your money. IEEE C37.20 says, .1 seconds to one second.

MR. MELLY: Yes.

MR. LEJA: But I still find value in two seconds.

MR. MELLY: Right.

MR. LEJA: Because I haven't really seen much tests at two seconds, because that's what we expect gear to be rated for. So that's why I see value in that.

MR. FUNK: I understand, Nick. And, again, I understand the tradeoff of "a waste of test" because you don't expect to see the substantial results.

Be aware though that that's out of line with the frequency calculations right now. That's the misalignment I see.

Because they're all included. Even those events that would now be your, a Category 1 or even a Cat 2 that you've defined in this meeting.

So we would need, or my recommendation then is, okay, kind of a new baseline we're working from here so let's go re-scrub the events and get the frequencies that are in alignment the way we're defining this testing.

MR. MELLY: That's exactly what we plan on doing with the collaborative work with EPRI on the HEAF program.

MR. TAYLOR: Yes. That's one of the reasons why we're working tightly with NFPA and everyone here to try and come up with the definitions because, you know, I think five, six years ago there was talks about, well, let's define a MEF and let's define a LEF. Or a low and a medium and then high.

So trying to take a definition that, with the categories that we've proposed right now, you know, Cat 1, well, that wouldn't be included in the HEAF. It may not even be included in 15.

Cat 2, maybe it's 15, maybe it's somewhere else. And a Cat 3, really what we're interested in here is the high energy arc fault type bin.

So, trying to work with, to formalize those and then, as the comment was, tie it into frequency, make sure everything is consistent in the PRA model.

Okay, so what I hear, two to four seconds seems, was one proposal out there. Is there any other feedback on the duration from the group? Okay.

MR. PLETZ: Hi, Rod Pletz from American Electric Power.

I don't have a good electrical background, my background is classical fire protection. And what I'm used to seeing is during a typical fire curve you'll get to a peak HEAF release rate and that will be sustained at some point and then it will drop off.

When we're looking at the duration of these HEAFs, is there a point where we're going to see that energy level peak out and then the duration of this event we're just going to see more product thrown against the wall, basically, and should we limit our duration to when we're going to hit that peak energy release rate?

MR. TAYLOR: Okay, so I'll go ahead and try and take a stab at that response. Yes, I think for most of the testing that we've done, and what we see, it's pretty constant, the energy release rate.

The one caveat being the aluminum. If you look at the test, was 23 the finish equipment?

MR. MELLY: Yes.

MR. TAYLOR: If you look at Test 23 and

you look at the timeline, you had the initiation of the arc up to about, right around one second. And the energy seemed to be pretty constant through there.

And then right around one second you had a large increase of what's going to be expelled and the energy that's coming out of that event.

We haven't got down to what caused that, was it because you got up to a certain temperature, did something change internally in the cabinet that caused that additional energy release. But that is one case, that I'm at least aware of, where the energy wasn't constant and you had a change during the event.

I don't know if, Nick, had anything else on that.

MR. MELLY: In terms of the energy release electrically, if you want to talk about the transformer breakdown where right now at KEMA we have the energy to look at the current constant throughout the event. Whereas in the plant you have the degree --

MR. TAYLOR: If you're cutting from a generator?

MR. MELLY: Yes.

MR. TAYLOR: Okay. So I guess the point that Nick brings up, if you look on your medium voltage bores and you're being feed from a generator during unit aux, typically if you don't clear that fault, as the EPRI document, you can back feed from the generator into the fault and the generator will wind down.

Versus how we test the KEMA where we basically have a constant current for the entire duration that we need. So you don't have the decay of the current.

I don't know if KEMA has anything else on their setup. Or Tony.

MR. MILLER: Yes, question.

MR. PUTORTI: Yes, the other change that we saw during the experiments, as far as the ZOI and the threat to surrounding equipment was, if you went long enough to breach the exterior of the switchgear then there was a change in what we would see as the threat to the surrounding equipment. So that would be one point in time where there was a change.

MR. VERHOEVEN: Bas Verhoeven from KEMA Laboratories. With regards to the current that we make during the test, we normally arrange our systems in such a way that we have a super expectation on the short circuit generator. That means it will not, it will maintain the steady state current.

In normal power networks, they say the feeding power is sufficient to have a constant short circuit current. That's why we can make it.

If you would like to see decaying current to reasons, just ask because we can do it. We can set the machines in such a way with the citation that the current can decay.

And also, the voltage level, let's say that is for the ignition of the arc after has occurred. And also, the current value. That's all part of means we can handle. So don't be too limited in your design of what you would like to see tested, we can make quite a bit. In terms of current values, the supporting voltage and the expectation occurs.

And also the borings where we switch on, in design way with regards to the DC offset. So don't bother too much with our capabilities, we can adapt according to your needs. So let that be your primary goal.

MR. FLEISCHER: Ken Fleischer from EPRI. Then I would like to emphasize that that's something we consider, and I can see Gabe putting it on the board.

Because the difference between an infinite bus feeding a fault and a decaying voltage from a generator where its exciter switchgear breaker has been open is a tremendous difference. Yes, the arc is sustained, yes, damage is occurring, but I anticipate that the actual energy, totally energy at the end of the extinguishment of the arc, will be significantly different and the damage should be different.

So, that's a capability that we should consider.

MR. TAYLOR: Okay, I think, as far as the NRC world, we're open to making those changes but again, to make a realistic from representative.

However, the question is, okay, how should we set it up, how should we have the equipment be, setup to model the plants.

MR. MELLY: And that will go in for medium voltage rate.

MR. TAYLOR: For that case, yes.

MR. FLEISCHER: Yes, it would be for medium voltage, you wouldn't see it at the 480.

To emphasize, think about this. Ashley has talked to me a little bit about this for some other aspects of the testing, but remember, the gear that you probably are going to get is going to have multiple cubicles.

And as I've seen in the other tests that I have reviewed, the entire switchgear is not entirely damaged, there are other cubicles that can be used. So one of the options would be, is to do a decay test and set that configuration up for a decay test and then setup an undamaged cubicle for the more infinite bus test.

So that might be how you can arrange your test configurations on one piece of switchgear with multiple cabinets, as long as they're not destroyed for one of the tests.

MR. MELLY: Yes. And in the first series of tests that we did we did try to utilize as many cubicles as possible during the test phase.

So for instance, we had cabinets donated from Japan which had multiple cubicle units. And we essentially worked backwards through that cubicle doing, I believe four tests per cubicle trying to maximize the testing within the same compartment, varying the parameters.

So we are looking to potentially do that. It really comes down to what equipment we buy, how much it needs to be refurbished and how quickly we can accomplish that.

MR. TAYLOR: Yes, and the other thing that the German regulator is interested in is prorogations to adjacent cabinets. So if we do get damage, we're limited to use of that second cabinet.

I think it's a valuable comment of comparison. So that's something that we should consider.

MR. MELLY: That also brings into question, so, one of the goals for this test program is to really limit variable so that we can have a consistent data collection process.

So by changing the cubicles, we need to change the arrangement of the instrumentation. And that brings into play trying to predict where the affluent is going to release from the cabinet. Which in testing is difficult.

MR. LOVVORN: Shannon Lovvorn, TVA. I guess somewhat of I hear in the feedback is, we're talking about a lot of different permutations here of, some of us are wanting to take a realistic case and then I think the NRC is somewhat interested in the failure case where the device does work as expected.

Even in Kenn's definitions of a HEAF

yesterday was suggesting that there is an adequate design or some sort of failure that contributes to the event.

And so, I guess I'm okay with understanding that phenomenon and how much damage that can be, but we also need to be looking at, there is a lower probability of that and putting a probability number on to that kind of failure, if we're going to take that larger damage.

So, I guess, that's why the duration discussion seemed pretty difficult because we all kind of had a different mindset of what's realistic and what we're trying to accomplish. I think there is different permutations of what you can consider.

One is that your system acts as design. I mean, I shouldn't have a HEAF really but if there is some sort of failure then hopefully there is some sort of probability that we can put on to that.

Because, the presentations last week in the fire forum, we all know that fire risk is dominating the risk picture. And part of that is because of over conservatism in the, what I'll call the immaturity of these models. So, we just need to be thinking about that.

MR. MELLY: So I'm going to, let me grab

that one real quick is that right now we currently, this ties in with the definitions, the frequency in all these pieces.

As the current Bin 16 frequency, or where we want it to go, I believe that every one of these events here, where you see these longer duration HEAFs, the ones where we would consider these damaging events with the zone of influence, every single one of these did have a protection level breakdown allowing it to occur.

So that reliability of the component, the failure of the component, will inherently be captured by the frequency of the events that we use for the input to the model. And that's currently the way that we're trying to handle it rather than going the approach of putting the reliability number somewhere within the equation itself.

MR. TAYLOR: I think that's a good comment and breakers and tracking devices are highly reliable. And so we were thinking along the same lines but then to get that conditional probability of becoming a HEAF becomes typical.

So I think what Nick said, it seems reasonable that if we can have a good definition of what these events are we can develop a frequency from the fire events to characterize the frequency and then the data from this just characterize the hazard that we have kind of continuity.

MR. MELLY: And from the OpE I think I only, I can only off the top of my head remember one single event in an ISO phase where there wasn't levels of breakdown where there still was huge damage states. But primarily, every single case that we've seen in the HEAF bin did have failures of protective levels.

MR. MILLER: And we did want to have an understanding of the extent of damage when we do have a HEAF like that.

MR. MELLY: Yes.

MR. MILLER: And we know there's been failures and it's a lower probability, right.

MR. MELLY: Yes.

MR. MILLER: So part of this is understanding that sort of influence of that high energy event rate.

MR. MELLY: Yes.

MR. VERHOEVEN: Bas Verhoeven from KEMA. The topic that has not been mentioned so far, at least not to my knowledge is, is that if you have an arc in a cabinet, and let's say the cabinet remains closed and it stays within that box, at some point of time it will burst somewhat out. The doors will open or it burns through the cycles. That means that the arc and the flash will go into different segments.

Is there thoughts being discussed of having the cubicle also inside the space, the volume, that is mimicking the, let's say the control room of the switchgear or is that just an open space where basically the fumes can go out because it will be a secondary buildup of pressure if that's a confined area?

MR. MILLER: Like with the one event where the fire door, the fire barrier door was breached, I guess that's what you're referring to?

MR. VERHOEVEN: Yes.

MR. MELLY: So we haven't discussed that right now because that is one of the goals is to understand the pressure.

So, the current test plan has us measuring the pressure of just the internal enclosure itself. And we have been discussing ways to try and extrapolate what the room pressure increase would be from that pressure reading. We don't have a good handle on whether that's going to be possible or not.

During the discussions we have had with

KEMA, as well as in the PIRT, there was the possibility of creating a mock room around the electrical enclosure and measuring the pressure rise of that room so that we can extent it to plant specific room designs so you know your, what the pressure rise in that room would be so it can challenge fire doors.

Another challenge there is fire doors typically aren't pressure rated, so making that connection is another effort. It's something that we are considering putting in limited number of tests so we can get a room pressure rise increase. Again, that's going to be up for discussion within the next weeks.

MR. TAYLOR: Yes, I think it comes down to the balance point of what's worth the cost on the effort on the NRC side versus how big of an impact it makes on the safety side.

MR. MELLY: Right.

MR. TAYLOR: So we haven't come up with a decision. We have been thinking about, I know Steve Turner has some information he shared and is available, and the literature on different ways that they tried to model pressures. So there might be some analytical approaches to model it but I'm not sure of how much are those, approaches are.

Do you want to add anything?

MR. TURNER: They are hard to do. At the minimum, it's very cheap to do. At least stick one microphone out at 15 feet and one microphone out at 20 feet and you get data, the acoustics are all terribly off, but you get some idea if you can see that in some results from a February 2017 test that we did. We got that data.

MR. MELLY: Yes.

MR. TURNER: So, just those microphones are cheap.

MR. MELLY: And we're also similarly starting that from scratch on the pressure measurements because during our first attempt, in the first test series when we measured the pressure, we had a lot of interference, electrically, to our measurement devices, so we weren't really relying or we can't rely on the pressure measurements from our first series to try and extrapolate.

And that's why in the OECD report you see that we've reported the pressure on the same graphic that we did for the electrical energy. And you see a direct comparison, or spikes in the pressure readouts, both on, the power turns on and when it turns off.

Which we would not expect when we turn it off. That huge jump and spike that we were getting in the pressure readings if it was just based on the pressure itself.

So we were getting interference. And a lot of that actually has been reduced from testing that we've seen from Steve and the Japanese.

KEMA, in their facility, had moved from a fiber optic measurement device which has given much cleaner results. And I think that it's true pressure reading that they received in their later testing.

So, that's one thing to keep in mind if you have reviewed the pressure that we have collected from the first series.

MR. TAYLOR: So, from what I hear, I think getting back on topic, we're talking about duration right now. I heard a proposal to change low voltage to the four seconds. I didn't, does that seem reasonable for the group? So I think that's one change we should make.

The other thing is, I didn't get much traction on the proposal to try to do the lower duration event, to have a second or whatnot. Is there any more discussion we wanted to have on that aspect?

MR. FLEISCHER: For the low gear?

MR. TAYLOR: Yes. For the low voltage. Or even medium voltage.

MR. FLEISCHER: I have some input on that. In a way, this is still on topic but bear with me.

One of the comments that I was, had offered up, and I think it's in the EPRI comment is that, probably the first thing we should do before we take off with all this testing, right, is to demonstrate that the gear that we're going to use, we understand its capability and its ratings and that we go ahead and take on the compartments which should not damage anything else and you shouldn't worry about, propagation of the arc outside its cubicle is to do a full standard C37.27.7 test.

The right size arc wire, the duration of only half a second protective device being used to limit the fault and all that and do a standard test in conformance with that IEEE standard, and then just say this gear has been certified suitable for use for this exploratory type testing. And so therefore that's my traction for the .56 seconds.

Yes, I do believe we should do it, but it would be part of the certification that the switchgear is healthy to continue with the testing.

MR. MELLY: I'll take that one. We may be able to do that for the low voltage cases.

For the medium voltage cases, we will not be able to do that because of the current contract that we have with KEMA, that will be essentially doubling every medium voltage test that we have. Which is expensive.

So based on our current restrictions and budget that we have moving forward, I don't know if we have the money to do a full another 16 or 32 tests.

MR. FLEISCHER: We're going to have that many switchgear components? I was think of certifying one as one design.

MR. MELLY: Yes. We may be able to do it if we buy one standard design for the other tests. For the donated pieces of equipment, I do not know if we can do one for them.

MR. TAYLOR: Yes, so donated equipment, we don't know exactly what we're getting from Germany, but from Korea we're getting 5 kV Magna-Blast with the protocol track and breakers and gear.

MR. MELLY: Also, I don't think, for the, are you discussing the metal clad switchgear standard with the, where we're not going to be ejecting the hot gas out the front with the cotton waste stabs and things like that?

MR. FLEISCHER: I'm trying to digest the question. I'm just thinking of the IEEE C37.20.7 test for metal class switchgear. Yes, it would be the medium rolls.

MR. MELLY: That's the guide on arc resistance?

MR. FLEISCHER: That's the guide on the arc resistance certification.

MR. MILLER: Yes, with the cotton.

MR. FLEISCHER: Yes, those are cotton targets, I do remember that.

MR. MILLER: That's right.

MR. MELLY: And if it failed that test, what would we consider?

MR. FLEISCHER: Well, that would be bad now wouldn't it.

MR. MILLER: What's the purpose of that though? We're basically confirming that the equipment was built to the original, per that --

MR. FLEISCHER: Right.

MR. MILLER: -- out there.

MR. FLEISCHER: And so, as we learned from Bas yesterday, only 25 percent of those, if you don't test them, you don't know. It might not work.

What's the purpose of the test? The purpose of the test is to demonstrate to us, and our stakeholders and the utilities, this test going forward is using gear that was sufficiently designed and rated, and verified rated, to be able to, for the test going forward.

MR. MILLER: But wouldn't that apply to ever piece of gear that we are, going to do the test? Do we need to do that for all?

MR. FLEISCHER: No, I don't know if we need to do it for all of them, but I do understand now the challenge. If we have different pieces of gear and it's a mixed bag, I understand the complexity and the cost impact.

I guess I was a little more idealistic that we would procure, until today I didn't know, but when I was thinking these comments through, I figured we were going to design and procure maybe a GE Magna-Blast switchgear breakers for all of the medium voltage tests. And you would just take one of those switchgear and verify that it was arc resistant for the IEEE standard.

MR. MELLY: But I'm also more worried that if I did that, let's say I reached out and I said, this is the most common piece of equipment that is in 20 plants and I'm going to go do the test. And then I run the certification at KEMA and I come back, this is not, it didn't pass the test. Is there implication for those 25?

MR. FLEISCHER: Well, that's a good push back.

(Laughter)

MR. FLEISCHER: The thing is though, is that then we'd have to look to see if it's a production issue versus a design.

MR. MELLY: It could open a can of worms though if we --

MR. FLEISCHER: It would.

(Off microphone comment)

MR. MILLER: Can I speak? But that's not the purpose of this testing either, we're not trying to certify the equipment that's built per the IEEE C37 standard, meets the standard, we're looking at stuff beyond that.

MR. FLEISCHER: So is --

MR. MILLER: So I'm still not seeing the purpose of what, of doing what you're saying.

Because that's not the purpose of the testing.

MR. MELLY: It's the baseline.

MR. FLEISCHER: Kenn, correct, it's not the purpose of the test. What it does is it verifies that the equipment we have chosen to do the test would have survived a standard arc fault at .5 seconds or less. That's all.

Just that the piece of equipment we've chosen is robust enough so that the results we get know that under ideal conditions of all protective device sparking, it was okay, now we're taking this beyond its rating --

MR. MILLER: So at baseline --

MR. FLEISCHER: It's a baseline.

MR. MILLER: -- this test.

MR. MELLY: Do the plants have that certification right now certification right now on pieces of equipment that are installed?

MR. FLEISCHER: I don't know. I don't think they all have it.

MR. MILLER: Well --

MR. FLEISCHER: It's a guide, right? IEEEs are a guide, so this is voluntary.

MR. MILLER: Kenn, I mean, when plants by equipment per a spec, they get a certain indication that it meets the requirements of the spec. well, it is.

I mean, that's the whole purpose of buying something per our spec. You get a certificate of performance.

MR. CIELO: Yes, you might get a certificate of conformance or you might get a COC. You're not going to get what Bas was describing yesterday.

Which is a certification from an independent test lab that it met 100 percent of the requirements of whatever the standard is. Which is a full type test, which is an independent test.

Which means that the manufacturer submits that piece of equipment, in our case, to our test lab. Our test engineer and our test team verify the device to the drawings.

They actually do a physical verification against the drawings and then they run it 100 percent to the requirements of the standard without any input from the manufacturer. It's to the standard.

We pick the circuits, we pick, you know, in accordance with the standard, all the voltages, the amperages, all those test parameters, every piece of equipment that we use in our test labs is verifiable backed NIST, in the U.S. anyway, because of our ISO 170.25 certification.

So we can vouch for every piece of equipment that we use to measure all of the, the results basically. And so when it passes 100 percent in accordance with the standard, then a lab like KEMA Laboratories would issue a certificate. But that's not necessarily what you're getting when you get a COC.

MR. FLEISCHER: On the interest of time I was going to try and get it back to Gabe here. So my thoughts are, why don't we just put it as a parking lot, a breakout session if you will, as a consideration.

And if it's viable or there is a way to make it work, that would be great. But it's essentially, it's a baseline.

The other thing to your question, I now know what you're asking. When you do a purchase spec for a piece of switchgear, you're going to put in the design standards.

MR. MILLER: Yes.

MR. FLEISCHER: Right.

MR. MILLER: This is all the standards that they're testing against.

MR. FLEISCHER: Right. But you may not --

MR. MILLER: They're putting, GE is going to say this breaker will meet those requirements.

MR. FLEISCHER: Right. But you may not put this testing standard in. In other words, you're only going to get what you put in your specification.

So I think the answer to your question is, probably a lot of the early nuke designs probably weren't aware of this testing and probably didn't have this done. So their certification search is to a design standard as opposed to a testing guide.

MR. MILLER: Yes. So, to me, I would attribute this to an assumption on our part with the beginning of the testing. Otherwise we're talking about a lot more testing and scope increase of what we're doing.

MR. FLEISCHER: Yes, okay.

MR. DALEY: I got this microphone about 20 minutes ago so this will probably sound like a non sequitur at this time.

I just got to keep on going back. I see this, we got to know what the end of this is and what, keep the end in mind of what we're looking at and look at it in terms of, I'm just thinking right now. I'm thinking your design basis event and then your external events.

So you got your design basis single failure type thing which has specific events, specific portions of this could potentially affect that. And then you got your 805 portion which is a totally different animal.

You're dealing with probabilities. I mean, some of the same things in deterministic, and the Appendix R plants are going to be similar but you're dealing with probabilities too so you're looking at that.

And then you got the deterministic plants, the Appendix R plants, which would be some of the things that you're looking at in 805 as a subset of that.

And then the last thing, and I haven't given a lot of thought to this is, is you got the seismic type event where you got, where you would almost half to be dealing with a non-1E bus that's in proximity to your Class 1E buses. Which is not that, that's not that uncommon particularly with older plants.

So, anyway, I just think you got to have the end in mind.

MR. CHEOK: So, this is Mike Cheok. A quick comment. And you know I am always interested in everything I just heard.

So the beauty of risk analysis is you do couple all the consequences with the frequency. So when you do PRAs you have large, medium and small LOCAs. Loss of coolant accidents.

And each one of these things come with a frequency. And for the large LOCA you have a much smaller frequency.

Enough even for a loss of offsite power so you have different durations, how long you lose your offsite power. And obviously, the longer you lose offsite power the smaller the frequency.

And you know, the other extreme is seismic PRAs. You know, you do the different hazard curves, you have the smaller earthquakes all the way to the large earthquakes and obviously the frequency curves would be, you have a lot smaller frequencies for the large earthquakes.

So I think the discussion here is a very good discussion and the results, I think one thing we have to be very careful about is when we're discussing tests and results and when we have the results that we want to display, let's say for a four second duration or even a eight second duration, we always have to couple that with a frequency. We cannot just go out and tell people the zone of influence is X without saying this was a very infrequent event that is coupled with several different failures and probably with a frequency of ten to the minus eight or whatever.

So I think we all have to keep the consequences on the damage states where the frequencies in our test and in our communications of results and things like that.

MR. SALLEY: It's a good point, and I'll give it back to Gabe, but you say, Bob, with the earthquakes. Look how we do earthquakes, right.

We have our design basis earthquake, which is what we expect to see in the plant, and we do that and then we have our safe shutdown earthquake. If you want to draw a parallel to this with the short durations, what we expect to see with the equipment and when it does work, that safe shutdown earthquake is what the HEAF is.

So, again, going back to the definitions I think is going to be key. Here you go, Gabe.

MR. TAYLOR: I think this is a great discussion, exactly what we want.

MR. MELLY: Yes.

MR. TAYLOR: So, next slide.

MR. TURNER: I got one more comment on the --

MR. TAYLOR: Steve Turner.

MR. TURNER: As far as talking about half second duration and one second duration, I think one of the things we're missing in this presentation is we look at our Phase I test, there is a huge data bank of half second tests out there that's in the IEEE and FDRA flash tests.

There have been hundreds and hundreds of tests at half a second and one second. The weakness it has is it barely touched on them. But I would recommend that you guys go back and grab the IEEE papers and write that up in some way to convince these people that at least it will cover half a second and one second is kind of covered and we're just going to focus on this new bin for the really bad stuff.

And as far as going back and doing the test and saying, look, it passed, my view on those tests have always been, and you saw it in his video yesterday, the first one of those I ever saw that passed I said, geez, if that's a success I'd hate to see a failure. Because it still looks pretty dramatic.

Those flames can still come out and stuff can still get lost. And so, it's just not a very appealing thing to say, look, this passed the test.

And the other thing is, the thought may be that if you do that easy test first you can do a test in it again, you probably can't. It's going to damage it enough, you won't hit it again.

MR. MELLY: And again, one of the videos we saw yesterday was a pass of the test because it didn't come out the front facing where the personnel would be, which is how that test is designed. However, for our zone of influence, I'm still worried about the back and the top and where the cables are.

So, running that standard test, if it's to a cabinet design to have a detachment plate or something along those lines, I'm still going to be worried about my cables, my other equipment and things like that.

While I do still care about personnel, it's generally not in the PRA calculation.

MR. TAYLOR: Okay, the next slide. And I think I've gone through this enough but the longer versions ties into our energy and the thermal aspects of that.

Obviously, that type of modeling is going to be different from expelling the molten materials, the shrapnel, the pressure, things we also need to consider.

But I think that's what a large scale testing, how good we can capture that through document it via video as well, on thing I didn't mention yesterday is, in the first series of tests we're going to bring up Sandia's, the plan is to bring out Sandia's video equipment and they can actually track particles and run them into their computer and they can get you miles per hour, where it's going, what it's bouncing off of. So we want to give that a shot and see if that works. That might help us on a non-thermal aspect.

Again, to characterize better the ZOI.

MR. MELLY: I think we've covered this part.

(Laughter)

MR. TAYLOR: Yes, we've heard a lot of discussion, maybe I should have showed this on the second slide.

(Laughter)

MR. TAYLOR: But if there is anything

else, we want to talk about duration right now, please, please do bring it up. If not, we will go on to the next topic. Unless we need a break.

MR. SALLEY: Yes, why don't we take a break, Gabe, 15 minutes. Okay.

MR. TAYLOR: All right. So, let me just check the webinar real quick before we break. And it shows no questions coming in.

MR. SALLEY: Any more out here?

MR. TAYLOR: It doesn't look like we have any questions on the webinar, so let's go ahead and take a break for 15 minutes and we'll come back at --

MR. SALLEY: 10:30.

MR. TAYLOR: -- 10:30. So almost a 20 minute break. 10:30 we'll be back.

(Whereupon, the above-entitled matter went off the record at 10:11 a.m. and resumed at 10:32 a.m.)

MR. SALLEY: All right. How do we turn this on? Okay, so we will pick it back up and, again, thank you, this is kind of what we envisioned, organized chaos.

I mean the discussion is great, you know, we want this input. Also we're reaching out to our folks on the webinar, you know, you all are part of this, too, so we got young Tom there on it, so please feel free to type any of your questions in and bring it in, so we want the people on the webinar to be a part of this process, too.

So with that, Gabe, let's go until 12 o'clock.

MR. TAYLOR: All right.

MR. SALLEY: At 12 o'clock we'll take lunch because the discussion is going to be a good break point and we'll pick it back up.

MR. TAYLOR: Okay. So the next parameter is voltage. Obviously, we are looking at low voltage as 480, the most common in U.S. plants although there is some 600s out there.

And then medium voltage, 6.9 is a lot more common in European plants, so, you know, there is a big push from the group to go at 6.9. Also, some of the later U.S. plants were putting in 6.9 safety buses, but there is a lot of variation.

6.9, as I mentioned earlier, about half of the plants in the U.S. have it, right around a half. 4160 is much more common in U.S. plants.

So if the plant is medium voltage, 6.9, they test it at that, however, if donated equipment doesn't go there we'll go to 4160, but, again, it's another topic for discussion.

If we want to do something 4160 or some other 7.2, 12, 13kV, that is up for discussion, but that would be something that Nick would have to take back and negotiate with the international, so just a little background on where we are with that.

I have some slides that might help the discussion along, so we can go to the next slide. So we talked about this a little bit yesterday, but what I did is I went back to the Phase I that the NRC ran, those test results, and the orange is the system voltage, so it was either 480 that we ran for the low voltage or, it's a little hard to see, but we ran 6.9, 7.2, one 4160, and then two 10kV tests in Phase I.

So the orange is showing the system voltage and the blue is showing the arcing voltage, so the voltage collapse during the arc, and you can see, although we have some variation between 4160 and the 6 or 7, 6.9 or 7kV, and even 10, the arc voltage doesn't change too much, too dramatically.

And some of the reasons behind that could be the bus bar spacing has an impact on what the arc voltage is. So just to make that clear, when you are looking at energies it's not the system voltage that you're concerned with it's the arc voltage that goes into the energy calculation.

Next slide. So just another way to look at this. What I am comparing is in the blue is our arc voltage and the orange is basically the distance between our buses in the gear.

So based on that trying to see if it tracked, and in general it tracks, but, again, there is some variation that doesn't align with, you know, a correlation on just distance between the buses.

Next slide. So there are some methods out there to predict what your arc voltage is based on your spacing. So this method here, without getting into too much detail, comes from the CIGRE document.

And basically based on your spacing it predicts a voltage per unit distance, or voltage in this case, kilovolts per centimeter. So the gray is basically that model and the orange is our medium voltage test and the blue is our low voltage test.

So if you look at the medium, you know, the medium, the general tendencies that the model tracks and however there is some spread for, more so for low voltage than medium voltage, and on the medium voltage side it tends to over predict the arc voltage compared to what we are seeing in the testing.

Next slide. This is showing the same information but now instead of distance, what I showed in two slides back, I am showing what the CIGRE document would calculate as your arc voltage, comparing it to blue, which is what we actually measure the arc voltage.

And so it is an important parameter, but just because you have a certain systems voltage doesn't mean you are going to get a certain arc voltage.

I think distance does have impact, but there is some scatter there. So being able to predict that is a complication that we are going to run into.

Next slide. Okay, so that's really what I had on voltage for background discussion. So as far as our testing, you know, I want to hear, get some feedback on, you know, is 480 reasonable, and then the approach for 6.9kV for the medium voltage gear.

Are there other aspects of the testing, the system lineup, the power supply that we are using at KEMA that comes in and impact the arc voltage.

So I want to go ahead and open it up to the room if there is any feedback on the voltage for the test.

MR. FUNK: Gabe, yesterday you and I briefly discussed, you know, fully being able to characterize the supply system. Can we get the characteristics for the KEMA generators so we can actually do a model with those, an impedance model, and that way we can predict voltages, the degradation in voltages with the new software that's out there? It's pretty easy to do.

So if that is available it would be of interest I think for some of us to get access to that, maybe just build it into the test plan.

MR. CIELO: Yes, this is Frank. When you say "characteristics," I mean it's not just a generator, it's everything in between, too, right? I mean because we can --

MR. FUNK: Yes, absolutely.

MR. CIELO: And that would be for the entire lab? I mean I am not sure what you are asking.

MR. FUNK: Not really. You know, in the electrical world when we model this we model the generation or the source and that's usually done with the transient and the sub-transient reactants, cable length, and standard distances between the phases.

It's not very difficult to do. So you black box it and you should be able to characterize it for us. You need the transformation.

MR. VERHOEVEN: Bas Verhoeven from KEMA. It will be very difficult because our generators are not normal generators.

MR. FUNK: That's why I am asking, I understand that.

MR. VERHOEVEN: And like I said earlier that we have a way with our excitation to counteract. But I don't really see the point of adding that into a model because most of the times the network is a very strong source with a certain impedance, of course, and that is basically the reference that you can calculate and that we make sure that our generators will mimic exactly that part, that's why we have that excitation.

The only part is when you were referring to that you have let's say being fed by the generator itself, that then drops down the frequency. That's something different. But for average short circuit calculations the system voltage are basically the impedance, in that case, the maximum short circuit value, and that's what we can adapt for strong networks, low networks, with very high DC offset or small DC offset.

MR. FUNK: Yes, I partially agree with you but maybe not completely. When we do a model you have a starting point, be it an infinite bus or a generator, once again the model of the generator, those standard parameters you would use, and I understand that your generator is different, so doing so in a conventional manner is maybe not as realistic.

But as a starting point the black box needs to be the voltage or typically an MVA available from the system and an X to R ratio which when married up within the in-house part of the configuration cables, et cetera, which we should be able to characterize, that's what gets you the, as Gabe had on his screen, the voltage, the X to R ratios, and the current.

And with those three parameters then you can move forward with an electrical analysis, so characterizing that shouldn't be completely impossible.

I mean if you are going to offset it with your equipment then you know what you are offsetting.

So, again, to do a short circuit model, to look at all the different quantities that are of interest, being able to characterize the generation source I feel is important.

It's not absolutely critical, but it would sure help when we went to pair up past events with test results as we try to define what categories things are in and using a predicted model, the software out there, eCAP, EasyPower, there's a million of them, they all work the same way and they are all sort circuit calculations conducted in accordance with IEEE.

So I guess that's where I leave this that we want to be able to replicate IEEE modeling to correlate the test results to what we have seen in our past events and without that information from the test then we cannot do that.

MR. VERHOEVEN: Yes, well maybe we have to take this offline a little bit, this discussion.

MR. TURNER: Let me try one quick one. We measured the generator voltage and then we measured the test object voltage, so we get a pretty good idea of what the I squared R losses are from the generator to the test object.

That's something, we get those white

forms to go along with things. We generally just report the test object voltage, but I think maybe with those two things you ought to be able to come up with some sort of -- it would be the black box but just based on the voltage you're dropping the I squared R losses.

We lose about 50 percent sometimes of the power just in I squared R losses from the generator out to the test object.

MALE PARTICIPANT: Would that give it to you?

MR. FUNK: No, probably not.

MALE PARTICIPANT: No?

MR. FUNK: The I squared R losses -- I understand the I squared R losses. What we are looking for is to characterize the impedance of the system because that's what drives for the medium voltage and high voltage AC systems, the entire analysis and also the functioning to some degree of the protective relays.

I agree, let's not get bogged down in some detailed discussion here, but it's something that I think we would want to pursue a little further offline. Thanks.

MR. VERHOEVEN: Like I said we can do

quite a bit with our generators in terms of settings. Basically it's the situation in your system, how it is, what is the impedance there, short circuit impedance, and the transients and sub-transients that we see, offsets and so forth.

MR. FUNK: Right.

MR. VERHOEVEN: So basically that's the value that you should use in your calculations of the short circuit in your system and those values we use to set our machines so that we mimic your situation.

So it's basically the other way around I would say. It's your system designs or dictates what is happening and in case it results in a short circuit code and duration depending on the voltage, and let's say for the test itself we set our machines in a such a way that it will represent that situation because we have impedances to that we can play around with the DC offsets.

MR. FUNK: I understand. You're saying let's reverse engineer the black box and you can do that. I think that's reasonable. I think that's reasonable. Please understand I am trying to foresee where ultimately the utilities are going to be. They are going to have to try to make their case based on your test results which aren't precisely what their system has.

So the closer we can draw that lane, the stronger argument, technical basis, they'll have for applying the results however this may work out. I hope that makes sense.

MR. TAYLOR: Okay. So on voltage 6.9kV is there any discussion or proposed changes from that approach for medium voltage?

(No response)

MR. TAYLOR: Anything from the webinar?

(No response)

MR. TAYLOR: Okay, what about 480, we're comfortable with testing at voltage? I see heads nod yes, so -- and one thumbs up, okay.

MR. MELLY: And this is one difference that we had. In the version that went out in June the medium voltage was designated as 4160 with the international interest more on 6.9.

We have moved it to that and we felt comfortable doing it because when we looked at the first series of tests between our 4160 and 6.9 the actual arc voltage did not differ very much between those two ranges.

MR. TAYLOR: Okay. So I'm not hearing anything, so we'll get to the next topic, current.

You've already -- Back up. All right, so this is our test ranges at the rate pressure 15/25 for low voltage, 25/35,000 amps for medium voltage. Go to the next slide.

MR. MELLY: Can we, just so -- We did show already we have the end values of how many plants we have collected this information from.

As we have said previously we don't have a very good avenue to go out and actually request additional information, so this is an area where we'd be looking for more information to kind of enhance our histograms and the analysis that we have here.

It would have to be done through EPRI, NEI, a voluntary, or any plant in the room, or other information to enhance our dataset to make sure these values are appropriate.

MR. TAYLOR: Yes, and on that, you know, I have one question for the utilities, I am not that familiar, although I have been at plants where I have seen the arc flash labels on the equipment saying this is the category of PP and this is the energy from this equipment.

Has the utilities gone out and done arc flash studies for their equipment that you are aware of?

MR. LOVVORN: Yes.

MR. TAYLOR: Shannon is saying yes. Anybody else? Okay, so there are some plants that have gone out there. That might be a reasonable area to look to see if you could open those analysis up and see where the currents are going out, because to do that you are going to come up with a voltage fault and you're also going to follow the IEEE, assuming you follow the IEEE guidance to do those analyses you'd have the arcing fault current.

You know, one thing that differ there though is the duration they are assuming the protection works. So that might not be as applicable, but, you know, that might be a useful source of information to help confirm or deny where we are sitting there.

And if there is even databases available for your equipment maybe that is something that may work with EPRI or NEI or whoever to at least compare with what we were working off of to make sure we are in the ballpark.

You know, we want to be, again, a realistic representative and the more information the better we can be at achieving that. So that's a request.

I don't know if there is any formal way we can follow up on it, Mark, but, you know, again, please feel free to contact myself or Nick if you do go back and look at that and say, oh, my gosh, we're 10,000 amps too high or too low or whatever.

MR. MELLY: And we can send out a meeting summary after this to the participants with almost the request action item below list and things like that. Tony has a question.

MR. PUTORTI: Since you are making that request and following on the previous discussion does it make sense to ask for a sample circuit that might be appropriate for low voltage and medium voltage and then provide that to keep the match up for the experiments?

MR. TAYLOR: So as far as the characteristics for the sample circuit --

(Simultaneous speaking)

MR. PUTORTI: Something that is representative of the plants.

MR. TAYLOR: Okay. I mean we could make that request. I think it would be worthwhile, you know, knowing there is a lot of variability.

But I think what where we are looking at and based on some of the EPRI stuff is the medium voltage boards coming right off of the step down transformer from the generator and then offset load extender right below your load extender, your regular load extender.

The other thing, too, that we haven't really got into, Mark brought it up, is your easels for the safety-related boards, you know, if there are any voting concerns there that tension could cause a longer duration type event.

Again, that's on duration, but, you know, that would be the other area where there might be some interest to get the circuit characteristics there to support this testing.

So I wouldn't -- That's I good point, I wouldn't make that offer. When we get those characteristics from the plants then we can make sure that the test generator is set up to mimic those.

MR. SALLEY: Gabe, we have a question on the webinar by the way.

MR. TAYLOR: Okay. Let's let Kenneth Fleischer from EPRI --

MR. FLEISCHER: Ken Fleischer from EPRI. This just hit me so it's more of a brainstorm comment on standby EDG. It's a worthwhile comment, but we talked about realism here and I don't think any of the OE we saw there was a diesel that was on the system and it is so infrequently on the system that I am wondering if it should just screen out from a probabilistic standpoint.

It's a thought. Keep it on the board for now, but that's just a thought I had on the standby diesel.

MR. TAYLOR: Okay, thanks. Tom, on the webinar?

MR. AIRD: This question is from David Lochbaum. The question is with NRC seeking voluntary info from industry how will the NRC ensure any info provided is representative of overall industry and not a non-representative best case?

MR. TAYLOR: So I think to respond to that we'd have to work with some of the experts at the NRC to run it by the electrical group. I am not, I wouldn't consider myself to be one of those experts.

But we're working with either in research with Kenn's group or even out in the regions with the inspectors that have the background and have the experience to confirm the information that we are receiving would be probably the most reasonable approach to addressing that concern.

I don't know if Mark or Nick has anything else that --

(Simultaneous speaking)

MR. MILLER: Now I would assume if we're going like through NEI and EPRI they would be doing that for us, too, right? I mean they would filtering, or checking data for us, also.

MR. SALLEY: Yes, I think you covered it. And, Shannon, I was just thinking of Kent Bryan at TVA when he would solve these types of problems the word he would also use was garden variety and I think that's kind of what we are looking for is that, you know, middle of the road garden variety thing.

Again, I'll fall back to request this Firewall III cable. We knew from all the questions we asked when we looked at that when we were testing that cable that was getting pretty much 80 percent of the plans for the thermoset.

So, again, we'd be looking for that same type of input and, again, the steel line, would be that garden variety circuit that we have been looking for.

MR. MELLY: Yes, and to reiterate what Mark said is that we will be getting that garden variety but that's also why we are testing at the current ranges that we have selected so that there is the potential when the model does come out it will have this, the dynamic zone of influence where you can use what's applicable to your plant-specific lineup with the research that we are conducting so that you can create a plant-specific modeling state.

We can't cover it all in our test program, that's why we would like to be right in the middle of the road with a range so that it can be applicable generically.

MR. TAYLOR: Okay, so good feedback on that. Thanks for the question. We can go to the next couple of slides. I have already gone over how I develop these and what we are basing it off of, but, again, any additional information to help support that by all means please provide that to me and Nick.

And, you know, we'd probably have to have a discussion whether we can have a follow-on go-to meeting or a webinar just to when we receive that information and further discussions moving forward to kind of remain the collaborative environment and to make sure that we are understand the information that we are getting and that we are using it appropriately to modify the test plan moving forward.

So that's just a thought that came into my mind. I don't know if the group thinks that this reasonable to have a call in the future, but I think it would help us out.

Next slide. Okay, so let's go back one. Any additional discussion on fault currents, where we are currently at in the information we have at hand, so it's 15K and 25K for low voltage, 25 and 35 for medium. Anything to add from the audience here?

MR. MELLY: Is there anything on the webinar?

MR. TAYLOR: Okay.

MR. MELLY: Okay.

MR. TAYLOR: So that's what we'll go with for the time being until we have any information to go otherwise. So the next question is on the system connections and to the generator they can configure and either be Y or delta connected.

Most of the testing that we did in Phase I was delta. However, there can be wye connections made at KEMA, so as far as the plants and the uses here, you know, which one do you think, or what combination of the two do you think would be appropriate, and that's something that we haven't specified yet in our test plan.

Obviously, there is a lot of transformers that are delta, wye, primary, secondary, vice versa, so looking at where the faults are is there any opinion on one over the other, one configuration over the other?

MR. MELLY: And just as a note from the testing in Phase I, the ground it seemed to use was primarily related to the test, the limited test we did in wye connection was because we were testing at a high voltage for a long duration and the generator and the setpoints we were looking for were more easily obtained using the wye configuration.

MR. LOVVORN: If I can just say that, you know, for those that are frustrated that the Y would be representative of the medium voltage connection and the delta would be representative of a low voltage connection.

So if I was going to pick for my plant I'd say wye on the medium and delta on the low, but I don't know if that's representative of the industry.

MR. MILLER: Another plant I was at it was wye for both.

MR. FLEISCHER: Kenn Fleischer from EPRI. I can go back through my drawings, but if I recall at medium voltage there is both, there is a lot of combinations of delta and wye.

So to get down into low voltage I see a more commonly grounded wye. There are a few systems, I know of one plant that is delta, and there is I think maybe a few others, but I would think that unless we can assure ourselves that there is no difference in the arc performance or damage between a wye and a delta I think we should test both configurations, particularly at the medium voltage level.

The low voltage level, unless I find a greater preponderance of delta systems in the U.S. nuclear power plants maybe we can just limit it to a grounded wye, and when I say "grounded" that may also have some impedance.

MR. MELLY: And one thing to note is that when we did have the, hold the PIRT this was one of the lower importance rankings to the eventual damage states.

We didn't see it as being a very high factor in any of the tests that we ran as the eventual damage state, so it is a lower ranking for the PIRT and I think on what I am hearing is I think we agree that it's going to be a lower importance in here.

MR. MILLER: It's more about the amount of all current.

MR. TAYLOR: Yes. So just to reiterate I think maybe that might be a secondary or even tertiary parameter and to make sure that the KEMA equipment can be set up to achieve our durations and our currents and then see, you know, whether we can support wye or delta for those.

And if we can't get a combination of both, we should attempt to do it to provide the comparison, but, again, it's not a, from what I am hearing it's not a primary important parameter.

MR. CIELO: Yes, this is Frank from KEMA. Yes, once you decide on what you want to do then it's a matter of, then we'll take that and we'll see how we need to configure the lab to be able to do that and we'll tell you if we can or cannot achieve it and then you'll be able to judge from there.

MR. MELLY: Yes.

MR. TAYLOR: Okay. So we can go to the next slide then I think. So moving on for the wye connections and grounding, what I saw was just the reactive or ungrounded, you know, what's the preference, and maybe I'll start out with KEMA, you know, what's your capabilities for grounding the system, the power generation system?

MR. CIELO: I would want to have some of our facility people be able to answer that question, but, again, I think also I'll just reiterate what I just said.

I think the way we work is you will come to us and say this is what we are trying to accomplish, this is what we need to do. We'll work with you with given the limitations of our equipment and the lab and so forth and we'll tell you what we can and cannot do.

So there is so many different possibilities here, so many different configurations that we could use, and, you know, at this point we don't see any limit.

The biggest thing that we are worried about is the thermal effect on our generators because we're not going to put that, you know, mocking up the test cell is one thing --

MR. MELLY: Yes.

MR. CIELO: -- doing anything to our generators is a completely different story. That's a completely different story.

MR. MELLY: Yes.

MR. TAYLOR: Okay. So from the audience I think we have a comment in the back. That would be Robert Rhodes from Duke.

MR. RHODES: Yes, this is Robert Rhodes from Duke, or Bob. Harris has, and I'm a Harris person so I am plant person, not a testing person or a theoretical person, we've got wye and it's high resistance grounding which limits your fault current.

We had the high energy fault on the ISO phase and the output was just exactly what was expected by or explained by KEMA. It went out, we had faults on the ISO phase, it blew the main transformer, it fed back because it's a high resistance ground with a grounding transformer, did the same thing on that grounding transformer and blew that out.

The bus stayed intact except for the piece that got ripped down through the neutral grounding transformer because the vehicle or the enclosure got destroyed.

So that resistance -- And I believe there is a lot of resist of grounding schemes in the industry that would tend to limit your ground fault and change your whole characteristic on a solidly grounded system and your results are going to be all different.

And I would warn the testing people because when they did this on our ISO phase it fed back into the generator and we blew out our hydrogen seal, so I would be very concerned about your equipment because I don't want to damage your equipment.

It didn't hurt us very long but we had to replace our hydrogen seals, but there you are.

MR. LEJA: While the microphone is here. I can't speak for the entire fleet, but for the sites I am comfortable with or know well, usually on a medium voltage you always have a grounding transformer or a resistive, a ground resistor, on the low voltage it would usually just be solid ground.

But I have seen that throughout, not just Exelon.

MR. DALEY: Yes, I was just going to say that I think Duke, the Duke plants are a little different. I agree, they do have a high resistor and I think that will affect how these events carry on.

But I don't know that that's very -- I mean for the plants that I have seen it is not clear to me that that's the trend in the industry.

I think you see some type of resistive

grounding or you see some solid grounding out there, I think that's more prevalent than a high resistance ground like you guys have, but that's just from the plants that I have seen.

MR. FLEISCHER: Ken Fleischer from EPRI. Yes, there's going to be all kinds of grounding schemes, but also HEAFs can also be initiated phase to phase which then takes that out of the picture.

So I'll see if I can do a little bit of work and maybe kind of get a representative of what I am seeing through the various U.S. nuclear power plants trying to bin that up for info, but, again, I think that if we look at a HEAF from phase to phase the grounding schemes will take us, that will not be too much of a big factor.

MR. MELLY: And we are initiating phase to phase in every case.

MR. FLEISCHER: Right.

MR. RHODES: One more comment. This is, again, Bob Rhodes from Duke. One other thing I have noticed through the years is when you see the high energy arc faults the arc faults tend to find or seek out the weak points in the system and the weak points in the system may be the bus bars but more likely they are transformers, bolted connections, things like that that go and the test seems to be ignoring all of that.

So I would at least look at that impact and see how you see it, because if you look at the Robinson fault it was the cable over the bus that was completely destroyed and the conduit that was steel, you just had a gap in the conduit, it's not there anymore.

So the weak point, wherever that point is, not necessarily a bus bar being the weak point.

MR. TAYLOR: Anyone have anything on the transformers?

MR. MELLY: Transformers were Mark's planned phase --

(Simultaneous speaking)

MR. TAYLOR: Yes, I think right now we've kind of excluded that from the scope of this work. I think internationals, Germany, in particular, is interested in that.

MR. MELLY: Yes, there has been several discussions of testing transformers at the higher voltages. It's a little bit outside of our scope right now, we're just trying to limit it to what was currently, what we saw as more dominant risk from the OpE that we have looked at, it being the bus, or the electrical enclosures themselves as the initiating points.

MR. TAYLOR: Okay, so go ahead and --

MR. AIRD: Gabe, there is another question from the webinar.

MR. TAYLOR: Sure.

MR. AIRD: This one is from Preston Cooper. He says from the original arc flash 1584 equations the grounding is basically broken into effectively and non-effectively grounded systems.

Are we wanting a more detailed view to the effects of grounding?

MR. TAYLOR: I'm not sure if we have come to a decision on that. I kind of threw it out there to add the, you know, realism to the event, but, again, I think it comes down to realism from your plants and what type of fault currents you can get and duration.

And from what I am hearing from KEMA they can basically configure their system to meet those parameters and for, you know, ground, phase to phase, as EPRI brought up, you know, the grounding is probably not as big of an impact.

So from that discussion, you know, I am kind of concluding that we're probably not going to evaluate the grounding versus non-grounding in the test parameter, but on, you know, the representative side, but that's really what the discussion was focused on.

MR. MELLY: And another additional factor to keep in mind as you look at the test matrixes that we have developed and how we are focusing a lot of the discussion here today is that you see us trying to limit our test variables and have direct comparisons between tests so we can draw one-to-one comparisons.

With such a limited number of tests as well as the difficulty in collecting data, especially the measurement of the heat flux, the slugs, ensuring that we are within the line of affluent, or the plume of the arc itself, we are trying to ensure that we can have comparable results which is why we are trying to do replicate testing, limit the number of variables.

So if we can through discussion or consensus deem that one parameter is less likely to have an impact it's of benefit to exclude it from the test scope.

MR. TAYLOR: All right. Any other feedback on that one? Ken?

MR. FLEISCHER: Yes, actually I'm getting this idea from you, Nick. I think the brainstorming whiteboard we got going on here is good.

I think at some point what we may want to do is bin these into what the priorities are, which are the most important, what's your absolutely must-do's for the test to get meaningful results, and which are the secondary and tertiary level items that if we can do we will and if we can't we don't. I think we should probably bin this at some point.

MR. TAYLOR: That's a good suggestion. I think I agree. Let's get through this and then see where that takes us and if we have to come back over lunch you can come back to this to do the binning, that's fine, but we still need an hour or two to get through Nick's test plan and comment resolution.

MR. MELLY: We may be able to handle that during the test plan discussion, because right now we have a large slot to discuss the comments that were received on the test plan and we're kind of knocking them down one-by-one as we're going around this discussion right now.

So I see us -- Right now we're moving at a good pace.

MR. TAYLOR: Yes, I think this is the

most important part of this whole workshop so I would like to spend a lot of time working on this discussion.

MR. MELLY: Yes. And the binning I think we can do during lunch.

MR. LEJA: So this is kind of going on a tangent I guess, and I'm not PRA person, but I can understand the fact of frequency for like the frequency level PRAs.

So for these medium voltage systems you do your tasks how you do your task phase to phase, but when you develop your frequencies I think that should be one of the things you guys kind of consider as this resister systems if it's phase-to-ground fault it's going to limit the current and typically that's how most faults start, it's phased to ground and then it flashes over.

Not to say it's not going to flash over if you have that resister ground, but it's probably something that you should keep in mind when you develop your frequencies for PRA.

So it's less likely that it will be a -- it'll be phase to phase fault if you have that grounding resister or grounding transformer. I am amenable to hear which is typical. I believe it's difficult.

MR. MELLY: I agree and I think that's something that we need to keep in mind when we do the re-review of the OpE for the binning and the frequency as to how much information can we get on the events that have occurred, type of grounding of the system, the duration, the current.

For a lot of these the information that we have is coming from the LERs which typically focus on the plant response rather than the electrical characteristics of the event itself.

I know that now that these events are happening if we can go out and collect as much information, for instance the Cooper event, Turkey Point, the Robinson, we have a wealth of information on what actually occurred, specific information on the duration, the current, the voltage, the configuration, if we can go back and collect that through the OpE of the previous, of the past events it would really help in nailing down the frequency and nailing down the OpE and how it correlates to what we're trying to do.

MR. TAYLOR: Yes, and I agree with that discussion. Just to clarify though, you're basically saying that if you have a high resist of grounded system the arc would stay phase to ground and it wouldn't flash over, was that the --

MALE PARTICIPANT: I think it was less of a chance.

MR. TAYLOR: Less of a chance.

MALE PARTICIPANT: But it probably will flash over.

MR. MILLER: This is Kenn Miller. Less of a chance of the initial line to ground fault.

(Simultaneous speaking)

MR. TAYLOR: Becoming a phase to phase fault is that --

(Simultaneous speaking)

MR. TAYLOR: Okay. Okay, I just wanted to be clear on that. But, yes, I think that is something that we can look into. Next slide. Nick?

MR. MELLY: Oh, sorry.

MR. TAYLOR: You know, one thing that I think is important, and I have mentioned this multiple times already, you know, today is where do we put that arcing wire to start the arc.

It has an impact on, you know, where it will transition if it will move, or, also more importantly, we need to collect data external to the equipment to characterize what type of thermal source is coming out from the event as well as our photography and videography to capture where any of the molten material is going and the vapor, the conductive cloud, cloud of death, whatever you want to call it.

So if you look at the guide, the IEEE guide, it tells you basically put it as far away from your incoming power source as possible, so that's one way.

I think a lot of the reasoning behind that, and I don't have it, so, you know, the background behind is that basically the magnetics that was going to push the arc away from the source.

So we have various locations where we put in Phase I, and this is actually a diagram out of the Phase I test report. In the back section of the cabinets we could always put it somewhere on the bus bar, so we could put it on the horizontal or the vertical bus bars.

Next slide. And this is was in a low voltage piece of the gear, or we can put it on where the stabs are on the front of the gear to initiate the arc.

So those are kind of the locations. I think there has been some OpE for where you have bus cables coming in to the back of the gear, there has been some failures there, and, obviously, you see failures at the stabs where the gear goes into.

So, you know, those are two places we want to focus in on, but also the bus bars in the back there has been some OpE on failures there, right?

MR. MELLY: Yes. Yes, and there is some challenges associated with both. So if we went with the approach putting it into the arc location of the front of the cabinet, which we did in a few cases in the first test series essentially the breaker misalignment, the stab misalignment going in and things like that, we can initiate the arc in the front of the compartment except the instrumentation becomes somewhat of a challenge in that orientation because the door will swing open, sometimes throw the door and our equipment stands, which would be located directly in front it, will take the brunt of the impact of potentially the door swinging open and knocking them out, whereas in the back of the cabinet or the sides of the cabinet we have less of a risk of impinging on our instrumentation stands.

So I know Tony has been giving this a lot of thought as to how to collect repeatable datasets and this was a challenge for if we do the front.

MR. PUTORTI: In Phase I if you take a look at the experiments we used on the equipment that was donated by Japan we were actually able to have the same HEAF result four times.

We placed the arc wire on both of the connections in the rear of a switch gear which was on the secondaries of the breakers where the voltage connection was between a bus bar and the cables that would be exiting to the load and we were able to, the HEAF exited right out the back in all four of those that we did.

So that was an example of a scenario that we favored because it would allow us to know exactly and hopefully be able to repeat again where the HEAF products would exit the enclosure and we would be able to put our instrumentation there to characterize it well.

MR. MELLY: Yes. In the front compartments there was a lot of, it was a little chaotic, either the door blew open and the energy came out the front or we would breach internally compartment-to-compartment or the exterior wall and it was somewhat of a guessing game as to the location of the arc agenda.

MR. FUNK: One quick comment, and I'll put Mr. Earley on the spot on this a little bit, but I believe in the most recent issuance of IEEE 1584 they found a definite distinction between the energy that was emitted form an arc created on a vertical section versus a horizontal section and they have changed some of their guidance based on that.

So that, again, I apologize I'm not as familiar with that as I should be and maybe I'll, again, put Mr. Earley on the spot to comment on that, whether that should be considered for our testing.

MR. EARLEY: Yes, that is true that the results from the vertical and horizontal test did yield some different results.

MR. FUNK: Thank you.

MR. TAYLOR: So any other feedback on that or is -- I mean in the vertical orientation was it more severe than the horizontal or -- I don't even know.

MR. EARLEY: I believe that the vertical was more severe.

MR. TAYLOR: So that would be, you know, something we would need to consider. Is there any other feedback on where we should initiate the arc?

You know, one additional comment was that when we did do the finish piece of equipment we put the --

MR. MELLY: This wasn't there.

MR. TAYLOR: No, this has been --

MR. MELLY: No, that's our --

MR. TAYLOR: You had the incoming power supply from KEMA coming here, we put the arc down here.

MR. MELLY: Right in the center.

MR. TAYLOR: Oh, in the center?

MR. MELLY: Yes.

MR. TAYLOR: Somewhere in here on the gear, so for that cubicle let's say, and all three phases tied together initiated the event and it quickly promulgated up into the back part of the gear.

MR. MELLY: So it promulgated from the front of the switch gear towards where you had more aluminum material and the horizontal bus bars and then you see the entire, from the video you saw the ejector coming out the side following the magnetic path.

But, again, that was -- We initiated the arc in the front cubicle and it promulgated up to the top.

MR. FLEISCHER: Ken Fleischer from EPRI. Yes, I like this more detail and thoughtful discussion where you put the arc.

I can't remember which report, or test report I read where some of the arc initiation was just not in accordance with any operating experience we have, removing the 24 inches of arc chute to try and get an arc to work was just in my mind not realistic.

So what I recommend we do is not place an arc somewhere where it is just not conceivable that we can even initiate an arc there, if that makes sense.

MR. MILLER: Keep the original configuration of the equipment.

MR. FLEISCHER: Right, right. Yes, I understand we have to cut a little bit into an existing gap that's in the insulation between maybe a bolted connection to get a good wrap of the wire, but not go into a part that's already got insulation.

It's kind of like I think the discussion about the non-safe bus, is it insulated bus or is not. You're not going to initiate an arc where the insulation is covering the buses.

MR. MELLY: Right. For our series of

testing what we plan to do for the Phase II, we did not alter the cabinets in any way besides removing the initial insulation at the arc connection point.

The only thing that we had that was a little strange in the initiation of one of our tests was in Tests 4, 5, 6 and 7 the Korean cabinet donated equipment we had a lot of difficulty in maintaining the arc itself, or initiating the arc where we had extinguishment immediately a few milliseconds after the test.

So Test 7 we have coined the Frankenstein test because you'll see bolts in there just as trying to have enough material to vaporize initially to maintain the arc.

That was the first series of tests that we ran and it was a very trial and error. It did not quite work and we have learned a lot more as we have moved forward.

MR. FLEISCHER: Actually, I'm glad you reminded me of that. And I am okay with experimentation, so maybe one thing we can do is if we decide to a test that is what I call experimental or exploratory and it's not expected in real life let's make sure we just very clearly state that in the final test report so that in the future the utilities can say, hey, this was not representative, this was an exploratory test.

MR. TAYLOR: I definitely agree.

MR. MELLY: Yes, we agree.

MR. FLEISCHER: The other thing we can do is, and if you say you're going to get to this later we will, but I also, I'm having a hard time getting my head around the size of the arcing wire using for medium voltage.

MR. TAYLOR: I was just talking to Ken about that.

MR. MELLY: Yes.

MR. TAYLOR: So if you look at guide, the IEEE C-37.20.7, it has two different wire sizes in there. I believe it's six and 24 --

MR. MELLY: Ten and --

MALE PARTICIPANT: Twenty-four is the medium voltage and ten for the low voltage.

MR. MELLY: Ten K strand.

MR. TAYLOR: Okay, ten for the low voltage and 24 for medium.

MR. MELLY: And the ten is K strand wire.

MR. TAYLOR: And the ten is K strand wire meaning that it has a lot more small strands to make up that ten gauge conductor.

So, you know, moving forward we want to understand, all right, the arcing wire is only there to create the conductivity in the plasma and really all we need is enough material to get the arc to initiate and then maintain it to allow the event to occur for the duration.

So Kenn Miller actually reached out to IEEE to understand what's the basis, what's the reason behind the different sizes, and we haven't gotten a -- They forward it on to their committee.

Maybe some of the individuals here on that can try to get some basis, but if there is anybody in the room that has some information, you know, we're interested to learn more on that.

MALE PARTICIPANT: Do you have any background on that?

MR. FLEISCHER: No. I can go back to the standards and see if I recognize anybody, but what I offer up is that I am not saying take exception but it would say, hey, we're going to initiate an arc for IEEE C37.20.7 and then we use a different wire size, I would just say if we're going to use a different wire size and a different wire type let's just outright say that it's going to be a deviation from the standard or not.

Yes, I'll take a look, Kenn. I will go look into the standard, who's on the standard board, and see if I recognize anybody from my past non-nuclear IEEE life. There might be someone on there I know.

MR. MELLY: Yes. And when we did look into it we noticed that there was a specific callout as to why they used the ten gauge K stranded wire to initiate the arc in low voltage because they had a greater success of maintaining the arc for the duration, the desired duration, and there was no explanation as the reduction in the wire size for the medium voltage.

I assume it's just because it's much easier at holding the arc in, but because we did see that explanation as for the holding for the desired duration our initial thought was we went with that for all the tests because that was one of our main parameters of interest.

MR. TAYLOR: And that's in the 2017 edition of that standard. They put that in in an annex.

MR. MELLY: Yes.

MR. TAYLOR: So I think moving forward, and Nick and I have talked about this a little bit, is that we plan on using what the standard, or guide, I guess, says to use for either medium or low voltage but we still want to hear back from that standard committee to see what the basis or logic is.

MR. FLEISCHER: Yes, and I'll try and look see if I can find something.

MR. MELLY: Yes.

MR. TAYLOR: We appreciate that.

MR. FLEISCHER: I'll get with you by either way.

MR. MILLER: Yes, I've sent an email to the chair working for them but I haven't heard back.

MR. TAYLOR: Okay, so go ahead and the next slide, Nick. Another picture I have taken out of the press report, again, trying to get the same thing, where do put the arcing wire.

This is just a medium voltage piece of the gear, so you have the bus cables coming in the back making connections to the bus bars within the enclosure in the middle section and then you'll have, this is a medium voltage, you'll have two sets of breakers in this case up front.

So we could potentially put the arcing wire right at the bus connection, the bus cable connections to the gear, we could make shorting in the bus section of the gear in the middle region, or we could make the arc connection in where the stabs are, where the breakers are located.

So those are possibilities. We are looking for feedback and --

MR. MELLY: And this is the test that Tony was talking about. We had very good success of getting similar arc conditions when we initiated it in the rear of the compartment than we did when we tested it in the front cubicle.

MR. TAYLOR: And I know I am probably stealing a little bit of Nick's thunder here, but moving forward we do plan on including breakers in the enclosures.

They may not be functioning and we might not have them racked in but they are at least there for their mass and thermal characteristics --

(Simultaneous speaking)

MR. MELLY: Yes, that was one of the resounding comments we received from internationally, NEI, EPRI, is that the picture that was depicted in the test plan did not have an actual breaker unit in it.

We have changed it so it does and we do plan on putting non-functional breakers in so we have the thermal mass, the fire load potential, as well as the pressure influence.

MR. TAYLOR: And breakers are the most expensive piece, so the non-functional piece is important. If we can get something that is the right size to put in there we will.

Obviously if we can get a one-to-one match that's what we'll use, but we just have to watch on the budget side because if we're going to have to spend, I don't know, X number of dollars on the gear and then we got to spend ten or 20 times that just to get breakers, you know, it's going to limit the amount of test that we can do.

MR. MELLY: Which is another reason why we planned on not testing at the breaker unit itself so we don't have to buy repetitive pieces of breaker equipment.

MR. PUTORTI: Tony Putorti from NIST. And in Phase I these enclosures and cabinets did have breakers.

MR. TAYLOR: Okay, next slide. So this is just the same piece of gear, just the schematic of it, so, again, in this case that's where they put the arcing wire.

Is there any feedback from the group of

proposed or suggested locations that initiate the arc?

(No response)

MR. TAYLOR: Okay. On the webinar, Tom, do we have anything?

(No response)

MR. TAYLOR: All right. Again, if you go back home and something comes in your mind please email us on that, otherwise I think you know those are the three locations that we were interested in.

OpE shows that events are occurring there and we'll probably pick, we probably won't just do one, but, you know, maybe two and possibly three, but, again, we want to weigh, you know, how repetitive we can get the, I'll call it effluent, the energy coming out for our measurement gauges. Next slide, Nick.

MR. MELLY: One more point there is that some of the parallel work that is being done by Japan as well as their testing agency CRIEPI, which is the parallel of EPRI in the U.S., they are doing a lot of testing as well to look at the energy levels to limit the amount of energy and they are doing predominantly most of their testing in the breaker cubicle itself or very close to the breaker cubicle because they are more interested in the threshold amount of energy that is initiating an ensuing fire which they are using as one of their damage states.

So by initiating at the breaker unit itself you have a higher chance of starting the fire in that breaker unit which is why they are doing the testing there.

So we had been working with the international community and we are going to try and leverage some of their testing experience through the use of IAs and other avenues so there is data that we might be able to obtain from that arc location given their test series.

MR. TAYLOR: All right, next thing is bus bar spacing and I show you that it is important for arc voltage, or it's one of the parameters that influences arc voltage.

The standards don't specify, at least I am not aware of any, and typically spacing that I have found is IEEE has some tables in 1584 that gives you either a range or a single point value for different types of equipment for bus bars.

So from that, you know, six inches, four inches, or one inch about for the different types of classes of gear. And then I also found a White Paper from one of the, one company that had some information as well. It was similar to what was in 1584 but it was, you know, typical bus bar spacing.

So I think it's really going to depend on what type of gear that we choose will depict on what the spacing is, but if there is any opinions in the room of, you know, this is the type of spacing we have in the plans or we bought this gear because of this rating we'd be interested in knowing that now or moving forward such that we can procure our gear that was representative.

MR. MELLY: The other important aspect of the spacing itself is that the way that we have set up the test plan that we'd want to compare the copper results versus the aluminum result, the spacing can be different based on the sizing that you need, copper versus aluminum, we don't want to do a this exact same size copper versus the exact same size aluminum because they are going to be differing in the field.

We want to potentially buy equipment that is spec'd out for either material and there will be slight differences in the spacing, depending on what material you are using.

MR. LEJA: So I understand, you're going

to be limited to the spacing based on the kind of gear you're able to get, but I would probably just note it in the report and maybe reference that table and just say based on, you know, this is standard, and here's what we tested, just so people have a comparison and could maybe have done something that might have skewed the results a little bit.

MR. TAYLOR: Okay. I think that's very reasonable. Okay. Not hearing anything, nothing from the webinar, we'll go to the next slide then. All right. Bus insulation. We can test bus bars with insulation or without. I think there's been some recent event where they had insulated buses in their bus duct. But not only bus duct, even in the gear, do you guys experience insulation on the buses or is it typically non-insulated or a bare bus or bus bars? So that's the kind of feedback that we're looking for because, again, we have prepared equipment, we could go either way or we can get a cross-section of insulated or non-insulated.

MR. FLEISCHER: One plan I'm intimately familiar with, the non-seg bus, it is insulated. It's that Norrell type insulation. But the fault that they had was another one of these maintenance errors. Apparently, they had done an inspection, and where the bus goes horizontal and then goes to a 90-degree with bolted connections, they forgot to put the boot back on. So that was exposed, and that was where the arc occurred. So, therefore, my one experience with an arc on that would be an exposed area of an insulated bus.

MR. TAYLOR: Okay. I think if we just add on, I think if we did test insulated buses, we could either test it where a connection is where there's an insulation and there's a boot. You might have to get the arc to stabilize. But also I think there was recent testing done where they removed insulation within the bus bar and caused a three phase there, so that's another approach we could take. And with the insulation removed, I think it helps stabilize the arc so it doesn't, you know, shoot down the bus bar. And that's one of the reasons why Nick put in the test plan for the uninsulated cases we have a cap so that the arc didn't just shoot down to the end. I think there are some cases where the arcs are stabilized and haven't moved that far.

But, again, from a testing perspective and to setup the instruments, we kind of have to make some modifications to make sure we can get the arc where we want it.

MR. MELLY: Right. Because if you remember the video that we showed of the bus duct that we did test, you saw this just plume just shooting out looking like a rocket engine. And if we're trying to refine the current model for bus ducts, it's this cone in a downward direction and we see in the modeling, as well as the OpE, is from these events where the bus ducts hung overhead. That's why the gap break was there because if we didn't put that we were worried it was just going to, the arc was going to migrate and move all the damage downwards.

We have learned a lot from the Cooper testing that was done. And they were able to stabilize the arc and center the cubicle or center the enclosure and get much more damage consistent with what you would see in the FAQ method, so we are trying to move forward in that respect.

MR. DALEY: Ours were variable.

MR. TAYLOR: That one comment was utilities would have bare conductors.

MR. MELLY: Does it matter whether it's an external or internal? Like for the Cooper tests, the Cooper bus duct was outside versus a lot of the bus ducts that we're worried about postulating for 60 to 50 are internal.

MR. TAYLOR: Okay. Not hearing any feedback, it might be reasonable, I'll put this on the table, to test some bus bar, bus bar configurations with insulation and another segment without and then have a comparison. So does that seem reasonable to the group? I'm seeing some yes, some yes nods in the yes direction. All right. So that might be something we want to change then, Nick.

MR. MELLY: Okay.

MR. TAYLOR: While I'm writing this, what about, for test bus ducts, what about gear? Is there configurations out there in the plants that have a lot of insulations on the bus section of the gear, or are they mostly uninsulated?

MR. MELLY: If you go back to this picture of the Japanese equipment, this was insulated bus bar material internal to the cabin. When we did initiate the arc, we removed, roughly, an inch of insulation around and connected the arc and wire at that location. Tony.

MR. PUTORTI: So there were a couple of experiments on these enclosures where we did remove the insulation when it was in, let's say, a middle compartment.

MR. MELLY: Yes.

MR. PUTORTI: When we did the four on the rear, the bolted connection was uninsulated, so we put the arc wire on the uninsulated portion.

MR. TAYLOR: Okay. I'm just looking at time and I think we got enough time to get through this. Was there any other feedback on insulation characteristics? All right. Not hearing any, if you do find that the gear is insulated or commonly insulated, please let us know. I think we have a path forward for the bus ducts.

Okay. The next couple of slides are looking into the pressure influences. So where the thermal is more of the energy, from the pressure it's more the arc power. Some of the literature we've looked into emphasize the DC time constant has a big role in how the pressure effects from the event occur or propagate. Asymmetric current to a point has some impact, but also looking at the volume of your enclosures and your openings, given a door opened or just the ventilation, also have an impact on pressure because you need some type of containment to get pressure obviously.

So, you know, I think, Dan, you had a lot of feedback on the asymmetric nature of these time currents or these current profiles and looking at the DC time constant and the asymmetric nature of these profiles. Is there any influence or interest in exploring those aspects of these events from a pressure standpoint?

MR. FUNK: I guess we could. You have characterized it well so we at least know exactly what we've got. To be honest, the testing is pretty benign in this regard to the offsets and the time constants are really low, and you don't include any feedback from motor contributions, etcetera, etcetera. So I guess that's my feeling on that particular part of this.

MR. TAYLOR: Okay. Anybody else have a --

MR. FLEISCHER: Just help me understand, DC time constant, are you saying DC offset which is part of the asymmetrical current? Okay.

MR. TAYLOR: Yes, I think it's the same. No, I think I'm referring to the CIGRE report, 602, and they identified that the time constants, how fast you decay.

MR. FLEISCHER: Right. So it's a DC offset. It's the standard asymmetric half cycle to the first --

MR. TAYLOR: The decay --

MR. FLEISCHER: Yes, okay, all right. I'm used to it referred to as DC offset, but CIGRE may call it different, but it's the same thing. That's all I needed to know. Thanks.

MR. TAYLOR: Is there anything on the webinar or in the room on that? It seems like it's not a high priority. All right. Just quickly on the equipment, a few things I want to go over on the next slide with Germany is planning. They're still working with their utilities. Korea already has lineup of what they want to provide us. All their equipment will be procured or donated, so if there's any plants out there that are upgrading or modifying their plant and then it gets representative equipment, you know, feel free to contact Nick or I. We can see if we can help arrange for that donation of equipment and get it into our storage facility up in Pennsylvania before that.

MR. FLEISCHER: Kenneth Fleischer from EPRI again. If it's going to be really impactful to do that based on the testing we talked about, we want to make sure that all the donated equipment, we get the vendor manuals, as Kenn Miller and I talked about, to get the vendor manuals, the factory test reports, everything that's related to that equipment so that we have something to at least review to make sure that what we got is what we got.

MR. MELLY: Yes, we're going to reach out and get as much information as possible about the donated equipment. There have been challenges in the past, either language barrier or vintage of procuring that information from country to country. We're going to, I think with this round of equipment that's going to be donated, it's going to be much easier to obtain that.

MR. MILLER: This is Kenn Miller. I know, too, when we were getting stuff from the Zion plants, you know, that plant was already down and being demolished and we couldn't get much information.

MR. TAYLOR: Yes, a lot of the documentation has been removed for, you know, non-safety or non-required to maintain. I want to put that out there because that can save us a lot of expenses and, if you save us expenses on that aspect, that means we can potentially do more tests or more analysis or more in other areas. So I want to put that out there, but I think, you know, Kenn's comment on being, you know, getting equipment that's very similar so we have some repetition is also something we have to weigh. And, you know, if we go out and procure equipment, I think that's what we tried to do is try to pick out we want this manufacture, this model number, we want X number of those types of equipment. We'll probably be going to basically salvages equipment or refurbished, as that's what we've done in the past.

MR. MELLY: There are potentials to have challenges with proprietary information, as well, in publishing those vendor manuals and things like that.

MR. FLEISCHER: Yes, I guess my point is it would be a shame on us not to ask at least.

MR. TAYLOR: All right. Next slide. So real quick, without getting into too much detail, Korea is on the left. I guess they're 5 kV rated breakers. We're not sure of the gears rating, but we're assuming it's also rated to 5 kV. As for the vendor manuals, we got a generic manual from them that's not specific to this set of what they have procured here, so I think Nick has asked them a couple of times to get more detailed information on that. But we know we have -- is it two or four?

MR. MELLY: Four.

MR. TAYLOR: Four sections of switch gear, so four cabinets and four breakers. These are the vertically racked-in medium-voltage breakers from Korea.

And then on Germany I'm not, we met with them a few weeks ago. They just switched plans with what utility was donating, so they didn't have all the information available yet. But right now I think they're donating four low-voltage switch gear sections and four medium voltage.

MR. MELLY: Yes, with the knowledge that this plant is shut down. The difficulty in getting equipment out is that the entire plant is dark, and they said there's rats everywhere. So they're trying to get a company to get out the equipment now.

MR. TAYLOR: Nick, do you know if these are air breakers, docking breakers --

MR. MELLY: I do not know.

MR. TAYLOR: Okay. So that's the only information we have to collect, but in these two countries they could not donate money, so this was the alternative to include their participation. And both have worked with us in past projects, so it was valuable to continue that collaboration.

All right. So this is something to think about, but, if we go procure equipment, what is representative, what's realistic, and what should we go out and -- and this isn't a complete list. This is just things that I've run into in the past. You know, you have the Gs, Allis Chalmers, the Westinghouse IT ADDs, other manufacturers obviously. But, you know, if I wanted, today, to go out and procure 30 pieces of gear or 30 sections of gear to do these tests or however many we need, where should I focus in on? What's representative of the plants?

So do we have comments on that right now, or we can wait until after lunch to give you guys time to think about it. I think it's very important for us, when we go for a procurement, to get the right equipment.

MR. MILLER: This is Kenn Miller. I'm familiar with the GE Magna-Blast and Westinghouse VS switch gear.

MR. TAYLOR: All right. And then on low voltage, my list was, there's going to be a lot more. But the common ones I've run into is, again, the Westinghouse, GE's. There's going to be other ones. Next slide.

MR. FLEISCHER: The previous one, the GE Magna Blast and Westinghouse were the most common for the fleet that I represented.

MR. TAYLOR: Magna or Megne?

MR. FLEISCHER: Well, actually, GE Magna Blast.

MR. TAYLOR: Magna?

MR. FLEISCHER: Yes.

MR. TAYLOR: All right. Next slide then, please. All right. And then the other thing that's important, you know, we talked about it a little bit today is you have the arc, you have your source term from the arc, but then to damage things outside the cabinet you need to get through the cabinet. And looking into enclosure thicknesses for the burn-through times, you know, what's typical? And I think, from the information we had yesterday, it seems like they're changing to make the minimum requirements to meet certain standards.

The only thing I could really find out there on material thickness was from the IEEE standards, and it's the C37.20.1 and also C37.20.2, so 20.1 is low voltage and 20.2 is medium voltage, and they have the same information on the minimum steel thickness of the enclosures being 1.9 millimeters thick for the enclosure and then partitions between the primary circuits would be 3 millimeters. So that's the minimum that's specified in that standard. I don't know what's out there in the plants.

So feedback on that would be, I think, important because one of the reasons why is the finish test that we did, we didn't have a complete lineup of gear and all we had was a section. And where the arc occurs, the partition seemed to be very thin. I don't know if you have a measurement of that. It wasn't representative of what we see in a lot of the other equipment.

MR. MELLY: We did not have a measurement of the thickness of the partition at that point, and it was a thinner material, as it was going to be buttoned up to another section. Additionally, something that gave us another indication was that we did use a thicker steel material to button up where the incoming power supply would have gone, and we've also vaporized that. But it was a question mark in our minds as to what was the importance of the various thicknesses for the external cabinet walls, given that we saw an immediate breach and larger damage state from this equipment. So it's something that we're going to be focusing in on, and we want to really get feedback on what's out there because we know it could be across the board.

MR. TAYLOR: We're getting close to lunch here so not much discussion. So another thing, you know, maybe after lunch we can come back and hit on it. But we'd like to at least, you know, be representative in this circumstance because it does have an impact on the energy that can get out of the enclosure.

And ventilation, again, we might be bound by what the manufacturer used for the equipment that we procure, but it does have an impact on pressure and we want to be representative. So any feedback on ventilation, we'd be interested to learn more on that if there are a lot of variations or if we should just, you know, with the equipment we select, use what's provided. Obviously, I don't think we should be out there modifying the enclosures to meet a certain ventilation but we want to have some feedback on that.

And the last thing before we break is on bus duct. We've just spent a lot of time on the enclosures, and I think that's where a lot of our testing is, but, from the informal survey that went out, it seems like there's a lot of bus ducts with aluminum on them. So I already talked about the configurations that we planned on doing, the bus versus enclosure configurations, so we're looking for feedback on that, as well as what is your bus bar configurations, square bus bars like we tested in the previous program, testimony six, rectangular, circular, or what's your bus bar configurations? I don't think we're getting into ISO phase buses, so we'd be looking more on the medium-voltage bus bars and not the ISO phase going down to your main transformer. And then the rating or the size of those buses.

So I think now we're almost close to breaking here. Those are the things maybe we go pig out during lunch, come back and have this discussion, unless anybody wants to bring something up right now. So we'll have the gear we should be procuring, enclosure thicknesses, bus duct configurations, and come back after lunch and have a discussion on that. And then we'll get into Nick's test plan response.

MR. SALLEY: Okay. So before we break for lunch, are we losing anybody this afternoon? Bob, Shannon, Greg. Well, thank you guys for attending. I really appreciate it. We'll soldier on without you after lunch, but we appreciate you being here.

Before we go, though, Frank and I were talking, there was a number of questions about the facility generator. Dan, you had a lot of questions about it. And one of the suggestions and actually an offer that Frank and Bas are making here, if we wanted to do a day trip or an afternoon to KEMA to see the facility, if you think that would help, we could potentially set something up. Ashley, I work through EPRI with you and Victoria, with NEI and Mark, if any of your folks think it would be worthwhile seeing it, if you could briefly get back to me. Frank would be gracious enough to set a field trip up and we could go and you could see the facility, see what they're doing. If you think that would be of value, how about getting back to me and letting me know from there?

MR. CIELO: We'd answer any questions that you have, show you anything, you know, have our facility people there and our test people available. Yes, I mean, it's not that we don't want to provide the information. We can provide the information, but we want you to be able to put it in a context of the lab and how the lab actually works and how we actually function. So we would, you know, we would absolutely like to, if you guys -- NRC is going to spend all this money, taxpayer money, and you're going to invest all this time and this effort and it's that important, I mean, I think you'd really want, I would think you'd want to see the lab and you'd want to see what the lab is capable of doing and how it functions and to meet some of the people that are actually doing the testing. So that's an open invitation, and I'll leave it up to Mark to let us know when that is and we'll work it out.

MR. SALLEY: All right. Mark, for the NFPA folks, if it's of value on that, and we'll talk to Victoria for NEI and see if there's value. We do this trip a lot. It's a day trip. It takes what? Three and a half hours from here? It's right up by our Region I office outside of King of Prussia and can do it in an afternoon. So we'll put that out.

So with that, it's almost 12:00. Let's break for lunch and be back here by 1:15 downstairs and let's pick it back up at 1:30 in the afternoon.

(Whereupon, the above-entitled matter went off the record at 11:55 a.m. and resumed at 1:28 p.m.)

MR. MELLY: Okay. Starting up, we wanted to discuss, as we're going to get started again --

MR. SALLEY: Before we get started, the

discussion we were having was pretty good, so we're not going to try to stick too much to the agenda now. I think it's more important to get the information exchange. We want to get that, Gabe, we got a couple of tables up here that, hopefully, when we rank some of these and bin some of these, we'll be able to take that away and we'll include that with this meeting in some of the information as we move forward.

Also, in the same idea of that, as we look at it, we had a thought over lunch that, you know, this is similar to what the week-long PIRT exercise did, and we have that result and we got that report published. So when we're done with that, Nick is going to pull out the PIRT and, just for curiosity's sake, this is what the internationals have been working on, we'd like to see how this group ranks the same things as, you know, what's important, what's medium importance, low importance, and just see if we're getting alignment between what we've done a year or so ago with the PIRT versus what we're doing today. So, again, we'd like to do that this afternoon.

So with that, Gabe, I'll turn it over to you and pick it back up.

MR. TAYLOR: From this morning's

discussion, I think it's important for us to go and kind of rank some of the parameters so we know what to focus in on or what's most important for the arc, arcing events, and also get into this because I understand, if you haven't had a chance to look at the PIRT report on this, to understand what they thought was important. That might help us with our ranking here.

Before we do that, Kenn Fleischer brought up some information. He looked at 28 plants over lunch to get information for their transformers from the unit aux. And from what he found, it's not a complete of all the plants, but it's a sample that kind of gives you a representative, hopefully a representative snapshot that a delta to Y, there's about 20 plants out of the 28 that has that configuration. Six of the plants had delta-delta, two of the plants Y-Y, and he didn't see any Y-deltas there, but that doesn't mean they don't exist, it just might not have been included in the sample.

So, again, just for the background and the follow on from the discussion this morning, so what that might tell us is that we maybe we need to spend more time looking at the Y configuration since there seems to be more of a population in that configuration versus the delta. So when we look at the split fraction of events, if we can modify the test plant to be representative of that, that might help us out. So I appreciate that information and we'll take that back as we go and change the test plant.

Okay. So with that, I think, Nick, can you go over quickly the PIRT results and findings from that effort?

MR. MELLY: Right. And what you're seeing here is the summary table. It's in Chapter 3 of the PIRT, essentially trying to look at all the phenomenon on the three scenarios that were ranked during the study as to what were the most important characteristics. They have put together level 1 phenomena as the highest importance, level 2 and level 3, as you go down, decreasing in importance.

And the report goes into specifically what all of these mean. I can quickly go over kind of what's included in the terminology there.

The target characterization essentially was what is the fragility of the targets that is being exposed to the HEAF effects, such as is it thermoset, is it thermoplastic, what's the cable, what is the damage state, what's seen as a very high parameter to determine what the zone of influence of damage would be?

Moving down, we get to the arc characterization that included things such as the current voltage of the arc itself, the arc mitigation, this would be your protective systems and devices as to what that can limit the duration of the event, where am I within the lineup of my specific plant, and how important is that to determining what the zone of influence will be?

Also, cabinet lineup effects, this was looking at cabinet damage for damage or, sorry, whether I'm going to damage an adjacent cabinet from the zone of influence. And you can see it's missing from the first two scenarios and only included in a third because the first two scenarios did not have a lineup as part of the scenario. If you were to look in each scenario's detail, we had a lone cabinet to a cable tray to a cable tray or a lone cabinet to a both trains of equipment cabinet lineup and it varied from case to case.

Moving down from that, we looked at the internal ensuing fire, such as what combustible materials would be in the cabinet as to how large of a fire we're going to have in that cabinet; external, what's outside of the cabinet, cable tray again, material came into play there; pressure effects, am I going to damage anything in the room from the pressure effects, and that was largely room dependent; the electrical configuration, a lot of factors came into that and they're explained in the report so I'm not going to dive deep into that one because it gets a little in the weeds.

Then when we get a little bit lower in importance, you see suppression effects, room configuration, and fire detection. Those are primarily listed as low because we didn't see them as an important factor for determining what the zone of influence would be. So for example, fire detection, these events happen so quickly that the detection is not going to play a role in determining if I have damage because, clearly, these events create so much smoke and they're happening so quickly that the detection is not going to limit the damage that we see from the initial blast.

Room configuration, as well. While we did see that as important, we tried to be in the mindset that the zone of influence can be used in any room configuration if you figure out, it's going to be scenario specific, which is why it's down low again.

Suppression effects came into play because there hasn't been much work on is my sprinkler system going to be reliable given that I've had one of these events, am I going to damage the capability of my system with an event this scale?

So this was the perspective of the members as to how important things were. It goes into great detail in the appendices on each participant's ranking, and it goes into the scenarios. So to scenario one, you see Train A, Train B, cable tray, and this is kind of how we approach the problem. And this is really in parallel of what we were discussing earlier of binning the importance of the characteristics, and I feel like this was the stab to do just that based on the result of phase one.

The report also goes into detail of these higher importance events in the summary conclusion. But it's definitely something that we would like feedback on if it hasn't been something folks have looked at. It's a pretty all-encompassing report and a lot of work went into it.

Does anyone, it's difficult to have the discussion without understanding exactly what goes into each of these categories, but does anyone see something that doesn't align with what they're thinking would be in terms of importance for determining a zone of influence?

MR. SALLEY: Before you go there, Nick, one other thing before you go into that is, in the PIRT exercise, this is to help us drive research. So the questions that are being asked when they're going through these scenarios is do we know how to do something? If we know how to do something, we've got a lot of experimental data. Then that shakes out because we can do it. A question will come up with phenomena, hey, this is the phenomena, now can we run the experiment, is it something that's reasonable to do that we can get information? So where does that lie in our rankings? This is where the identification and ranking table piece comes in, and so it goes back to this work that we're talking here with the experiments. What experiments can we do to get data to fill holes so that we can better do the risk analysis on? So that's kind of the underlying premise that the group was going in.

Now, if you wanted something that was just pie in the sky $10 million to do it, you'd obviously washed it off the table because it was not achievable. So the goal was to get to achievable research to help better the problem, and that's the underlying premise that PIRT starts out.

MR. MELLY: Yes, and you can see that the questions also ask here that Mark was getting to is that's the state of the knowledge of the parameter itself. So is there -- model adequacy was is there models that can handle this currently? Data availability is does the data exist to apply into a model? And the ability to collect the new data, so how easy it is to collect data on this particular parameter. It would be easy to collect the data, it would just be extremely expensive to collect the data, so that was also taken into account as the ability.

But this might actually be a good place to show the breakdown that was included in each of these phenomena.

So this was probably the better place to go. For the electrical configuration, we're talking power supply, electrical tension coordination, internal cabinet configuration with things like the breaker configuration, cabinet compartmentalization, cabinet combustible loading, bus bar configuration. This gets to the horizontal/vertical discussion that we were having as affecting the energy release. External cabinet. Again, ventilation, structural design, cabinet penetration. Arc characterization, arc migration, breaching the enclosure, electrical characterization, thermal effects of the arc, magnetic effects of the arc, electromagnetic interference. This one, as you can see here, low, medium, and these are the rankings of the individual members and they're compiled in that summary table you saw above.

A lot of them also have notes as to why some folks differed from others in their rankings. Not all of them, though. Fire protection, presence, characterization of the system. Fire suppression presence, the fire suppression effects. Pressure effects, projectile, missile damage, pressure wave, internal ensuing fire, fire ignition, characterization of the fire source, fire development. This gets into the T=0 that's currently frequently used. Smoke generation, altered ventilation effects, the ensuing fire. Very similar, smoke generation and things like that.

Then we get into the room configuration, that was room integrity, the room arrangement, room ventilation. Then we get back up to the summary.

But when we do our discussion here, it's going to be interesting. And we can go back to this PIRT if we think that the current in the voltage, as well as the protective systems, are the highest important parameters, we can compare with what the PIRT has ranked those on the individual parameters throughout this report.

And, again, this was a week-long phenomena ranking elicitation exercise with, I believe, seven countries who participated.

MR. PLETZ: The conductive cloud, is that included under the pressure effects?

MR. MELLY: That will be included, I believe it is in the arc migration. We discussed that in the arc ejecta.

MR. SALLEY: Nick, why don't you walk through the parameters to see, generally, how the people ranked them, if they're in similar alignment with what . . .

MR. MELLY: It's a little difficult to do that with the three scenarios differing.

MR. SHUDAK: Can I get a clarification from this morning? The medium voltage testing, are you still planning on doing it at the 4 kV and 6.9 kFV, or did you say you're only going to be doing it at the 6.9?

MR. TAYLOR: So the question was, for me, voltage testing, are we going to be testing it 4.160 or 6.9 kV?

MR. SHUDAK: Or both.

MR. TAYLOR: Or both. Right now, the majority of the testing will be 6.9, except for that equipment that was donated. From the specifications that they sent us, it looked like it's only rated for 5 kV, so we'll test that at 4.160 if we receive it.

MR. SHUDAK: Okay.

MR. TAYLOR: But right now, the plan wasn't to test anything else at 4.160. And if you look at the arc voltage, the presentation I provided, it seemed like the system voltage didn't have much of an effect on the arc voltage. That's one of the reasons why I put that together. So I don't see, we don't have any real preference, but, right now, the plan was to go 6.9.

MR. SHUDAK: If you're looking at other donated equipment, if it comes from, you might get other donated equipment that would be 4 kV equipment. I'm assuming you'll test it at that?

MR. TAYLOR: Yes, correct. So the question was if we get other equipment donated that's not rated for the higher voltages, what are we testing that? We're not going to test it beyond what it's rated for, so if we get a 4 kV or 5 kV piece of gear, we're not going to test it at 6.9 or do anything higher. We'll test it at 4.160.

MR. MELLY: And to answer the previous question, the gas and the cloud conduct with particulate is included in the arc characterization portion of what you saw in the above table, and that was one of the high parameters ranked for importance of determining the zone of influence. So it's one of the relatively high ones.

MR. FLEISCHER: Kenneth Fleischer from EPRI. The one thing I don't see in there that I noticed in the background on page eight of the phase two test plan is it said that the PIRT panel covered three distinct HEAFs, the first was an HEAF occurring in an electrical enclosure with a cable tray passing over the enclosure, but I don't see anything where the test plant gets into considering the enclosure as being a target in the zone of influence.

MR. MELLY: The enclosure. Do you want me to speak to --

MR. FLEISCHER: I'm sorry. It's the cable tray.

MR. MELLY: The cable tray. When we get into my presentation as to how the test, the phase two will be performed, we'll get a little deeper into that. But I can speak to it briefly here is that we hadn't looked into putting a physical cable tray above the cabinet that we're going to be testing because we were going to try and focus on the ability to put instrumentation into measure the effect. By putting a physical cable tray above the cabinet, we would be limiting our ability to collect information at varying distances away from the cabinet. We were trying not to shield our instrumentation with the physical cables above the cabinet. So we're attempting to get all the information we needed which could then be applied to determining target fragility and determining whether that cable tray would be damaged or ignited in that case.

We've received several comments on that on whether we would have a physical cable tray above, as well as what materials would be put into that cable tray, whether it be thermoset or thermoplastic cables. However, the current plan was to focus on collecting the heat flux data at varying distances so that it can then be applied to the target fragilities. Gabe spoke a little bit to that, but that would be a secondary piece to make the link-up between the data collected in phase two and the probable damage states. So that's what we had currently planned for the phase two of testing.

MR. TAYLOR: And just to add a little to that is that, you know, let's say we go out and want to put in, hypothetically, a test tray. Obviously, we're going to have limitations with measurement and devices, as Nick mentioned, and also what cable do we test? You know, if we test one cable, does it represent X, Y, and Z, and also, you know, you're looking at does the HEAF damage the cable from a functionality standpoint and does it ignite a cable from a fire propagation standpoint. And both the material and configurations are going to have a lot of influence on those two aspects, so it's another parameter that's just going to add a lot of variability and we can't reproduce enough tests to capture all those variations.

So we felt that hanging good measurements with the instruments would serve us better than trying to get a cable tray in. But, you know, if there's ways around that or if there's ways to bound things, you know, we're still open ears.

MR. TURNER: It's so cheap just to stick

on a couple of cable samples, like I used to on tests. One of my hindsight things was I should have been sticking little cable samples around all over the place and didn't. You know, you just do the resistance before and after if you want to, but it's cheap and it's quick. So tests are so expensive and so rare, in hindsight, I would have done a lot more of that if I had a chance, so you ought to think about doing that.

The other thing is, even though you're measuring these fluxes, the exposures are so short, I don't know how you can relate it to something, like cable ignition where we not only have to have fairly long durations of exposure, like 30 seconds, you would say here's the flux it takes at 30 seconds. We got this flux over two seconds, I don't think you're going to be able to figure out if the cable without the actual cable.

So it's cheap. I put cable samples up there. If you look at the IE we're working on now where I did a lot of cable sampling, I would just change that from, rather than solid metal sample holders, use expanded metals so it gets air behind it and it's got more of a chance to ignite it when it gets hot enough.

MR. MELLY: Yes, that's a good point.

MR. PUTORTI: That's currently in the test plan is to put samples of cable along -- Tony Putorti, NIST. The current test plan has small samples of cable. We just have to make sure that we don't pack things so tight that we disrupt, you know, the various levels of measurements that we're trying to do and different distances.

MR. TAYLOR: Okay. So I guess the change then is the cable tray. All right. That is one change that we're making.

MR. MELLY: And this is what Tony was referring to. In the current plan, we do have cable coupons on the mock test stands that we've discussed, as opposed to the full tray. We didn't receive much feedback on the PIRT when it was published and made publicly-available. We're open to any review or any comments on differing opinions as to the importance of certain characteristics, and it is a pretty in-depth report. It's very difficult to skim over the entire thing within a few minutes of today's effort without wasting too much time but --

MR. TAYLOR: Yes, and the feedback doesn't have to be different. If you think there's a conclusion in here that you guys agree with, I mean, that's just as valuable feedback.

Okay. So not hearing anything on the webinars, all right. So then, Nick, can you pull back the presentation from this morning and go up to an earlier spot where it had all the variables? Actually, let's stay here because we kind of, it was kind of getting towards lunch and we were kind of winding down.

So after lunch, has anybody thought of other equipment models that are common that you see out in plants? Right now, we have identified the GE Magna Blast and the Westinghouse DB-50s that I believe are common from earlier discussion.

MR. MILLER: Another low voltage one is ITE. It's pretty old. This would be, like, 60s or early 70s.

MR. MELLY: I believe that was the one that was at Fort Calhoun, as well, the ITE series.

MR. TAYLOR: Okay. Well, again, if you go back to your plants and you have that information, please get it to Nick or I.

Next slide. Keep going. Thicknesses. You know, these are minimum in the standard. I don't know when the standard had these in it versus when it didn't and when the standard came out. So given the vintage of the plants, I'm not sure that this was applicable at those times, but this is kind of what we're working on. I think what we do for equipment, we make sure that we're meeting these minimums. But, again, the realistic side, does anybody have any thoughts or feedback on what the actual equipment enclosure characteristics are?

MR. MELLY: That's a tough one off the top of your head.

MR. TAYLOR: Without looking.

MR. MELLY: But this is one where if anyone digs into this from spec sheets or things like that as to what the actual equipment thicknesses are, it would be a good comparison to what we plan on purchasing.

MR. TAYLOR: Enclosure ventilation. I think for this morning it's going to depend on what we procure. I'm not hearing other feedback, so I think that's kind of where we, I believe, want to comment.

MR. FLEISCHER: Ken Fleischer from EPRI. I was thinking earlier about what you said. You were making a distinction whether it's indoor or outdoor, right? I'm familiar with outdoor units that actually have heaters and vents, so they actually do circulate the heat rise through them, whereas I'm also familiar with indoor. They're more sealed. I don't know, are we, I don't think, are we considering trying to represent any outdoor bus testing?

MR. MELLY: We were not going to, we had not focused on that as a major parameter to look at, whether it's indoor design versus outdoor design. We are trying to stay middle of the road again. From our phase one of testing, when we did have to create a mock cabinet, we were donated breakers and we built a cabinet around it. We created typical venting at the top of the cabinet, which we've seen throughout several plants. It wasn't louvered design, but it was almost checkerboard top vent. So we're really just trying to be representative of what's out there, and we've seen a lot of cases where you just have the louvered design on the back face of the cabinet.

MR. FLEISCHER: Okay. My thought would be is maybe we don't put a lot of importance on the outdoor, just similar like the large transformers, I think, that were discarded because they're outside pretty much, you know, the air is like a heat sink, it's just not really to just go right into atmosphere and pretty much be attenuated. You could treat the outdoors non-safe bus the same and really consider what the representative types are indoors.

MR. MELLY: So would you say that they're representative type for indoor switch gear and medium voltage would be sealed, not vented?

MR. FLEISCHER: Yes, the ones I've seen are pretty much sealed, non-vented. This is non-safe bus, right, we're talking? Not enclosures. We're talking -- did I get on the wrong topic here?

MR. MELLY: I was talking about the enclosure, but if we're talking about ducts, yes, I would say no vent.

MR. FLEISCHER: All right. My mistake. But I have seen, we do have outdoor turbine decks where we do have some of that equipment outdoors, but it's non-safe.

MR. RHODES: This is Bob Rhodes, Duke Energy. The non-safe bus ducts that I'm familiar with at Harris Robinson, they all have a breather about the size of a quarter on the bottom of the duct. It's sealed at the top, but it's not airtight, which is one of the reasons that we assume that the smoke would get into there and cause an issue. Of course, ours all have the coating that was mentioned earlier, so they're all insulated. Norrell, yes.

MR. MELLY: The one we pulled from Zion

also had the boots, as well as the insulation on it.

MR. MILLER: Could we go back to the panel thickness one again? So are we asking that because we're going to be fabricating --

MR. MELLY: No, we do not plan on fabricating the cabinet --

MR. MILLER: We're just going to be testing the equipment we've got which has already got a defined enclosure, right?

MR. MELLY: Yes.

MR. TAYLOR: So I think it's getting at the phase one testing where we have the international equipment that got donated and the partitions weren't these thicknesses. So, you know, we wanted to make sure that, moving forward, we test equipment --

MR. MELLY: In addition, we were hoping to get some information as to when we do procure the equipment to test that it's representative of what is currently out there.

MR. TAYLOR: I think, along your lines we get equipment from whatever manufacturer and it meets these, then we should be okay.

MR. MILLER: Or I guess if it doesn't, we would just make note of that? Because, I mean, if they were bought to all the standards before these took place or they changed --

MR. MELLY: Yes, that's a good point. And I guess it's definitely what we want to consider when we're going through a procurement.

And then the last one on bus ducts, was there any additional thought on the configurations, how we had it broken down in the test plan and mixed tree of tests, aluminum bus, aluminum duct, and so forth, on different configurations? Does anybody in the room say, hey, we don't have aluminum bus steel ducts or whatever their configuration is? I know we have aluminum and copper, aluminum bus bars/aluminum enclosure, copper bus bars/aluminum enclosure, I'm assuming we have copper/steel. So nobody is objecting to any of these four configurations?

MR. EARLEY: And while you're on this piece, I'll mention that I checked out one of the papers on this. The horizontal configuration is worse than the vertical configuration. And the horizontal configuration, the magnetic effect propels the plasma cloud outward.

MR. TAYLOR: Thank you. So it is more on the plasma cloud being more --

MR. EARLEY: Well, the incident energy is higher.

MR. TAYLOR: Incident energy is higher also for the horizontal configuration. Okay. And then, you know, ratings of the buses, I think that's something that I do have access to in the information we have, but if there's any feedback from the group here on we know our buses rated to 1600 amps or whatever it is, we'd like to test something that's close to what's out there. So any feedback on that? All right. So I think I can work with our electrical group and see where the population is. Nick, do you have anything else on the test parameter?

MR. MELLY: No, not at this time. But one thing in the test parameter that's not currently well defined is the physical arrangement of how the bus ducts will be tested. There's some pictures in there. So that's one area that we are going to be enhancing as we go forward with the test plan. It's going to be the second phase of testing, so we're most likely a year away from even beginning any bus duct tests.

There was a very robust design and test that was done by Cooper on their bus ducts, and it was very interesting and the results seemed to work very well with what we're trying to do. So we may be piggybacking off of tests that have already been done.

So this is actually, what was in the test plan, we received several comments as to why there was the physical break in the bus duct that was depicted, and that was an attempt to try and keep the arc in this location because we were worried about just continuing down the magnetic path and having the arc migrate to the very end of the bus duct.

After seeing some of their testing, at least with insulated bus ducts, we don't know if that's going to be necessary to put that physical break in there if there's the insulation. If there's no insulation, we still don't know whether that's going to be a problem. But, again, you can see that we would have the instrument tests then located at various distances around the bus duct itself.

In another picture, we had a cabinet determination point, and we do not know if we are going to need that arrangement set up. So this picture here was we had it terminated again to a cabinet. We don't think that we will need that arrangement.

We'll go over this in a little bit more detail when I'm doing my presentation on the phase two test plan. But any thoughts on this would be --

MR. TAYLOR: Yes, I think from this morning's discussion, we talked about maybe splitting it up half insulated/half not or some fraction of that. And for the insulated --

MR. MELLY: For the insulated cases, I think, you know, we can do what was previously done by Cooper and peel the insulation off from a section where we initiate the arc and it should stabilize in that location. But for cases where we don't have the insulation, does anybody object to what we had here where we actually physically separated, had a separation along the bus and we initiate the arc obviously on the power side of the bus, and, again, it's to help maintain the arc in one location so we can get good measure, decent measurement in that location, because without that the magnetic forces should push the arc out and away from where we initiated that. And, you know, not having it confined and not having a more continuous configuration is basically just blow everything right out the end and we don't have open bus ducts in the plant. So that was kind of our approach.

MR. SHUDAK: This is Tom Shudak from Nebraska Public Power. Related to the Cooper testing that was done, the picture you showed there has the switch gear at the end. We had a lot of discussion on what we tested ours, and if you put caps on the end of them as you guys did on the Zion where you capped that end of it, we didn't feel that was realistic. And so we spent a lot of time and modeling of it to see if we needed to have caps on it.

So I guess if you're not going to put the cap on there, I guess we'd like to know, I'd like to know if you're going to put something on the end of those. There's lots of supports that go along the way that would slow down any pressure wave, and these things just keep going on and on, right? They're very lengthy. They don't end. So I guess if you're going to turn that one at the end of it, that's going to impact, I think, your test results.

MR. MELLY: And that's also, that's one good point you brought up is that, in that testing that was done, you did not have a cap on the end because you did have those supports periodically beyond where the test was initiated. We have not procured these yet, so we don't know how they're going to be physically arranged within the bus duct itself. If we do have those supports, it might not be necessary to put the cap on the end. However, if it is just a continuous run without any support in the way from procurement, we may need to physically cap the end or have a termination into a cabinet.

MR. TAYLOR: And it doesn't necessarily have to be a cabinet that we procure. We can build a cabinet and put some ventilation on it and just terminate it into that just to kind of represent the end effect of a long run. But I think it's a good point on, you know, you have the support pieces, the support members it goes down the length of the bus, and, you know, the question I then was asked is do we include those? I think we would, depending on what we procure and what the design spec is.

MR. MELLY: And one other consideration is that when we had put together this test plan, one of the reasons why we had the cap in originally, as well as the reason why we had this physical termination, is we were testing in one of KEMA's test cells, it's test cell seven, which had their medium-voltage incoming power supply on the left-hand side of the cell and the low-voltage on the right-hand side of the cell, and we were very worried about damaging the adjacent power supply from that cloud that you saw in the test video.

We have moved all of our medium-voltage

tests, I believe, we moved them all to test cell nine where we don't have that concern. One of the test cell walls is completely devoid of any kind of power supply, so we'll just be able to not worry about damaging anything. And that cap did not work very long, as you can see by the video.

But as you can see here, I'm getting a little bit ahead of myself, but we have the varying levels of instrumentation stands so that we don't have just one static three-foot instrumentation point, so we can actually get different levels of instrumentation. And if we damage one, we'll have backups at different distances. For the Finland test that we did run on test 23, we destroyed the instrumentation tests they have, so we have very little information as to what the flux was at the three-foot zone of influence, and we had no redundancy beyond that. So while we do have other instrumentation at different points around the cabinet, it gives us very little information as to the immediate effect from that test.

MR. AIRD: We have a question from the webinar from David Lochbaum. His question is do the cameras provide information needed to assess the severity of the HEAF event or is their role to help market the badness of HEAF events?

MR. TAYLOR: I can attempt to address that. So there's two types of cameras that we used in the past. There's the regular video cameras that take high speed photography video of the event. We can use that partially to look at the shrapnel and any type of metal that leaves the compartment. And then we have the thermal measurements, as well, so we have some high-speed high-arc cameras that we've been using that NIST has. I think there's some limitations with their initial camera that we used, and we've been working with his to get a camera that has a larger, what they call dynamic range, and it automatically changes the ranges, meaning it can capture different temperature ranges of the event.

So with that information, we can better characterize the temperature rise of different components or surfaces of the enclosure and use information that way. I don't know if NIST or Nick had anything to say.

MR. MELLY: The high-speed camera that we actually used, it was also possible to watch the arc migration from point to point within the cabinet in certain cases. There was some early on testing where you could actually see the initial arc strike and then watch the arc move to a different portion of the cabinet, and you could see it re-strike and start the arc in a different location. So that video was very helpful in watching what was occurring during these events.

MR. PUTORTI: Tony Putorti from NIST. So one other thing that we plan to do with these extra cameras that we've added is that not only do you get a qualitative idea of the extent of the arc ejecta but also most of these cameras are not going to be at a right angle, so it's relatively easy to go and get a quantitative view of where the arc ejecta is, what the extent is, and where it is in relation to the instruments that we have installed.

MR. FLEISCHER: Ken Fleischer, EPRI. I like how you set up the three-tier there so that you said before if you lose something you get the next level. Should the bias be significant, some of those coupons may fall off and onto the floor. They're going to be individually marked, so you know when you pick them off of the floor which rack they came from. Good.

MR. MELLY: The answer was yes to that question.

MR. FUNK: This is Dan Funk. A quick

question on --

MR. TAYLOR: Let's go to Dan, and then we'll come back to Stan.

MR. FUNK: A quick question on the test setup. We're going to force the damage to be where you started obviously. That's the intent here. And so you're going to prevent the natural phenomena that I think we all agree takes place typically to a termination point. Is the intent of this design to simulate a segmented bus duct to where you're failing at a joint or is the intent for this to apply to both segmented and non-segmented, and that's going to tie back into our current practice, which for non-segmented bus ducts, because of the magnetic effect, we postulate the HEAF event actually at the main breaker terminals and not anywhere along the path. This, depending on how the results are applied, could dramatically influence that.

MR. MELLY: This was more taking in mind the segmented effect, so we'd be doing it at the joint or at the bolted connection in the bus duct. For those that are occurring at the termination points, we were trying to map that to the damage of the enclosure testing, rather than the bus duct testing. So those plants which welded the bus ducts rather than have the bolted connection, they would be matched to the enclosure testing results, and we're going to try and clarify that in the methodology.

For here, where we're actually trying to focus where it occurs, it is to try and simulate that bolted connection in that case.

MR. JOGLAR: So before we run the test, vision is to stay consistent with the FAQ on the zone of influence for this thing?

MR. MELLY: We are using that as the starting point. However, there's no way for us to locate that 37 feet above the ground.

MR. JOGLAR: No, no, but at least for the non-segmented ones, I think you said just put it on the breaker.

MR. MELLY: Yes, we're staying consistent with that because we have no OpE to make us think that anything has changed in that realm. Any other follow-up questions from the --

MR. GARDOCKI: Well, where are you going to go into, you've got another presentation, positions, the racks and where --

MR. MELLY: So the question was how many racks are we going to place. The picture on the screen right now depicts three above and three below.

Tony, do you want to take that? Right now, the current plan is to have three varying levels.

MR. PUTORTI: Tony Putorti from NIST. So are you referring to the bus duct here or to the enclosures?

MR. GARDOCKI: Test coupons. You're going to have one position?

MR. PUTORTI: For this particular setup?

MR. MELLY: So for this particular setup where you see the three racks, each rack will be depicted or placed with, this is what the proposed rack would include. So each rack would include these instrumentation pieces, so multiple coupons and the depicted instrumentation.

MR. PUTORTI: And so we have slugs, the classic slugs for clothing around there. Click thermometers are on there used for measuring heat flux, as well as a new tee-cap sensor that we're working on now which measures, we'll be able to measure very high heat fluxes, as well as some coupons to collect any types of materials that may coat things in the vicinity, as well as the samples of cable.

MR. MELLY: And, again, right now, what we're showing on the screen is for the enclosures.

Again, you see that the three test stands, again, this is not done on scale so don't think that they're all going to be that close together, but the intention is to have the varying distances of instrumentation racks that are not cluttered enough to actually impede the hot gases, so we have included instrumentation at varying distances. That was one of the questions we got that these were not consistent with the mentioned spacing that was consistent with the IEEE guide, and that was for a reason in that we're going to be designing these with minimal impedance for the hot gases coming out.

Any other questions before we move on?

MR. TAYLOR: So, you know, we still have Nick's presentation on the test plan and the counter-resolution, and we're going to get to that. But one thing that came out of this morning's discussion was should we look at the parameters and the things that we can change and kind of rank their priority?

So what I've done is I've put together a list here on two sheets, everything from arc location, grounding configuration, winding configuration of your transformers, the supply, whether we're going to model from their generator at decaying current or a steady-state current as we've done in the past. Obviously, duration voltage and current are going to be important.

And on the second sheet here, you know, enclosure thickness, bus insulation, circuit characteristics, and that was, you know, providing a sample from the plant of the circuit characteristics. Bus bar, gap separation of the buses. Equipment separation. You know, older plants and newer plants have differences in designs. Is that important? DC offset or phase initiation angle, ventilation, aluminum alloy or bus material.

There's more. We can put them up there, but what I'd like to do is kind of go through those and rank them from a priority or importance standpoint, how important is it to our test protocol? High, medium, low. So I think that's kind of the suggestion earlier from Ken, so is it okay if we just start going through those and kind of throwing out our plans? I'm going to use a different color for the ranking.

So starting off on these three, I already think that they're going to be high importance. So duration, does everybody agree it's of high importance? Anybody disagree? Okay. So we'll put high for duration. Voltage, high, medium, low? All right, okay. Any disagreement with high on voltage? All right. So the comment was the excitation voltage isn't going to change much. The arc voltage is what we're interested in. The batteries might be dead in that one, Ken.

Okay. So arc voltage, high. And then current, is that going to be high, medium, or low? High? Medium? Low? Abstentions? All right. So high on that one, too. I kind of thought that's where those would fall.

Arc location, you know, I put horizontal and vertical, and that was the feedback from NFPA that showed, the recent research showed that horizontal had a higher incident of energy than the vertical orientations. So that might influence where we put the arcing wire in our experiments, maybe more on the bus section of the enclosures.

So for arc location, how important is that to the overall HEAF event? Do I have any highs, high importance rankings? Medium? What about low? I'm getting zero feedback.

MR. FLEISCHER: I think it's still high.

MR. MELLY: I have one question on this as to, for the results that were during the NFPA testing that showed horizontal, initiation showed a higher energy in the plume, is that because the instrumentation was located in a horizontal direction or was it not due to the instrumentation locations? So that's what I'm trying to get at is that, if I initiated the arc in a vertical orientation, were there vertical instrumentation locations that would have still been in the plume or was the energy, were the results calculated at the front face of the cabinet because personnel were the objective of the testing?

MR. TAYLOR: Well, of course, that is a major objective of the testing is the personnel and how much it tends to impact them. And the plasma did move in that direction. Of course, the magnetic effect pushed it in that direction, and it also indicated that the effect was worse when the fault took place deep inside the cabinet.

MR. MELLY: So that's, I think, a good clarification because if we are going to be putting our instrumentation both horizontally and vertically because we're worried about both the three foot and the five foot, I think it's something to keep in mind that it might not have the same effect because we're worried about the plume and the magnetic effects in both the horizontal direction, as well as vertically.

So it may have a lower importance than what some people have typically seen in literature for our specific case.

MR. TAYLOR: Yes, it may not have the effect on the overhead cable tray, whereas that was non-arcal.

MR. MELLY: Right. So if I can, I actually have a test --

MR. EARLEY: I think I know what test he's talking about, and the sensors were in the front so they were engulfed in a side plume that came out horizontally.

MR. MELLY: And I can show the --

MR. EARLEY: The vertical plume is just looking at the side and it's not engulfed.

MR. MELLY: And I'll show one of the tests right after the break. I can pull up where we had a test that was initiated on a vertical section of the bus bar material within the cabinet. It was our OECD NEA Test 11, and the arc was directed vertically, in the vertical orientation, but we do have test stands in the front of the cabinet, so you'll completely see that we're going to get lower results on our horizontal facing where the personnel would be versus where we're instrumenting at the vertical case. So that's just something to keep in mind when we're putting this ranking on.

Okay. So, again, for arc location, who thinks that that is of high importance? Dan.

MR. FUNK: I'm looking at the recommended updates to 1584, and horizontal versus vertical, they say it's about twice the impact. So I think it's probably important because if we're going to be playing with zones of influence, it's something we need to know. Maybe it can all be handled by research of what 1584 did. And you're correct. If they're relying on it for the tests, it's kind of what you would expect. But it's probably something we should know a little bit more up-front than before we spend all the money for the tests.

MR. TAYLOR: So we have two votes for high. Anybody else? Three. All right. Raise hands for high. Now we have three, four, five, six. Mediums? And lows? One medium. Okay. So three lows, a medium, the majority high.

Grounding configuration. It seemed like, because we were doing three phase, that the grounding configuration wasn't that important. So, you know, we could go and we could solidly ground it or we can higher-resistant ground it or we could leave it floating, right? And I think some of that has to do with the machine team, what they can best protect from overheating losses. So they left, but that's something we also have to consider.

But from the group that's still here, how important do we think grounding configuration is for the test that we plan to do? Do we think it's a low priority, a medium parameter priority, or high? Okay. So for high? Who think it's of high importance? We have one in the back, two. Medium? One, two, three, four, five. And low? Two. Two-five-two. Oh, I missed Nick. Two-five-three. So you're doing high, medium, low, right?

MR. MELLY: Yes.

MR. TURNER: I'll just cover, the way we do the test for Japan is we're mainly looking at energy and really high energy events. We don't care what the grounding is, as long as we get the current we ask for and the duration we ask for. And the reason we do that is KEMA is setting up with you to meet your best for 23 kiloamps. They look at the variety of circuits they can do and what combinations of things can give them a nice, steady 23 kiloamps with the duration you asked for. Sometimes, it's steadier in Y and sometimes it's steadier in delta, and so they'll just recommend a circuit to me and I don't care whether it's Y or delta because we rarely see anything --

MR. MELLY: Yes, I'm with Steve. Change mine to low, so change one of the mediums to low.

MR. TAYLOR: I'll go back through. Dan, you had a comment?

MR. FUNK: Yes, I'm going to basically qualify my high. Some of what Steve said, I think the grounding configuration, where it's important is actually in frequency. If you have an ungrounded or a high-grounded system, you're likelihood of protection failure is actually, in my mind, going way down, so I think it's a frequency issue more than maybe the testing which is what you're interested in. Does that make sense?

MR. TURNER: Yes, and the testing at KEMA is, of course, complicated because the frequency is going to go down as the rotor slows down to give you the power. So an example, a test where you're running 40 megajoules, they might start out running them at 60 hertz on the generator, but by the time you finish the test it's running 48. It slows down that much. When you're out there in the generator hall, you just hear it grinding down.

MR. FUNK: Yes, I'm sorry. When I say frequency, I mean probability --

MR. TAYLOR: Okay. So let's go ahead around the room again for the grounding configuration, importance of that parameter to the actual testing, who think it's a highly important parameter? No hand raises. All right. What about medium? Medium importance? And low? One, two, three, four, five, six, seven, so it looks like it's, for those who voted, it's low on that, Nick. We're not putting your names up here, so don't feel bashful. Please provide the feedback on this.

All right. Grounding configuration, delta versus Y. I think the information that Ken gave us is pretty useful for when we split up the different configurations but then, again, you know, comments we've heard, as long as we get the characteristics of the fault that we want from the laboratory, it may not be that important.

So for delta versus Y winding configurations, what's the belief for its important? Who thinks it's a highly important parameter for the testing? Medium? Low? So we have one medium, and one, two, three, four, five, six, seven, eight, nine, nine on the low.

MR. FLEISCHER: I would like to ask a question on that because I think maybe you guys have experience. So the face-to-face voltage between a Y and a delta is different, but you're saying that the testing you've seen is always the arc voltage and have you seen the arc voltage similar, regardless of whether it's a Y or a delta?

MR. MILLER: Yes.

MR. FLEISCHER: They're the same?

MR. MILLER: Yes.

MR. FLEISCHER: All right. Then go ahead and change mine to low.

MR. TAYLOR: Okay. So that's another unanimous low, a unanimous decision on that one. All right. Another thing that we had for a variable is the supply. With KEMA super-excitation configuration at their site, we can basically do a steady-state current, which is what we've been doing in the past. However, for medium voltage with the unit conducted designs, the generators want to trip. It's going to coast down and continue to feed the fault, so you'll have a decaying current for as long as that fault is locked in.

So the question here is how important is it to test the actual decay that you see in the plants versus the steady state that we've been doing to the testing?

MR. TURNER: How big is the decay before the generator can't hold it anymore? Ten percent, thirty percent?

MR. TAYLOR: The question is how big is the decay before the generator can't maintain the voltage.

MR. FLEISCHER: So I don't want to steer anybody in the wrong direction. I don't know off the top of my head. I don't want to venture to guess. I'd rather get facts. I'm going to see if I can find a digital fault record that would accurately record that type of information. I'm aware of one plant where I may have access that was a generator, it was a six-second generator fit fault. No, Turkey Point suffered a flashover of the main power transformer. Actually, the arcing fault was on the high-voltage terminals, so the main power transformer. But it would show you how the generator responded to it because remember we did a root cause.

I'm going to see if that -- and I remember we pulled a DFR. I'm going to see if I can find that DFR. That would then tell me what happens, but I would anticipate, again, let's walk through the scenario, right? You're basically, you've tripped, you got a HEAF. The plant has tripped. Part of that is a plant differential. You open the yard breaker, so you have no voltage contribution from the switch yard. You're now just with the generator with maybe like a stuck breaker. So you're going to have an immediate step change because the exciter fuel breaker is going to half open, so really it's going to be the residual magnetism of the rotor. The rotor won't even be excited. So, therefore, you're going to have an immediate step change down and then, from there, you will have a decay. And I think that's what we saw on the digital fault recorder.

So I did make a note to go see if I can find that. Is it 70 percent? I don't know. I can't remember.

But as far as going for a vote, I think right now, unless we run into a technical feasibility, I vote yes. That's a tie. Fifty percent of the plants are on off-site power, fifty percent are off the generator.

MR. FUNK: I'd like to second Ken's perspective. It's not, you don't run into a practical limitation because right now these unit-connected designs or that coast down are, quite frankly, what's driving some of the answers we're coming up with in our database checks. So understanding that phenomena I think could be pretty important if that holds true that the unit-connected design is vulnerable.

MR. TAYLOR: Any other comments before we go to vote?

MR. TURNER: I'm thinking we're mainly trying to learn about energy and the ZOI, so I'd say if the current only drops ten percent that doesn't change the energy very much and you don't learn anything. If it changes 80 percent, you may as well have run just a duration half as much. But I don't know if KEMA can do as much as 80 percent. They can probably do probably a 30 percent drop-off.

MR. FUNK: That's fine, but just understanding the phenomena, I think, so we can go in with our eyes open and not closed is what's important.

Tests aren't ever perfect.

MR. MELLY: One thing to note, we do plan to make a test plan change to include this decay as part of the medium-voltage testing. It will require plant information where we are looking to dig deeper on this so we do know what to tell KEMA to do because, currently, it's very easy to -- yes, we will need a sample profile to give.

MR. TAYLOR: Yes, and then we'll also have to enter discussions with KEMA to see what they're capable of doing. And if they're not capable of doing what's representative, we need to maybe see what they can do, run some tests with that, and then have comparison.

Okay. So if there's no more discussion, we'll go to see where we are. So for the decay versus that steady state, who thinks that's a highly important parameter? One vote, two vote, three, four, five. Five for high. Medium? Six for medium. And low? Two for low. I think that's it for this sheet.

You have a question from the webinar? Okay.

MR. MELLY: We have another low from Dave Lochbaum on the phone.

MR. TAYLOR: So one low from the participant on the webinar.

MR. MELLY: Also, for those on the webinar who are listening in, feel free to also voice your opinion and we will include the counts. That's very easy for Tom to relay that information to us.

MR. TAYLOR: Yes. And just to add on to Nick, if we missed you going through those, the rankings, you can see them on the screen. Please feed that to Tom and we can update.

MR. MELLY: Yes, if we can update any of these fields, if you would like to provide your input on what's currently shown on the screen.

MR. TAYLOR: Okay. Let's just work down my list. It's not in any particular order. Enclosure thickness. Who thinks that -- is there any discussion on enclosure thickness? So who thinks that's a highly important parameter? Medium importance? One in the back, two, three. And low importance? Eight. So three for medium and eight for low.

The next one is bus insulation. I think what we talked about earlier is we tried to split the experiments up half insulated and half not. But, again, do we think that's important for, an important variable for the HEAF phenomena? Do you want any discussion on the bus insulation?

MR. TURNER: Can you define it a little bit more? Are you talking about the really thick ceramic we put on bus bars sometimes, or are you just talking about some insulation that's thermal, like a boot?

MR. TAYLOR: I'm not an expert in the bus insulation. I don't know if anybody --

MR. SHUDAK: Ours is a thermal boot.

MR. TURNER: Yes. And so those, the arcs just tend to blow right through those. If you have a heavier ceramic that surrounding, like a square bus bar, it doesn't tend to burn that back as fast. You won't burn as much of a bus bar. And if it's aluminum, you won't need as much aluminum in there because you didn't run as much bus bar. But if it's just a heat shrink wrap on there or a boot, it's hosed. It's going to go right through that stuff, and it just makes the experiment messy.

MR. TAYLOR: Are we aware of any that's ceramic configurations out there?

MR. TURNER: Well, that's what you tested on the bus duct design, that real heavy ceramic that was --

MR. FLEISCHER: Yes, probably Norrell, right? It's like a sleeve. It's actually, it's not rubber, it's a sleeve you slide on.

MR. TURNER: Yes, and it's pretty heavy.

MR. MELLY: And where we initiated the arc, we removed that wrapping.

MR. TURNER: It's one of those, I think it's high. If it's just a boot, I don't think it matters.

MR. TAYLOR: Okay. So I think what I'm hearing is it depends on type, but, you know, I think, with that understanding, whether it's either the shrunk on or the ceramic type, do we think that's important for the HEAF phenomena?

MR. FLEISCHER: I have one clarification. Ken Fleischer, EPRI. So I think what I'm hearing, though, is maybe we separate that bus insulation for switch gear in bus insulation. We're not saying bus. It sounds like it makes a difference there. It sounds like for one it doesn't make a difference. You said, regardless, whether it's the rubber or the boot, it's going to blow by anyway. And I think a majority of the switch gear is either non-insulated or if it is insulated it's that, whereas a non-seg will typically have that more robust insulation. I would recommend splitting that. Yes, so the first one would be a bus insulation for non-seg bus, and the second one would be bus insulation for load centers and switch gear.

MR. TAYLOR: All right. So on the first one, bus insulation for enclosures, votes for high importance? Medium? Low? Eight for low.

MR. MELLY: Do we have anything else?

MR. TAYLOR: Nobody for medium or high. Bus insulation for non-segregated bus duct. High? High importance? One, two, three, four, five, six, seven, eight. Eight votes. Oh, nine votes for high. Medium, medium importance? One, one vote for medium. Low? No votes for low.

All right. Next is circuit characteristics. And this, I think, from our discussion was characteristics from a plant to help us inform and understand how to set up the generators that came up. I don't know if we want to have any discussion or clarification on that, Dan. I think that was one of the comments you brought up.

MR. FUNK: Well, I think you probably did.

I think the discussions over the past two days, the voltage current, time duration, detriment, we've probably beat that to death. And the idea of being able to characterize the test circuit, you know, we got feedback from KEMA on that already. We've discussed that we may need to try to come up with a representative system that we would expect them to at least be able to replicate within reason.

MR. TAYLOR: Any other discussion?

MR. TURNER: And I think they can probably give you, once they set the circuit up, they give you an effective reactance for that circuit, so here's what it is and here are the components we used to get it. They're still confused on why you need that information, but I said don't worry about it, they do models and stuff.

MR. TAYLOR: Okay. So from the ranking, who believes that to be highly important for the program? We got one high, two highs. Medium? Four, five, six, seven. Sorry, seven. Two highs, seven mediums, and low? Anybody believes that to be of low importance? Okay.

Bus gap separation? I think we've kind of shown that it has an effect on your arc voltage, and we already ranked arc voltage before as being a highly important parameter. So, you know, we could group it there, but keeping it separate, who believes that that's highly important to characterize and understand what we're testing in the program. So for high? Eleven, eleven highs. Medium? And low importance? One low.

MR. TURNER: And let me explain why I'm low. Usually, when these arcs set themselves up, they're trying to go phase to phase. What matters is where they can find a way to connect the circuit so this phase can connect back to that phase. And it could be a metal wall that's a certain distance away where it's just at an open space. It really doesn't matter how far the bus bars are apart, even if it's a half an inch or an inch. It's the length it's going to to find its way back to the phase it's trying to come back to, so I don't think the spacing has as much effect as the surroundings, but it's the closest thing by which usually is what sets the arc voltage.

MR. TAYLOR: Okay. We're going to skip over this one. We'll come back to it. DC offset and phase angle. And phase angle when you initiate the arc, so it's this phase angle. You start the arc, and it has some effect on your asymmetric nature of your current wave form. And I think just from what I discussed earlier, it may have some effect on the pressure. But from the overall program, you know, what do we expect the importance of the DC offset or the asymmetric nature of the wave form on the HEAF event? Is there any discussion on that parameter?

So who believes it's a highly important parameter? Medium? Five mediums. Low? And three lows.

I don't know why it took Kenny so long to do. We're doing this in an afternoon. I wonder if Ken is still on the line.

Next one is ventilation. So this is the ventilation, and this one might be one we were going to separate enclosures and bus ducts, as well. But ventilation for enclosures, who believes that to be a -- well, first, is there any discussion on the ventilation aspect?

MR. FLEISCHER: This is more for clarification for me. So we're talking about a ventilation, I think I heard earlier that it can make a difference as to where the arc plume is directed.

MR. TAYLOR: Some of the literature I've looked at, it can have an effect on the arc characteristics: the diameter of the arc, the arc voltage to a point. I don't know if Steve has got anything else on that piece.

MR. FLEISCHER: All right. Since we're worried about the zone of influence and whether it's going to be directed at it or away from it, and it sounds to me that, okay, so it sounds to me it's really important.

MR. TAYLOR: I think the other thing is, you know, Nick brought up yesterday with the louvered vents in some of those, and Mark touched on it, too, some of the effects there, that might have some impact of where the arc projects energy out of the enclosure and the breach occurs or a door opens.

MR. MELLY: Well, what we've seen in testing is that the ventilation points for a lot of these cabinets are typically where the plume and the plasma is directed just from that's where all the material is going. We have seen the louvers just completely vaporize, but that is the location where the louvers are that these zone of influence is typically directed. It's a weak point in the cabinet. It's where the easiest, the path of least resistance.

MR. TAYLOR: Okay. So any other discussion on that ventilation?

MR. RHODES: And this is Bob Rhodes, Harris. I've seen buses, I've got buses that have a ventilation that you all haven't discussed which is on the top, it's got a top hat arrangement, and so I haven't heard any discussion about that.

MR. MELLY: So we have had experience with the top hat arrangement in some of the Japanese testing that was done. When they were trying to recreate the event that occurred at Onagawa, they did use a top hat design, and we, again, saw that that was the direction that the plume and the plasma wanted to head because of the ventilation.

MR. TAYLOR: Okay. So for ventilation on enclosures, not bus ducts but on enclosures, who believes that to be a highly important parameter? Nine. Medium importance? One. Low importance? Zero.

Okay. What about the bus ducts now? I think we've had a discussion of some of the variations. Who believes that to be highly important, ventilation on bus ducts? Medium importance? One, two, three. Low importance? Seven on low.

Okay. And on the last one that I have, well, second to last, aluminum alloy. We haven't really talked too much about this. In the test plan that we had for the small scale, we had some discussion in there on the different types of alloys that can be encountered. And I think, you know, we picked one of the alloys in there, but I think there's going to be some variation of what's used out in the plants.

So just on that variable of different alloys, aluminum, I don't think there's going to be much variation, but do we believe that there's going to have to be a big impact from the HEAF phenomenon that parameter? Any discussion on the alloy aspect?

Okay. So who thinks that's a highly important variable or parameter?

MR. TURNER: Discuss it a little bit more. You mean an actual alloy, or do you mean the type of aluminum, or do you mean --

MR. TAYLOR: Type of aluminum. Type of aluminum in the bus bars, yes. Well, bus bars or bus duct. So who thinks that's of high importance on the HEAF phenomenon? I've got one. Medium? And low?

MR. MELLY: And I'm going to explain my --

MR. TAYLOR: Seven on low.

MR. MELLY: Let me explain my high is that if we did this testing for the first round and someone asked me if aluminum versus copper was going to be of high importance, I would have said not at all. And we thought that going into the first round of testing. So I think my state of knowledge as to whether aluminum is going to be such a large impact is so low that I'm going to err on the side of caution.

MR. TAYLOR: So you're making the discussion of we didn't think aluminum versus copper would be much of a difference, but we saw a big difference. I think what the question here that we're asking is does the alloys make a big difference, and you're saying that, because we saw a big difference in the other things and also the alloys, there might be differences between aluminum material. We're not comparing it to copper and aluminum. So is that the --

MR. MELLY: Yes. Because if we had a state of knowledge ranking, as well, it would be low.

MR. TAYLOR: So I think we had seven. One low -- sorry. One high and seven low, eight low. Who votes low on that one? Seven. So it was seven.

And then the last one doesn't really have too much to do with experimental plants, but we did bring it up when we were talking about the pilot plants and that relates to the equipment separation and understanding, you know, out in the plants, the different separation of equipment that's important for either safe shutdown or redundant divisions. I wanted to bring up a discussion point. It may go into some of the decisions of where we put the racks, the instruments, you know, how we space those.

So I put up here is there any discussion on aspects of equipment separation out in plants and how we would then instrument the experiments as that being an important parameter. I think right now, just a little more clarification, we're basically looking at multiple distances, so we have maybe three feet, six feet, nine feet, something along those lines, from a horizontal distance out from the enclosure is what we're planning on doing right now. You know, is there some logic or some configurations where we would look at something different?

MR. AIRD: A question from the webinar real quickly back to the aluminum alloy. The question is from Preston Cooper from TVA. His question or comment is that can we include the testing of this alloy using a chemistry tape analysis?

MR. TAYLOR: I'm not sure I'm following the comment.

MR. AIRD: If we get better information from Preston, we'll get back to you.

MR. TAYLOR: Does anybody else in the room have an idea of what their comment was --

MR. PELLIZZARI: Well, I guess is the intention to, I mean, are you going to intentionally test different alloys with aluminum, or you're just presupposing you're going to get different alloys with aluminum in your various equipment?

MR. TAYLOR: So we don't know what the population is out there. So we looked in a little bit, and there's some variation among the alloys that we could procure that are commonly used in electrical conductors. So we wanted to make sure that we were being representative but also, if there is variation among there, that, you know, we vary it accordingly. And what we're asking here is do we think that that parameter has a large effect on the HEAF phenomena, HEAF energy?

MR. MELLY: And as part of the Cooper testing, it was also a question that came up as to what the composition or the alloy of aluminum is used for the enclosure. This is very difficult information to obtain from the specifications that were done 30 - 40 some odd years ago as to specifically what alloy of aluminum is used in the manufacturing of the equipment, and there are primarily two different predominant alloys that can be chosen for use in the electrical distribution, as well as the enclosure design.

MR. TAYLOR: Did you get any clarification? Okay. We'll wait on that. Again, I put this equipment separation up here because it was on the board back there and I thought it might have some impact, at least for the instrument. So is there any additional discussion on that?

MR. SHUDAK: This is Tom Shudak from Nebraska Public Power. So just a sort of clarification on this question. Those rotation racks will have coupons on there that will be able to determine the impact on equipment. I think it's important that we are going to have cables on there to see if those can ignite.

The location of the equipment is also important, too, and that they can penetrate that equipment because that's one of the ways we're looking at it. It's not just a three foot or five foot. It's also to the point where it comes up against something non-combustible that's going to stop the projectiles. So those facing that is, I think, critical. Right now, I think we're using three foot and five foot, so I think we have to follow on at least with the current, and the tighter those are the better. I'd hate to have to go from three foot to nine foot if I modeled it in our current plan.

MR. TAYLOR: All right. So maybe I can rephrase this. Rather than equipment separation, sensor separation or measurement device location. That might be a better way to characterize it.

MR. MILLER: Was that what the item was? Like GDC 17 separation?

MR. TAYLOR: So I think it was related to one of the comments that Bob brought up of over equipment having both safety and non-safety equipment in the same room and the separation can vary. So that's kind of where I got it from, but, you know, from a test parameter, how do we relate that into what we're going to be capturing? I think it might fit better on where we locate the instrument rack so that we can then, you know, look at the impacts that we're measuring from the instrument racks to the separation because separation is plant specific. I'm not sure we can go out and capture everything for the test years that we're going to do.

MR. MILLER: This is Kenn Miller. When I think of separation, too, I guess the conducted plume aspect of this is of interest because of the visibility to reach beyond the range, particularly filling the room.

MR. TAYLOR: So on that piece, we're looking to use those aerial gels by carbon tape and then do the XPS analysis to see what the conductivity is. We don't have a live measurement of conductivity, like a temporal measurement. Obviously, if anybody knows the way to do that, we're more than interested to learn about it. But that's one way we're looking at measuring the conductivity. And, again, those coupons can be put on these instrument racks and post-analyzed.

So if I can kind of rephrase the parameter to measurement, what did I call it? Measurement separation or measurement locations. Maybe in the comments, we can put target locations. And position, yes. So distance, as well as whether it's above, to the side, in front for positions.

So anymore discussion on that parameter there? Okay. So who thinks that this is a highly important parameter for the experimental? Thirteen. So thirteen high. I don't think there -- that was pretty much everybody. Medium? Medium importance? And low?

MR. MELLY: We also got the most votes for this one.

MR. TAYLOR: Okay. Make sure you save that file, Nick. I don't want to lose the progress we've made so far. So I think that's all I had for the list. Were there any other parameters that we thought were important, or not important but we felt should be considered and ranked? Okay. Not hearing any. Is there anything else from this morning's discussion and early afternoon's discussion on test parameters that we want to touch on?

MR. MILLER: Or definitions.

MR. TAYLOR: Is there anything on the webinar?

MR. TURNER: Does anybody ever anticipate using arc resistance switch gear in the future where the flap opens and all the hot gas goes out a vent and goes around a corner and gets dumped outside or something like that? Does anybody anticipate having that? Because we haven't done any testing on that stuff, even though it really helps the worker who's standing right in front of the cabinet. We keep telling the people that invented it that this is really bad for us in fire protection because now you just put the flame over there. The response is yes, but we've got barriers in there. It captures most of the heat, and those emissions only last for a couple of tenths of a second, so they're consumed. So if we had one of these long arcs, here I am putting the flame out 20 feet away from where the accident is and changing it. So I'm just curious if anybody ever plans on putting those things in there, which are great for personal protection but horrible for . . .

MR. MELLY: Stan.

MR. GARDOCKI: We are in discussion on our panels. We were discussing how the arc transits through the atmosphere, so one of the parameters I was thinking, the atmosphere conditions, whether it's humidity or dryness, temperature, if that's the case of the arc transiting through an atmosphere but arc versus a thermal arc or something like that, is atmospheric conditions going to influence how far this heat goes with the aluminum that's in the cloud? I would open that for discussion for anyone who thinks that would be an impact on this aluminum heat.

MR. TURNER: A parameter of interest?

MR. TAYLOR: Was that something that the NFAA or IEEE will do for all their arc flash testing that you're aware of?

MR. EARLEY: No, we did not.

MR. MELLY: As part of our testing on phase one, we did record all atmospheric conditions on test days: humidity, temperature --

MR. MILLER: Those were outdoors, right?

MR. MELLY: -- barometric pressure. We were outdoors. So we did have a range of conditions that we tested in. Rain the Japanese tested in, but a lot of snow. We were outside. We covered a fairly good range in Pennsylvania. We have not taken the time to look into the effect, primarily because we didn't have the electrical conductivity measure live to make the comparison to humidity or other conditions. But that's something that I guess is still open for discussion right now whether we think that's an important event.

For my opinion, I think it may be of importance to the initiation and to the frequency, as well, and some of the events, the Monshawn particularly saw the humidity, the atmosphere, and the salt, potentially the outdoors, that could have contributed to the initiation of the event. I don't know about the consequence of the event. Dan.

MR. FUNK: Yes, I would second what Nick is saying. I've seen an amount of research done for pollution and surface contamination but only as an initiator. Like, a lot of utilities have programs where they go out and wash down switch gear and stuff for just their very purpose for the measure, what part of the country you're in or where you're at for cumulative deposits of pollution and continue to degrade the overall surface resistance, but I've never heard it being a factor once you get an arc started. It's such a minor contributor to the temperatures and forces.

MR. TURNER: My perception of it is the original atmosphere that starts in the cabinet is completely changed in five milliseconds. Everything is completely difference because you push all of that out real quick. And then the plasma itself is behind the initial pressure front, and it's kind of doing its own thing in its self-made atmosphere. There's not much difference in that self-made atmosphere, depending on the original conditions.

So I agree. It might have something to do with the initiation of the fault that started it. But once you get that arc going, it kind of, I don't think it's going to have much effect at all. And you can see some of the effects on the atmospheres around it because there's a lot of tests with SF-6. So you don't even have air insulated anymore, so you know that SF-6 and air insulation see some differences in terms of how the arc is located and the energy, but not as much as you'd think. So I don't know if you'd want to handle SF-6 different than here.

MR. TAYLOR: Okay. That's great feedback. Any other discussion on atmospheric conditions for the actual HEAF event? Okay. Let's take a quick vote then. So who believes that the atmospheric condition parameter has a high impact on the HEAF phenomena? Medium? One for medium. Low? Ten, ten for low.

Anything else that we've missed?

MR. MILLER: I'm sorry.

MR. TURNER: Oxygen availability. Is that an atmospheric condition?

MR. GARDOCKI: You need to oxidize the aluminum to get the --

MR. TURNER: And we're not sure how that works in the testing we do. When I've made calculations, I said let's just assume the oxygen is there. It might run out of oxygen, we just don't know because I've run tests where you get a nice plume going out the top, you could conceive that it could actually draw air in, like your fireplace in your house when you've got plenty of oxygen because arcs feed the oxygen going into the arc, not this way. They feed it from the ins where it's starting.

We plan to run some tests to try to figure out how the oxygen level changes in these larger things. So that's a big effect that we're testing for Japan.

MR. TAYLOR: So any other discussion on the oxygen availability ventilation aspects?

MR. PUTORTI: Tony Putorti, NIST. But that was something that I was thinking of when we originally were looking at ventilation. So, you know, is that something that we've already covered in ventilating the enclosure up top?

MR. MELLY: I think they're linked but a different aspect.

MR. TAYLOR: It might be worthwhile to separate, as you've done here. So, you know, ventilation is just more of a physical configuration and the impact it has on the event versus, you know, oxygen availability, especially on the aluminum piece. Do we have enough oxygen to oxidize the metal? So let's go ahead and -- I mean, it makes sense to me to keep them separate. Does the group agree? I see some heads nod.

Okay. So for oxygen availability for aluminum, who believes that to be a highly important parameter? Eight. Medium importance? Two, three.

And low importance?

We'll do the same thing for copper. So high importance for copper, oxygen availability? Medium importance? Two. And low importance? Nine, ten. Your hand is up, right, Nick?

MR. MELLY: Yes.

MR. TAYLOR: Yes, ten. Anything else? Any other parameters? Anything from the webinar? Okay. So I think that kind of -- I appreciate all the feedback. It's really good information. I think, especially if we go and formalize the test plan and finalize what we're going to do moving forward, it's going to help provide feedback to us.

I think at this time it would be a good time to take a break. So it's 10 after right now. Let's come back at 3:30. And then Nick will get into the test plan and the changes that he's made to it that resolve the comments at the high level and then anything we want to bring up with regard to the test plan and that aspect, we can do that. So we'll go on break now until 3:30.

MR. MELLY: Small-scale testing, you find something or add, I mean, is that going to input something to this, or you don't think you'll have enough time after the small-scale testing to impact this?

MR. TAYLOR: So the question is we're doing small-scale testing and how will that be used to impact how we're going to change the test program for full scale. Okay. That characterizes the question. I don't really see a lot of the small scale on the HEAF phenomena or the energy output really supporting much on the large scale, but the real purpose of the small scale is to characterize the particles to help further develop the model that Maryland is working on. So there will be some information there that can be used, but also it's proof of concept so those aerial gels and the black carbon tape, we can then use that for here and we can put those at those test stands, as Nick was showing you earlier, or we can even put those, because they're passive devices, we can put them inside the enclosure which is really where we want them because that's where a lot of the additional energy from the aluminum is going to occur inside the enclosure. So we'll have some feedback there.

But as far as, like, the HEAF phenomena and the parameters that we're using for large-scale, I don't see the small-scale informing that much. I don't know if Nick or anybody else have anything to add.

MR. MELLY: Yes, I agree. It's more for the additional instrumentation which may be used for the large-scale testing to focus in on that conductive cloud of aluminum, as well as some of the videography that we'll be doing to capture the particulate.

MR. TAYLOR: And that's a good point. And, actually, the question that David Lochbaum brought up, that's one thing we missed is that the Sandia equipment has the potential to be able to track particles to get the velocity, which can be important for the model that we're working on. So we'll probably try that out. We are going to try that out on the full-scale side, so that's another thing in the small-scale we'll be using.

MR. GARDOCKI: How about the percentage of aluminum of the components? Are we going to be able to draw an analogy to how much aluminum grams inside the cabinets, per se, and draw that out to say the more aluminum the larger HEAF, or are we going to do some kind of staging or percentages of aluminum content?

MR. MELLY: We can get into that a little bit when I discuss the test plan as our plan for evaluating that and trying to make some energy calculations, yes, energy correlations based on how much aluminum is missing from the bus bars after the test program, how we're going to be collecting that information, and post analyzing it. And, hopefully, there will be drawbacks to the small scale because, as Dave said, one of the things that we're looking at is the amount of aluminum that is removed in a small-scale testing to do our energy calculations there, which is one of the reasons why we're downsizing the bus bars at Sandia so that we can more accurately predict how much aluminum has been removed from the bus bar.

MR. TAYLOR: Does that answer --

MR. GARDOCKI: Yes, I mean, I don't know if you want to incorporate in your test parameters to get good representation of how much will be consumed or if it happens too fast, consume all of it, or how much in a particular time period. I'm not sure whether the physics of these dynamics of how the plasma develops and time spanning of the arc.

MR. TAYLOR: Yes, I think that's something that we'd probably measure on the back end, so measuring before and afters.

MR. GARDOCKI: If you don't have enough

aluminum in there, then you're not going to get the spectra.

MR. MELLY: I think we have that covered in both the factors that we have on the board, such as the ventilation, oxygen availability with the aluminum, as well as the duration of the event will both influence how much aluminum is involved in the process.

MR. GARDOCKI: But your cabinets are going to have a certain amount of aluminum or you're going to add it into it.

MR. MELLY: The cabinets will have a certain amount of aluminum, and we will be measuring the total weight of the bus bars before we run the test and after we run the test so we'll know exactly how much aluminum was lost during the test. One of the uncertainties, I will say, will be that we do have this particulate and you can see the objective, which is solid aluminum, rather than oxidized or vaporized aluminum, so there will be particulate when we have these tests to see the multiple aluminum pieces, as well as the slag thrown in all directions in the high-speed videos. That will be the uncertainty of the test. But in terms of the bus bars, we will be doing putting in post-monitoring of the weight of the bus bars themselves. So that's one aspect that we'll be looking into in greater detail in the phase two test program, which does add a lot of time to the post-processing and the analysis of each test that we plan on running. And I'll cover that in a little bit more detail on my next presentation.

MR. MELLY: All right. I think we're ready for a break, and we will come back in 15 minutes.

(Whereupon, the above-entitled matter went off the record at 3:14 p.m. and resumed at 3:34 p.m.)

MR. MELLY: Okay, we're going to get started here real quick on the -- this is the second to last presentation. It may end up being the last.

A lot of the comment review, we've kind of knocked off one by one throughout the discussion in the morning.

I'll quickly go through that last presentation, but I think that we may have covered almost everything.

So, this presentation is focused on the second draft test plan, what we've been talking about mainly all this morning, a lot of the parameters and things like that, but this will dig in to the actual document that we released for public comment as well as the updated version that we released for this meeting.

So, some of the objectives that we have semi already covered is discussion of how the phenomena identification and ranking table influence how we are going to be doing the testing.

Some of the experimental variables that we are going to be focusing in on for this second phase of testing, how we're going to be doing the measurement for the second phase of testing, what members we are currently working with inside the OECD.

We've alluded to the fact that we do have 10 members. We'll share those members right now.

We're going to discuss the test structure which we've also shown a little bit, the experimental approach and the time -- the current time line which is very fluid, depending on how -- when we can get arrangements, contracts in place, updated test plans and things like that.

So, these were what the phenomena identification and ranking table identified as high important phenomena.

So, the cabinet to cabinet fire spread and secondary arcs and cabinet line ups, this was seen as a high parameter of interest from several countries, especially because we did see cabinet to cabinet fire spread in the Onagawa vent as well as additional secondary arc potentials in that lineup.

The thermal damage criteria and target sensitivity, for the short high heat exposures which we've discussed earlier, this gets to what we've been discussing this week as the -- we've been terming it target fragility as to how we make that link between this high heat extreme exposure for a very short period of time and whether that cable or secondary piece of equipment, will it be damaged?

Also, the likelihood and severity of secondary fires. We've been discussing this as to, if we have a short event, it's unlikely to actually propagate a secondary fire or a fire within the actual cabinet of origin, different methods of getting about that.

One of the high parameters was also the performance of HEAF shields. This is postulated method for mitigating the effects of damage from a high energy arcing fault through the use of a barrier between the cabinet of origin or the bus duct of origin and your secondary targets.

The performance characteristics were looked at as highly unknown and it was important to gain more understanding as to how those would perform in the actual HEAF environment.

Also, a high parameter was the likelihood and severity of damage from the arc ejecta on electronic equipment. This is what we're referring to for the aluminum cloud that's created as to what effects that can have on potentially shorting out secondary equipment.

Metal oxidation, that is in terms of the effect of aluminum and copper and the added energy from the oxidation of that aluminum material and the electrical -- the arc electrical characterization is to the points of voltage, current and duration. And, they're not in order of 1 to 10, these are just the high parameters.

So, these are the focused variables and we have covered this in great detail. And, you can see here that I've identified that this was going to be a focus for a later discussion through Gabe's questionnaire is that we're trying -- we were going to try and pin down collaboratively the current and the duration of testing which we have done, and discuss the methodology that we created and put in the test program.

So, the current that we discussed earlier of using was a range from 15kA, 25kA for low voltage and 25kA and 35kA for medium voltage.

The arc duration, I think we discussed that and have decided that we should nominally be testing at the 2 and 4 seconds for both the low voltage and medium voltage range and the bus ducts, I think we maintain that we'll still be testing at 1 and 3 seconds.

There were two additional tests at 5 seconds and the driver for those were some international focus to have a longer duration event that corresponded with some of the operational experience, and especially on the generator-fed events.

Also, in the Phase 2, we've discussed that some of the main priority in the U.S. is this aluminum versus copper, so the electrical enclosure conductor material as well as the different configuration of bus ducts switcher I think that we have covered adequately.

Again, very little changes. You see a lot of what we've done here is in the last exercise we did that went to binning as well as I think that we've covered every single one of these that's on the board in terms of the importance to the zone of influence calculation.

Equipment type, bus bar material, bus duct material, voltage, current, frequency, power configuration, equipment grounding, arc duration, arc energy, bus bar insulation, bus bar spacing, bus bar size.

We did a pretty good job during our discussion this morning.

So, the measurement parameters that we're going to be focusing on, we had the presentation yesterday from NFPA where they had to develop a lot of the instrumentation it was using because of the challenge to actually collect the information.

We did this in parallel and it seems like we actually ended up in a similar place as to how we were collecting the information and what we were collecting.

We're going to be -- in the test report, there's actually a great detail into how these were developed.

Tony published a paper for the SMiRT which covers in great detail how these heat flux measurements are working and detailed.

We're going to be looking at the temperature and the heat flux, the pressure we've discussed at internal to the cabinet.

For room pressure is an area that's not currently in the test plan but it may be slated for one of the spare tests if we have the budget.

We're also going to be documenting the furthest extent of damage. This was one of the tools that we were using the video for as well as post-test analysis.

We're also going to be looking at the mass of material vaporized during the tests. We discussed that in the last presentation. We're going to be doing pre- and post-test measurement of the cabinets themselves for the potential to develop the approximate energy release models from the classic energy conversion models.

This also has ties to some of the small scale testing and whether linkages can be made in the small scale energy release versus the large scale on mass loss.

We also discussed the cable sample materials. This is the cable hoop-ons that we discussed. We're not going to be doing full cable trays. And, we covered that one in pretty good detail.

And, the byproduct testing. So, we're also going to be looking to do the conductivity measurements through, again, the proof of concept small scale work that we're doing, capturing that affluent that comes off and also coats material. We're going to be doing spectroscopy on that.

One main difference between the RGR fault Phase 1 and Phase 2 is we will not be measuring heat release rates in the Phase 2 of testing.

There were several reasons for that, one of them primarily is being that we only really saw the benefit when we were collecting heat release rate information on that in during fire within the cabinet.

If it was actually under the hood, that initial blast overwhelmed the hood with, I believe our max capacity for that hood was around 1000 kilowatts, 3500, but it mainly was based on how much smoke we collected in a short period of time and you can see the entire facility was full of smoke, we're losing it. We had -- were exposed to the atmosphere and wind conditions.

We used -- tried to use a lot of curtains

-- wind curtains to capture as much as we could. But, we didn't really have a good way to capture all of that.

Additionally, it was extremely time consuming to set that up and work around when we were trying to put the instrumentation stands up and things like that.

So, by removing that, we'll have a higher focus on being able to collect the heat flux data at varying distances away from the cabinet.

This goes into the measurement devices that we plan on using. For the temperature, we have thermocouples, plate thermometers and the IR imaging camera we referenced.

For the heat flux, we're going to be using the plate thermometer for the time varying.

For the average we're going to have the plate thermometer and the thermal capacitance slugs which are new for this Phase 2 program.

Incident energy, we're going to be doing the equivalent slug calorimeter so we have comparisons to the NFPA testing as well and to the IEEE.

For the compartment internal pressure, we're going to be doing the piezoelectric pressure transducers.

We also, in terms of videography, we've covered that fairly well.

We have the IR filter videography, the IR imaging. We have high speed cameras and high definition cameras placed at various locations around the test.

And, again, we're going to be doing that surface deposit analysis with links to the small scale testing.

So, in terms of the international members, we have Belgium, Canada, the Czech Republic, France, both their IRSN and which is the regulatory body and EDF which is their -- on the power generation side.

We also have Germany, Korea, Japan, again, we have CRIEPI which is their electrical power research institute.

And, we have the NRA which is the regulatory body.

We're also going to be including the Netherlands and Spain.

So, from the previous test program, we are gaining EDF, the Netherlands and Belgium and the Czech Republic as additional members from the first round of testing.

The only member who is not participating in the second round that was in the first is Finland. And, this is primarily due to resource constraints, personnel challenges and for the ability to participate.

So, we have covered this in fairly well detail, but just to go over it again, is that the tests in blue will be part of the OECD test contribution and the ones in orange were those specifically driven by the GI program.

And, our focus, the U.S. centric focus on additional aluminum tests.

Same goes with the bus duct testing. In blue is OECD and in orange is the USNRC.

So, we discussed this in detail as well. One of the main things we want to do is limit the test variables. And, this was so that we can have the direct comparison between tests, a low voltage 4 second, medium voltage 4 second.

And, we can look at the differences in the zone of influence, the differences in the calculation hoping to have an identical cabinet so these can be single variable differences in hopes to create that dynamic model based on the parameters that we have deemed to be high importance and we can adjust those to evaluate the zone of influence.

Again, we talked about the repeatable arc location. This becomes very important in the discussion we had about the NFPA testing in that --

In the NFPA testing we discussed that the horizontal direction showed a higher energy flux based on the calculations.

And, you can see on the tests on the picture in the upper left-hand side that, if we had a horizontal orientation and our instrument racks were located in the horizontal direction, clearly we're going to show that there is a higher influence or a higher instant energy reported there.

However, if we have test stands vertically above the cabinet, the vertical orientation is going to most likely show the higher flux from that testing.

So, right now, we want to be able to ensure that our test stands are located in a repeatable direction so we can get the affluent coming out of the cabinet from one of these tests.

If we -- if the arc location comes out the top and we have all of our instrument racks on the side, we're still going to be collecting data, but is that data relevant to the energy release during that actual test?

So, we want to make sure that we can have repeatable tests on whatever cabinet we use, which is why arc location becomes so important where we initiate the arc. If we miss a test, that's a full test where that data is not really applicable or relevant for comparison on the other ones.

Again, instrumentation will be the primary means of data collection. This is in terms of we're not going to have that cable tray above, but we're going to be using the instrumentation, the heat flux, the temperature as a surrogate to make that linkage between the actual materials.

And, again, I just wanted to reinforce this, that no testing will be performed -- no testing to be performed will be subject to any equipment to get to conditions that exceed the equipment ratings.

And, what I mean by that is, if we have a donated cabinet that's rated for 4160, we're not going to subject that to a 6.9kV situation.

So, this was the general lab that you've been -- that we've shown a few times. Multiple equipment rack locations to capture the direction of where we believe the arc is going to go.

This is discussed in detail in the test report in that we're going to have a -- essentially a week -- the first week of testing will be a shakedown week where we are going to go with the proof of concept where we believe the instrument rack should be located, where the arc location is going to be.

And we are going to try and confirm that we can collect repeatable information from these tests.

We're doing that because we don't want to go secure 40 lab days and go just 40 at one time. Because, if we need to make adjustments to the test plan and to how we're collecting the information, we can adequately do that.

Test days are the most expensive part of the project along with the equipment that we're going to be testing. So, we are going to approach it in a careful manner.

So, the time line for the testing, it's not head workshop, but right in here, we're at the April 18th and 19th, the workshop date.

Next week I have the meeting with the OECD International Members where I'm going to relate this information to them. And, essentially discuss how we plan on changing the test plan and finalizing the test plan.

I will also receive their input. I know many of the members have been on the webinar. And, I just want to make sure they have a fair chance to have an equal level of discussion of any plan changes or test changes that do come out of this meeting, that they are fairly gone over with them.

We will be doing a comment resolution. Essentially, we're still working on the comment resolution, we have to go over it a little bit. And, we've received a lot more information during this meeting.

So, we hope to finalize all 91 comments that we have received by mid-May. And, we also plan to revise the test plan based on feedback from this meeting and the international meeting, again, in mid-May.

We discussed earlier, the international agreement is currently held up with the lawyers. And, I left it a little bit vague as the summer is hopefully the data that we will have it signed, towards the end of summer, August.

I think everyone in the room realizes the difficulties with getting past lawyers. So, I really

-- that's a shot in the dark.

Again, one of the aspects of the project is we do have equipment delivery and that becomes a very complicated process from country to country as well. So, we're hoping to have everything shipped to our storage facility which is down the road from the Chalfonte facility in Pennsylvania in the fall, October time frame. And, we look to do the initial test series in October, that is the target date currently.

That first test series will most likely be on equipment that we do purchase, so the purchasing is in that range.

Depending on feedback from this meeting as well as management how the agreement goes, that October date is aggressive, but we hope to be able to do testing then.

Again, the second series of tests, we wanted to correspond that with an international OECD meeting to have our international partners a chance to witness testing. Again, this is in Pennsylvania.

And, Mark has already opened this up to try and set up a field trip up to the KEMA facility so you can see the generator capabilities as well as the KEMA facility.

There will be several rounds of testing. Typically, we like to do a week or two weeks of testing in a row. That can usually accommodate one test per day because of the amount of effort that goes into instrumenting the equipment, safety related checks, high pot testing, prior to testing.

And so, we usually have one test a day for that week.

So, there will be several rounds of testing that goes on to complete the full series of tests which are currently slated at 36 tests. So, there will be opportunities in the future to potentially have visitors a the KEMA facility to witness testing.

We'll coordinate all that under the EPRI MOU or other avenues, I think.

And, that is our current time line of actions with the Phase 2. I think we covered most of this actually in our morning discussion, but does anyone have any questions of the overall picture of how we plan on performing the next series of testing?

MR. CHEOK: What do you mean by initial test series?

MR. MELLY: Initial test series is, that's document and the test plan is our week of scoping tests and to ensure that we're collecting the correct information.

Tony may want to speak to a little bit more of that as to what we envision and why we are calling them scoping tests.

MR. PUTORTI: Because we're using some new measurement techniques and also because we want to make sure that Nick alluded to earlier, that we can get the arc to exit the enclosure where the instrumentation is.

We wanted to just have one week of experiments. If you go and you book two weeks in advance, that doesn't really give us -- if we have to change something, it doesn't give us much time to change it and test days are very expensive so that's why we just want to do just one week to start with.

MR. FLEISCHER: Kenn Fleischer, EPRI.

The small scale testing, it's not integrated in this schedule? I thought it was going to be a predecessor.

MR. MELLY: Yes, the small scale testing is separate from the overall OECD arrangements. So, that's an oversight on my part of not putting it in here.

That testing will fall on the time line, I believe it's June 25th that we're planning on doing the small scale testing at Sandia, that's the initial date we will start.

PARTICIPANT: They're not really tied together, right?

MR. MELLY: No, they are not.

PARTICIPANT: They're independent?

MR. TAYLOR: Yes, so, Nick's correct. June 25th, they start testing, that's the plan. And, we have the final report by the end of September. And then, publication on our end will take some time.

MR. MELLY: Any other questions on the path forward?

(No response)

MR. MELLY: Okay, I'll jump into the comments and I have a feeling that almost every single comment I'm about to show, we have covered.

Do we have any questions from the webinar?

PARTICIPANT: No.

MR. MELLY: Okay.

MR. MILLER: Well, that's good.

MR. MELLY: I'm hoping.

So, again, we've seen this slide. We've got 91 comments in total. Again, that is through the

Federal Registry as well as the EPRI MOU, 27 comments were received by EPRI.

I tried to breakdown the comments into categories because we did receive a lot of redundant comments as well as I wanted to find a way to cover them here.

Some of the comments were on the generator capabilities and the applicability for the HEAF testing. So, the decay of the generator itself as we have received a few comments on as well as the 2250 MVA rating.

We received a lot of comments on the protective relaying and the duration of testing, the equipment ratings and how we're going to be selecting the equipment.

The test conditions, the equipment set up combustible load and cable trays.

Test parameters such as the voltage current grounding team and a lot of comparisons to the IEEE guide for the metal enclosed switch gear rating.

So, some of the main comments that we have -- that we haven't talked about, actually, is that we received one comment that the stated generator capabilities at KEMA were 2250 MVA. That is the maximum capability of KEMA's generator, but that's not what we're going to be testing each piece of equipment to.

So, there was a misunderstanding as to how much power we're going to be using for each test. I think that we've cleared that up through our discussion this morning. That is just their maximum capability.

And, KEMA does essentially dial in the current, the voltage and the duration that we're looking for and we have discussed even the ability to have that decay put on to certain testing. So, we've covered that pretty well.

We've also discussed the -- how they'd use process of the SuperX excitation to compensate for that decrease in voltage, and they have the ability to change that. So, we're going to be looking into that for future testing.

We also are still going to be putting out a request for an example of what that decay looks like.

So, there were a lot of comments as well on the ratings of equipment. And, we've been looking at the apparent power range of the values we selected versus the industry sample averages that Gabe has not shown.

This was part of his evaluation to look at the capabilities. We were looking at the apparent averages and the range that we're going to be testing at.

So, using the above calculation, the square root voltage times current, we calculated the range of applicability for the 4160 as well as the 6.9 versus the industry averages that we calculated from looking at plant to plant variability.

PARTICIPANT: Sample averages?

MR. MELLY: Sample averages, this was not across the fleet. This is tied to the amount of plants that we had access to this data. I believe it was 18 and 23 plants, respectively.

MR. TAYLOR: We had more information of these ratings, so it's -- I don't have the actual numbers.

MR. MELLY: Right.

Well, we can see from this quick look that we were well -- we were inside the potential sample industry averages for what we're going to be testing at.

And, there were a lot of comments on the fact that most equipment is equipment is rated to 500

MVA.

I think that we've covered this one in fairly good detail. There was a lot of discussion of the protective relaying and the potential to test these are going to fault to .5 seconds and 1 second.

And, we discussed why we're not going to be doing the testing in that short duration range.

And, the ability to separate the arc faults in to bins.

We saw those short duration events go into the Bin 15 frequency, not high energy arcing faults. This is a typical electrical cabinet fire because you only have that cabinet damage.

And, the potential to split Bin 16 into these arc blast categories as well as the full on high energy arcing fault, larger extended damage bin.

Again, the frequency of the HEAF events is a current area of work that we're going to be working on under the MOU. And, we plant to start that official work, I believe it was stated this summer on our plan.

MS. LINDEMAN: Yes, later on.

MR. MELLY: So, later on this year, we're going to start that work under the MOU.

Again, duration, I think we've beat this over the head quite a few times. So, we're going to be basing that on operating experience as well as the plant specific designs. And, their circuit protection scans.

That is one area that we want to focus in on under the MOU as well.

And, a good place to look at the current work that's been done on that is in one of those EPRI white papers.

So, again, this is actually a picture from the Fort Calhoun event, the one that did last for 42 seconds. Just kind of wanted to show it as an example of these low voltage events that do hold in for an extended period of time.

Additionally, that event that I alluded to which is the 8 second German arc, and there is a link to where there is more information about that event.

So, we do see that some of these can hold in and there is an extensive amount of damage and vaporization of the conductive material from one of these events.

MR. MILL: Is that an aluminum bus bar?

MR. MELLY: That is aluminum bus bar.

So, in the Fort Calhoun event, the

cabinet itself had the aluminum bus bar and conductive material. And, where the event actually occurred was at a transition point where it went from the aluminum bus bar to a copper stab for their breaker. And, they were using a silver oxide to -- as the transition point for the aluminum to copper.

So, this is one that we discussed a little bit earlier. There were a lot of comments received on the fact that the initial test plant had no breakers installed in them due to both pressure, combustible load and things like that.

We have made a change and included the breakers, all breakers will be included in the cabinets that we're going to be testing.

Again, we talked about the cable trays and how we plan on making the jump from instrumentation to what would be there if we tested a cable tray and why we're not.

We also received a few comments that we need to do a better job at the internal combustible load, what is in the cabinet, how we load the cabinet, what arrangement the cables are in, whether we are introducing cables or we're using stock cable material that come with the cabinet purchasing.

And, we will be documenting all of that, including the size, orientation, mass, cable jacket material, cable instrumentation material. And, hopefully, we'll be including pictures of the internals of the cabinets with each test prior to the test.

The last category was the comparisons to the IEEE guide.

We've covered that in a fair detail right now, but the main point is that we're not trying to replicate the IEEE guide. We have different goals for what we're trying -- the data that we're trying to collect and different objectives.

Our objective is not personnel safety in this case, so we're not going to be -- that's one of the reasons where -- why we are not using the cloth targets.

What you could see from the test videos that Bas showed yesterday is that those cloth pieces of equipment or those cloth markers actually take up a lot of room as well as can potentially inhibit the flow of gases out of the cabinet.

So, we're not looking to do that because, if we show that we burn a cloth target, it's not giving us much information at the location they're specified in the IEEE guide which is very close to the cabinet.

I expect that if we run one of these tests for 2 seconds, those cloth targets will be damaged in every single case.

Question?

MR. FLEISCHER: Kenn Fleischer, EPRI.

Not so much a question, but this is good info, you know, as we've gone through this workshop, a lot in my mind as to the paradigm we came in with has changed significantly.

I think what you're saying would really serve the industry well from a historical perspective is if this is all documented.

MR. MELLY: So, we do have an official comment resolution format. And, I think our plan is to make that public. That's an option that we can make it public as we move forward.

To every comment received, we've identified, if it were -- if it resulted in a change to the test plan, where that change was, how will that comment resolve or potentially an explanation as to why the difference is there.

MR. FLEISCHER: Yes, and that's the important part.

MR. MELLY: Okay.

MR. FLEISCHER: Yes.

MR. SALLEY: Nick, we can make that a part of the CP.

MR. MELLY: We can make that a part of the CP, yes.

Again, one thing that we already did discuss in detail was the wire sizes and why the first round of tests was done at the 10 gauge class case standard versus what's specified in the standard.

We are reaching out for more information on that. I think moving forward, unless we receive some information from IEEE which is in conflict of what we're trying to do, we plan on following the guide and using the 10 gauge for our low voltage and the 24 gauge for our medium voltage.

As we identified in the first series of testing, we had no problem initiating and holding an arc for the medium voltage tests where we did see an issue with the low voltage tests even using the 10 gauge wire.

Another comment was on the arc location and the arc initiation phase angle, how we're potentially differing from the IEEE standard. We've discussed that as well as identified the reasons why we're going to be potentially differing from that location.

Primarily so that we can collect the information in a repeatable manner.

So, that's very important as to where we put the arc.

Again, I pulled this from Gabe's discussion. We flip-flopped, so these were everything we planned on talking about this morning that we've already covered.

But, that is a good point that we did receive all these comments and we have spent a considerable amount of time going over each comment, discussing with our partners, both NIST, KEMA, the International members as to how to resolve these comments, get clarification on what we need to understand in the comment and how it could potentially change the test plan.

So, it is a good recommendation that we publish it with this CP. I believe it'll give a historical perspective on how the plan has changed. We won't have Rev numbers, but it'll give an overall picture.

MR. MILLER: It also documents the interaction with the industries.

MR. MELLY: Yes.

Any comments? Questions? Stones?

MR. GARDOCKI: What's your outcome of this? Are you going to put out a NUREG or --

MR. MELLY: For the comments?

MR. GARDOCKI: For the tests?

MR. MELLY: For the tests?

So, there is a plan.

MR. TAYLOR: You're not going to be able to talk about it?

MR. MELLY: I can get into it and you can correct me if I --

MR. TAYLOR: Okay.

MR. MELLY: -- get it wrong.

So, the test is going to be covered in several different ways. Because this is a complicated project where we are working with the international community as well as we have different phases where we are going to be -- some of the tests are going to be OECD, NEA, some of the tests are going to be NRC exclusive.

The plan is to publish the OECD tests which we are going to be doing internationally under that collaboration the same way that we did with Phase 1 where we have a Report of Test published in the CSI -- CSNI documentation style much like the Phase 1 test with some conclusions of the test program and in that same format.

Additionally, this test will include two NUREGs. One NUREG including tester report of the aluminum tests as well as the overall picture.

And, a NUREG on enhanced methodology. That one's going to be the analysis of all the data and the initial work towards refining the zone of influence, the modeling approaches that we've discussed and things like that.

We do plan on that's a little bit down the road after the test program and we still need to discuss with EPRI -- it would be beneficial to do it under the MOU so we can get involvement and do the analysis much like the Helen Fire Program and the Rachel Fire Program were successful. And, that's a good model to approach this.

Additionally, I believe we're going to have a standalone NUREG for the small scale testing.

MR. TAYLOR: That's correct, yes.

MR. MELLY: So, those are the four pieces that are going to come out of this as well as the NUREG/CP which documents this interaction, so five NUREGs, one CSNI. And two IAs on the international work.

MS. LINDEMAN: Two more IAs?

MR. MELLY: Two more IAs.

So, the Japanese have been performing additional tests focused on parameters such as pressure. And, we're going to be working under an MOU with the Japanese to publish two additional IAs to collect that information. So, we'll have the full leverage of information.

MS. LINDEMAN: And, I assume you'd have a joint NUREG after your report for the briefing you take for it?

MR. MELLY: Yes.

MS. LINDEMAN: Are we talking about that?

MR. MELLY: I should have made a slide on this.

MR. AIRD: Nick, we have a question from the webinar.

MR. MELLY: Okay.

MR. AIRD: It's from Mark Hewitt.

His question is, in the documentation of the enclosure, would an assessment be made as to the inclusion of any other aluminum pieces -- piece parts other than the conductor or enclosure duct?

For example, it uses relays, control

cables and the frame structure?

MR. MELLY: That is a good question and we have started to think about that. And, the questionnaire that went out to NEI was phrased in such a way that if aluminum was part of the conductive pathway that can experience the arc and become consumed during the arcing event, that was what we were looking for in terms of, is aluminum in the cabinet?

So, the real importance there was, can the aluminum become involved in the event and can we have the additional energy release from the oxidation of that aluminum?

So, if we did have aluminum pieces, parts that could be part of that pathway and consumed during the event, we would be -- we are interested in collecting information on that as well as having that part of the test program.

That's going to become important for what pieces of equipment we collect or procure and how -- where we initiate the arc within the cabinet.

So, yes, that is an important part and it's still to be determined based on the procurement of equipment.

MR. GARDOCKI: Gabe, as far as small

scale testing, when do you think you're going to get your report done?

MR. TAYLOR: So, right now, like I said, I write it down to the contractors at the end of September.

So, we'll probably get a draft sometime late to early -- late July, early August. And then, go through an internal review and then Sandia will respond to those comments and finalize their report.

So, a final report from Sandia, I'm expecting by the end of September and then it'll go through the publication process which takes a few months.

MR. GARDOCKI: Months?

MR. TAYLOR: Yes, that's been our recent experience.

MR. GARDOCKI: And, it won't be publically available until next year?

MR. TAYLOR: That's right, late this year or early next year, depending on the politicians, the publications branches.

MR. MELLY: It took them six months to publish the PIRT.

MR. SALLEY: So, you know, did everyone see Stan put on his project man?

(Laughter)

MR. SALLEY: If you didn't, okay.

MR. TAYLOR: The other option which, you know, this is more for the NRC management type direction is, you know, we could always issue it as a Sandia report rather than a NUREG. That would get it out a lot quicker, but it wouldn't have the, you know, the NRC NUREG stamp on it.

I'm not quite right now, but that's something we'd probably take back and discuss.

MR. GARDOCKI: Well, just for the eyes to see the report and the results at a quicker pace before the --

PARTICIPANT: Will this be released for public comment?

MR. TAYLOR: We weren't -- so, the question is when -- how fast we can get the information out and also will we release it for public comment.

For a lot of the testing that we've been doing lately where we've issued it for public -- the test plan for public comment, we haven't been going through a draft version followed by a final version.

In a lot of cases, it takes over a year between the draft version getting put out and getting the final version.

So, we weren't planning on doing a draft for public comment on this one. And, Mike Cheok has a comment.

MR. CHEOK: So, I think, you know, we can -- as soon as we approve the reports and your report, we can have a public webinar to announce the summary of the results and for results that might influence the next set of tests we do through that publically, we are now in a public meeting.

MR. TAYLOR: And that's a very good suggestion.

MR. GARDOCKI: Yes, I was just concerned of getting the results of the small scale testing. I'll be fully due to initial testing, in the time line of there. But, your initial testing, I've forgotten the date.

MR. MELLY: It's on the other presentation.

MR. TAYLOR: I think it's October, right, the first phase?

MR. MELLY: Yes.

MR. GARDOCKI: So, you think we can get something publically out before that October?

MR. TAYLOR: We can probably have a call

or a webinar to discuss the results, but the actual get a document out in the public around, I'm not sure we can meet that.

MR. SALLEY: Gabe, with the schedule here, I understand that Nick's schedule is very aggressive.

MR. MELLY: They tend to be.

MR. SALLEY: Yes, it's extremely aggressive. So, please don't hold us to this schedule. I mean, with some of it, the challenges we've got with the --

You know, we've got to work with the lawyers. We've got to get that right and we've got to work with our international partners. And, those things all take time.

So, we're not going to sacrifice quality for speed here. So, you know, we'll slow it down to ensure that we get the quality.

So, again, this is very aggressive.

MR. MELLY: For the first phase, I anticipated getting done three tests a day. And, that did not pan out, and 5 tests a day for the low voltage.

We did not pan out meeting that goal. KEMA usually shuts down shop at around 3:00. They're on a different schedule than most.

We got done one test a day.

MR. TAYLOR: Yes, but I think, you know, as soon as we can get agreement with the results, we can communicate them in some form to the public and move on and not have to be delayed by the publication schedule.

MR. GARDOCKI: Especially with the important players. I know you're going to need the results very quickly, the small scale test, right?

MR. PUTORTI: Not to do our part.

MR. GARDOCKI: No?

MR. PUTORTI: You would need the -- I think that you'd need the small scale results for would be where would technologies you're going to take from small scale measurement technologies and use them in the larger scale. That's what you would need the results for.

But, as far as the results, I'm not sure how much that's going to change the first round of the full scale. I don't see that.

MR. GARDOCKI: I was thinking more along the lines of coupons and degrees of temperature, ranges to measure what the expectation of plasma coming out of this would be.

MR. MELLY: Right. And, we will have -- those are developed right now and we will have those available to be putting in the first round of testing. We just won't have the results published by the time the initial tests are taking place.

MR. PUTORTI: All right, but if you're referring to the techniques that Sandia's looking at using for the small scale and bringing those into the large scale, that will take time for them to field. But, it won't change the rest of the large scale plan.

MR. MELLY: For instance, those coupons that Gabe was referring to to collect the eject of the aluminum, they are developed and available now so we can still use them in large scale testing.

Whereas, the relevance and whether we should be investing our time and energy is going to come out of the results, that's where the main trust and the main resource drag is for the small scale.

But, we can easily put them in the cabinet right now, shelve them and wait to see if they're worthwhile to be tested.

MR. FUNK: This is not the first time we ran into this issue. So, what we did in the past, I know, Gabe, you're familiar with this, once the NUREG report has gone through tech review, and we're really confident there's not going to be any technical changes, that's when we started using it.

Can a target date be established for tech review? Because I believe that would be within your control where publication will not necessarily so.

MR. TAYLOR: I think that's reasonable. It's really going to depend on the quality of the first draft that we get from Sandia and how much, you know, feedback or changes the NRC reviewers see from that document.

And, but, if there's not much change and we don't see technical changes from the first draft, they may well make quick changes to address those comments. And then, at that point, we could get agreement within the NRC to, you know, issue the results or have the discussion of the results at that point.

So, I think that's the reasonable approach.

MR. MELLY: Yes, and again, to keep in mind that the small scale testing is going to be much in the style of a report of tests where there will not be any methodology changes proposed in that small scale testing.

MR. TAYLOR: Yes, they're not going to try to, you know, do some type of modeling of the results to extrapolate different variables and how it affects particle sizes and whatever the other aspects of the testing are.

It's just you test at these variables, this is the size distribution, this is the fraction of oxidation, whatever they need to report.

MR. MELLY: Any other questions, time line, schedule, outcomes?

MR. PUTORTI: Just one small detail, we discussed this earlier in the day.

But, when we decide or when we get the enclosures that we're going to be testing, the question out there about if they do arrive with bus bars that are insulated, do we want to leave them in that state or remove the insulation?

MR. MELLY: I think that is going to depend highly on some of the things we have discussed here today.

For the internal or for the cabinets, the enclosures themselves, I think that we will most likely be -- it depends on how we procure them, but I see that typically they're not going to -- no insulation for an enclosure cabinet, we may be removing.

If they're for the bus bar or for the bus ducts, I think the decision was to test half and half with insulation and non-insulation.

MR. TAYLOR: I wouldn't see us going out and making a change to equipment. I think we'd want to procure it.

MR. MELLY: Yes. Now, one question that I think we may have missed in the discussion earlier, we were talking about procuring these cabinets and the initial thought was that if we're -- let's say, we're running 20 tests, 10 at copper, 10 of them at aluminum.

If we can procure both copper and aluminum from the same manufacturer, we will do that and the bus bar spacing may be a little different.

However, if we can only procure aluminum or a copper conductor, are we going to fabricate the aluminum equivalent for the other test series or for the other tests that we're going to run and what factors would be important if we go down that route.

Because, our electrical contractor right now does have the ability to wholesale and replace all the copper conductors inside the cabinet with aluminum conductor material. I know that may alter how the design is working based on the spacing of the conductors internal to the cabinet.

Are there anything -- any concerns or approaches that anyone has in the room that we should keep in mind of if that's the route that we have to go?

MR. SALLEY: You're driving into the heart of Ken's discussion about the we won't buy the equipment starting out.

MR. FLEISCHER: No.

MR. MELLY: Yes.

MR. SALLEY: And, we can't take that. And, that's was -- Ken, that's what I got from your whole discussion on that.

And, we need to start out with something that is certified.

MR. FLEISCHER: Right. Well, that discussion -- Ken Fleischer, EPRI.

That discussion was based on the premise of my paradigm coming into this workshop was that we weren't getting donations, I didn't know about donations and we would procure the equipment.

And, therefore, we would have total control over configuration.

In this particular case, I guess my

thought is, is why don't we just review what is our end game in mind? Our end game in mind is to see if the zones of influence are affected by the additional vaporization or oxidation of aluminum.

If our target is to set off or find out what kind of switch gear is going to do that to set off the equivalency between copper and an aluminum switch gear configurations may not be as important.

But, I think we should strive to try and keep some similarity with what we've got and minimize modifications.

I think if we start modifying things, then we have thrown in a new variable that we may not have fully thought through and have unintended consequences.

MR. MELLY: I agree.

And, on the flip side of that is that because that is one of the main parameters that we're looking at is the copper versus the aluminum, and the delta of the damage states between them, trying to minimize the amount of variables that we have different in that case is very important.

So, for instance, if I buy all aluminum GE Magne-Blast and all copper Westinghouse, that's a huge difference immediately as to the potential damage state.

So, it -- whereas, I may be qualified aluminum for the Westinghouse and qualified copper for the GE, those are two immediately different cabinets which may have distinct zone of influences just on the cabinet design.

I wanted to try and limit the variables and I would love to find a manufacturer that can spec the copper conductors and the aluminum conductors in the same box. I just am not too familiar with manufacturing processes or the catalogue availability of this.

MR. MILLER: This is Kenn Miller.

I agree with you. I mean, if a manufacturer can sell above waste of waste --

MR. MELLY: Right.

MR. MILLER: -- that gets over this issue of making a new design yourself. It's not, quote, certified.

MR. MELLY: Exactly.

MR. MILLER: Whether that's true on that.

MR. FLEISCHER: Yes.

MR. MILLER: You should certainly start with that if possible.

MR. FLEISCHER: Ken Fleischer from EPRI

again.

Yes, yes, I'd buy that that's what would be preferred. I guess maybe the bigger question, because I'm still not sure, are we looking to try and do this testing program with 100 percent donated equipment?

Or, are we looking at donated equipment and then maybe with what we're going to get and we find out what we have, we can contact, let's say, the majority is going to be the GE Magne-Blast copper. Can we contact GE to maybe replicate a unit in aluminum?

MR. MELLY: That would be the ideal.

So, to answer the first question, no, we're not looking to have the majority of the test program on donated equipment. We're going to be using donated equipment for several of the countries who are not unable to provide monetary donations to be all inclusive to our international members who are interested in this work.

The rest of the equipment will be purchased and procured through several of the contracts that we have in place right now.

MR. FLEISCHER: Okay. Well, then that sounds good. And, I think we can be smart about it by looking to see what we have.

MR. MELLY: Okay.

MR. SALLEY: Or, as we -- or, Ken, as we discussed today, if we have some, you know, U.S. participation, well, some of that equipment we would be more than happy to work with you.

MR. MELLY: Yes.

MR. SALLEY: So, again, if we're looking at some of the plants that are closed up or -- I talked to Brenda Simril a little bit, TVA's cleaning out some warehouses, looking at some surplus. I know there's a lot of stuff out there, there's more out there and it would be very open to working with the industry on some of this.

MR. MELLY: Yes, and if we do receive more donated equipment, that is a good suggestion that, whatever we do receive in donations, it actually allows us to test more equipment because that's large cost driver for the test program, but we can reach out and see if there is an equivalent design or specification for how the internals need to be swapped out if we're going to be changing the conducting material.

MR. MILLER: Kenn Miller, NRC.

So, that is captured, though, what we try and when we try and go out and buy the additional, we will look for that option of getting the same design with both types of material.

MR. MELLY: Yes.

Sorry, I went off on a tangent there.

MR. TAYLOR: Anything else then on the test plan?

MR. MELLY: All right, is there anything else on the test plan, either webinar or in the room?

Anything we think we haven't covered or something you had in mind prior to the meeting that they were looking for a discussion on?

MR. TAYLOR: I think there was one follow up question from EPRI. I think Ken, he went back and looked at the fault monitoring equipment for the one event he talked about earlier.

Did you want to add anything on that?

MR. FLEISCHER: Ken Fleischer, EPRI.

Yes, I need to go back and go through the data in detail. So, I can put something together concise, but I have very high resolution digital fault recorder raw data that we can pull together.

It's for a 6 second -- it was not a -- well, I don't know, I mean, it was an arc but it was an arc on the high side of the bushings of the main power transformer.

And, I have the high data resolution just to give you a quick summary of what it looks like, it looks like in the first 26 cycles, it drops to the pre-position point for the voltage regulator. So, it goes from about 22 kV down to 17kV for about 26 cycles and it holds steady. It's a very short duration.

My belief is that that's where the exciter switch gear breaker is still in service actually exciting the rotor.

Then, after that, you see a quick drop to about 50 -- so, that was about a 20 percent drop.

So, then you see another 30 percent drop down to about 50 percent. And, I believe that is when the exciter field breaker now pops open so now the field is no longer excited and it's residual magnetism.

And, yes, it slowly decays from there just as I would expect. It's a, you know, an exponential decay. It's not as fast as I thought and it continues well beyond 6 seconds. But, the final arc finally extinguishes at about 6 seconds.

What I can do is compile that together and maybe like a small mini white paper. I could provide that back to the group and we can send it to KEMA to see if they can replicate that decrement curve.

Now, the thing is, is that it doesn't have to be an exact replicate, but I can give them the raw data, they can get as close as they want. But, it's definitely clear, there's a lot less energy coming out of that generator than if you were infinite bus through a transformer.

MR. MELLY: So, one of the things that would be a potential work around as well, if KEMA cannot replicate that decrement curve, there is the potential to calculate the energy release during that event and align the duration to the equivalent total amount of energy release.

MR. SALLEY: Ken, yes, that's a great idea. And, if we can do that, you know, this CP that we're talking about isn't going to happen overnight. So, if we can work with EPRI and do that, we'd be happy to include that and document that in here.

So, we're really open to that.

MR. TAYLOR: Any other follow up from this morning's discussion or this afternoon's discussion on the test plan? Are there any, especially on the test plan, are there any comments that Nick really didn't cover and you need a little more information or background on the NRC's initial disposition of the comment?

MR. MILLER: This is Kenn Miller, NRC.

I will do something probably with the HEAF definition and adding back in some time data based on the 2 and 3 seconds, based on the switch gear and the breaker ratings.

And, maybe we'll put that out to -- that's the only thing I'm thinking of in terms of definition changes that we've talked about. But I'll put that out there and we can look at it.

Unless anybody else had anything else on definitions?

(No response)

MR. TAYLOR: Just getting back to, if there's nothing else, so, as far as the generic issue program discussion, I think it's worthwhile on our end to go back and formalize the milestones and dependencies so that when we do get asked questions, we have a more formalized and clearer response to that and direction on of how and when these different milestones are going to be completed.

On the PRA realism, I believe we need to continue working with EPRI on the frequency and the classification as well as these definitions. I think it's going to be very important especially from a PRA model to make sure everything aligns.

And, I should probably also put up here the very important thing on the pilot plants. And so, we'd like to identify some pilot plants for the GI program, potentially go out to the pilot plants and understand what the risk is for these HEAF scenarios with aluminum.

So, identifying the right pilot plants. Nick talked a lot about this about, you know, if they already assumed top isolator, everything in the room's lost, well, you increase ZOI, it's really not going to have that big of a delta risk for those scenarios.

But, there could be other modeling or compartment configurations where an increased ZOI may have an impact.

So, understanding what the risk change is in the plant for these events is important. So, I'd look to EPRI and possibly NEI to help us out to identify the pilot plants and support that understanding.

So, I think that's very important in how we go about that. We'd have to work with the Stan and the GI program and include everybody that's in that program working on it.

Also, we had some discussion of going back and understanding what tests IEEE and NFPA has performed for their research and make sure that we're not being repetitive and understand what came out of that work. We have that action item.

We talked about fault currents. So, for the personal safety, I think there's a lot of information that the plants have already done in that analysis. And, this gets into the fault currents that we're proposing for the test plan and the sample data that I pulled up, you know, is that representative of what we've seen in the personal safety assessment?

So, that's one for industry to go back and look in and just verify what we're doing, if it's in line with those studies.

Also, on sample circuit characteristics, this is one that Dan and I identified if there's any characteristics that are important for the tests limiting X over R or anything else that we would want how KEMA sets up their lab, we'd like that feedback.

We talked a little about the arc locations. Really need to get a clearer understanding of where we should put the arcs. So, I think we have the three, at least for the enclosures, the three locations where we potentially put it.

But, we haven't come up with a definite road we want to go there. So, any feedback on that one would be important for us.

And, we agree, the equipment document when we get, we need to understand what the, you know, the manuals are for that equipment and document it in the report, this is what we got, this is its rating, this is how we tested it, pretty straightforward.

A more recent discussion, manufacturer design verification for the aluminum versus copper. Once we identify what equipment we want to procure, we have to reach out to the vendors and say, hey, we will bind this in copper.

If you're going to have aluminum or maybe they have aluminum in that product line, how can we configure it or could you maybe point us in the right direction to procure that equipment if we can't find it.

So, bringing the manufacturers in to make sure that we can test real representative equipment, it's important. That's on the NRC side to perform and go through procurement.

And, the last one I have here is I put EPRI on it, but the decrement curve. If we can get some information on that, we can work with KEMA and go from there for that.

So, I think that's the majority of it. I don't think we have too much traction on the verification tests. So, right now, I don't see that as being forward on our end. If there's discussion otherwise, we can bring that up now.

And, the other thing that we haven't really resolved is the grounding. So, you know, should we just move to ungrounded, resistance grounded? I don't think we can come to a conclusion here on that.

MR. MELLY: No, we have not.

MR. TAYLOR: We did rank it the day before, but I don't remember what that was.

MR. MELLY: We ranked the importance during -- we ranked it as low here with a few highs. A high left the room.

And, we had it ranked in the PIRT as well, so we'll take that into consideration moving forward. And, I'll discuss it additionally with the international members next week.

MR. TAYLOR: So, I think that's kind of the action items we have coming out of this meeting. Is there anything else that I missed?

MR. MILLER: Kenn Miller, NRC.

One thing on the equipment documentation, I know you mentioned the equipment is being donated by the Koreans and Germans.

Depending on who you're getting equipment -- who we're buying stuff from, if it's secondhand refurbishment commonplace, they may have access to documents that we would need for the other items that are donated, assuming we get the information on what exactly they are donating.

So, there may be ways to get documentation through that same contract that we're buying the equipment from to help us with this part of the deal.

Unless, I mean, we may get stuff from the people that are donating it, but if not, that may be an option to get it.

MR. MELLY: That's a good point.

MR. TAYLOR: That is a good point.

MR. MELLY: In terms of output from this meeting, what people can expect, we do plan on issuing the NUREG/CP which will document all of the presentations that have been given, some of the notes that we've taken during the meeting. That's a little bit longer term.

Do we plan on putting out a meeting summary?

MR. TAYLOR: So, this is a public meeting, there will be a meeting summary, short two-page meeting summary of what took place. But, it won't be as detailed as the CP that we'll put out in the near future.

Questions in the back?

MR. FUNK: Kenn, I think this question is directed to you.

Yesterday, you mentioned that there is going to be an interest in looking at this testing and the results from a more traditional Class 1-E general design criteria perspective with regard to the generic issue.

What about your fire guys, for all practical purposes and so you can see that's the focus of everything here.

So, with regard to the pilot plants, what are your expectations or what do you see their involvement as it relates to the generic issue from the perspective of single failure and GDC-3 explosion?

They might not approach it, I mean, just as good to go forward with the blinders on if fire PRA unless we know there is some difference.

MR. MILLER: I'm not really sure how to answer that, to be honest with you. Because I'm still a little bit fuzzy on how this plays over on the GDC side because of the single failure criteria.

And, by definition, these HEAF events are indicative of a fault and then failed protection which goes beyond single failure.

So, I'm not really sure how to can that yet. But, I guess my thought was at least being aware of how this plays out and see if there's any issues with, for instance, some of the criteria we have for physical separation between safety trains and whether or not an event like this, you know, has the potential to affect and alternate train.

So, I'm not really sure yet how that plays. Just know that, you know, on the surface it's we've got to think about independence of safety trains and how this could affect that.

MR. FUNK: I understand. What is the inherent nature of doing the deterministic safety analysis, we know that fire can affect multiple trains, you know, as a common cause. But, the Appendix R analysis --

MR. MILLER: Yes, fire --

MR. FUNK: -- deals in that so, it depends on while we're looking at this as this is a fire event or something else? Because that determines whether it's a single failure impact or not.

MR. MILLER: Well, in GDC specs --

MR. FUNK: Under the design basis criteria.

MR. MILLER: In GDC specs, it's a single failure. I mean, that's what you talk about, you know, the safety systems, what your dual train and you have some fill there of safety function assuming it's single failure.

So, I'm not sure.

MR. FUNK: Okay. There again, the safe shutdown analysis, if you separate -- and the single rule specifically states you do not assume single failure so, that's a rimless oxymoron.

MR. MILLER: Right, that's -- that's kind of a separate thing.

MR. FUNK: I've reviewed this.

MR. MILLER: That's a separate rule. But, yes, I'm not sure, I'm not sure.

MR. FUNK: I understand, sir. Thanks.

MR. MILLER: That will be an interesting observance when it comes out. And, I know that's what Bob was thinking also.

MR. GARDOCKI: To follow up with your saying that, there are some mitigated measures that we explored during our committees. The heat shield was one that we kind of touched on but we didn't go into depth on and I don't think industry is really, well, explored that and come up with anything that's qualified on how this is going to affect that type of mitigated measures.

So, this is really going to affect some of those mitigated measures.

There is some photo detecting, you know, light sensitive tripping breakers that the industry is exploring right now.

I'm not sure what stage industry is taking credit for those as mitigated measures for this kind of arc flash and tripping the breaker within microseconds.

So, those are some exploratory mitigating measures out there that we don't know exactly where industry stands. I don't know if anyone here can touch on that.

MR. MILLER: Kenn Miller.

I know one thing I would say, based on looking at this type of event, certainly preventative measures is something I would be looking at from GDC deterministic perspective, obviously, that your protected schemes are proper in terms of clearing faults as quick as possible within the 2 second limit of the equipment which should preclude this type of event in the first place.

So, I mean, from -- so, from that side of the house, I would -- that's something I'm hoping to see out of, you know, reaction to the industry and they go back and look at their preventative measures and getting in a position where this kind of event can't occur.

So, that's an important lesson here, I think, just because the potential of this event to do damage.

MR. TAYLOR: Anything else? We're getting -- I think we're starting to wind down here.

Anything from today's or even yesterday's discussion?

(No response)

MR. TAYLOR: What about on the webinar,

Tom, do we have anything coming in through the webinar?

MR. AIRD: No public comment on the webinar.

MR. TAYLOR: We do have to open up for public comment before we close.

MR. AIRD: All right, let's do that right now.

MR. TAYLOR: Okay, so, for those on the phone line, I'm going to have Tom open up the phone lines which will take a few seconds here. And, if you do have any comments, please identify -- unmute your phone, identify yourself and then make your comment.

So, I'll wait for Tom to give me the nod that the phone lines have been unmuted.

Okay, the phone lines are open, so if you have a comment, please identify yourself and make a comment.

Okay, so I don't hear any comments from the public. Okay, no comments during the public comment period.

With that, we'll go ahead and move to Mark Salley for some closing remarks.

MR. SALLEY: Yes, and then, Mike Cheok is going to make a couple closing remarks here at the end.

But, thank you all for attending. Gabe did a good job covering the actions. This is a couple I just wanted to touch on here.

Actually, working under the MOU, I'm sorry, I just wanted -- yes, work on the MOU, two things I just want to touch on.

Again, you saw the KEMA offered on the field trip if that makes it more understandable, the generator, the facility and that, please talk with NEI. If we have anything there, we'll be happy to set something up.

And then, do a -- meet you up there for a day trip or something along that line.

The other thing is, Gabe, again, touched on this, too, and it's the risk analysis nuclear pilot plants. Again, that's an area where we could work with you to get that and move the generic issue along, we would like to work with EPRI on that one.

MS. LINDEMAN: We would need to understand your expectations for a pilot plant as well.

MR. MELLY: We'd need a follow up meeting to be sure on specifically the pilot plant questions and actions.

MS. LINDEMAN: Do you want me to repeat?

MR. SALLEY: Sure.

MS. LINDEMAN: Yes, I think just clarifying the timing of the pilot plant just seemed that was uncertain. And, where the intern ZOI fit in to all of this, that and then, just what your expectations are.

As you saw, there's a wide variety and just tell us what you need.

MR. SALLEY: Okay. And, working on the MOU I can get with you and we can talk about that.

And, let's see, that's the only thing I've got, so I will give it to Mr. Cheok.

MR. CHEOK: So, thank you again for coming out. I know two days is a lot. And, thank you all the people on the webinar and the public phone lines, two days is a lot of time to spend with us and that's not even counting travel time. So, thank you.

And, hopefully, you'll have learned something about our process and understand it a little bit more.

I know, I sit in here and I understand your comments and your questions and concerns a little -- a lot better. So, I'm glad I showed up and we had this thing.

And, I apologize to those people out in their presentations yesterday afternoon. I fully intended to be here, but I made a mistake of opening some emails at lunchtime. So, that kind of affected my afternoon.

So, again, thank you. But, I want to mention something else, too. So, the generic issue process and everything else involves more than just the Office of Research.

NRR is also a player there, you know, our counterparts they are totally involved in this. And, I know my counterpart, Mike Franovich has been following this here with EPRI now and I've had a couple of emails from him, you know, actually making comments and asking questions.

So, he has been listening in. He's not been here, but so we have been working fully with NRR and they are on board and we will continue to have a panel basically with NRR and Research as we go forward.

Again, thank you.

MR. TAYLOR: Okay, with that, that's the end.

MR. SALLEY: Oh, one other thing. I'm sorry.

MR. TAYLOR: One more.

MR. SALLEY: Before Mark calls, is Kenny Hamburger not here, he's in Paris, you know, he did a lot of work to set this meeting up, do all the presentation material put together. So, I think we should thank Kenny for doing all that.

MR. MELLY: He's potentially still on the phone still working at 11:00 Parisian time.

MR. SALLEY: Mark Earley turned around and he reminded me of something.

So, Ashley one other thing with the definitions, NFPA and Research have been working and we've been having a few webinars, exchanging some ideas.

Mark has a very impressive thing that we've been talking to and we've been talking to and we've been learning a lot about the work they've done.

If you want to dial in with us on the definitions, Mark, if that'd be okay, we'd get EPRI, you know, you and Kenn work with us, we'd really appreciate that. And, I think, again, with that collaboration, I think we could really get some high quality work turned around and a lot of work.

Okay, with that, we'll go off the record and we're done.

Thank you very much.

(Whereupon, the above-entitled matter went off the record at 4:52 p.m.)