UNITED STATES OF AMERICA

U.S. NUCLEAR REGULATORY COMMISSION

PUBLIC MEETING WITH INDUSTRY TO DISCUSS

SAFETY/RISK ASSESSMENT RESULTS FOR GENERIC

ISSUE 199, “IMPLICATIONS OF UPDATED

PROBABILISTIC SEISMIC HAZARD ESTIMATES IN

CENTRAL AND EASTERN UNITED STATES

ON EXISTING PLANTS”

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9:00 A.M.

TRANSCRIPT OF PROCEEDINGS

Public Meeting

APPEARANCES

Panel:

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NRC Staff:

Brian Sheron
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P R O C E E D I N G S

MR. SHERON: Okay, good morning. We can get started. Thank you all for coming here. My name is Brian Sheron. I am the director of the Office of Nuclear Regulatory Research at the NRC.

One of the activities administered by the Office of Nuclear Regulatory Research is the agency-wide generic issues program. My technical staff has been working since February 2008 on the safety and risk assessment for Generic Issue 199 entitled “Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States for Existing Plants”. Generic Issue 199 has presented a number of technical challenges, particularly in the areas of developing an analytical approach and identifying appropriate data to use. We have overcome these and other challenges to complete the safety and risk assessment.

The purpose of today’s public meeting is for the staff to communicate the safety and risk assessment and methodology and results for Generic Issue 199 and to discuss NRC’s plans for going forward. Following our presentation, industry will have an opportunity to give remarks and all stakeholders will have an opportunity to ask questions. Today’s presenters include authors of the Safety and Risk Assessment Report: Jon Ake from the Office of Nuclear Regulatory Research, Division of Engineering, who is a seismic expert, and Marty Stutzke from the Research Division of Risk Analysis, who is a probabilistic risk assessment expert.

In addition, John Kaufman [spelled phonetically] is here to give an overview of the generic issues program in order to provide some context for the Generic Issue 199 work. John has been the Generic Issue 199 project manager since January of 2009. Toward the end of the presentation, Pat Hiland, director of the NRR Division of Engineering and the Generic Issue 199 panel chair, will talk about the regulatory path forward on this issue.

I apologize; I'm going to have to leave. I've got -- I mentioned I have three more meetings this morning and the like, so I'm going to turn it over to John and I'm sure I'm leaving you in capable hands. Thanks.

MR. KAUFMAN: Thanks, Brian. I'd like to welcome everybody in the room for attending today's presentation. This meeting is also being webcast, video teleconference to the regions and we hope to have a bridge line up and running.

This is a Category 2 public meeting. That means that we will be discussing an issue that could potentially affect multiple licensees. We are here to get stakeholder feedback on the work that's been done and the path forward and there will be a period for public question and answers.

Couple admin items. There are sign-in sheets. Anyone that hasn't signed in, please do that. There are also meeting feedback forms that we would like filled out so that we can learn and do better in meetings in the future. Brian briefly went over the agenda, and I will give some background. Marty and Jon will talk about the work they did for the safety/risk assessment. Pat Hiland will talk about the path forward. Industry will be invited to give summary remarks, and then the Q and A period. Next slide, please.

As Brian mentioned, the generic issues program is an agency-wide program administered by research. We have a Management Directive 6.4, so it is a formal program. Primary value that our program adds is we try to advance understanding of issues, we find the best place in the agency for the issue to be worked, we keep other offices involved and informed and develop consensus on how to move forward, and we engage stakeholders at key points throughout the process. For GI-199, for example, we had a public meeting after the completion of the screening back in February 2008. For those that are interested, we have a link to our public website that is at the bottom of this slide. Next slide, please.

Our program has five stages. They are identification, acceptance, screening, and on this slide that's highlighted, safety/risk assessment portion. This is where we are now. So we are far along in the process. This issue has been analyzed, it's been paneled with a multi-office panel, and a report's been issued and our recommendations have been endorsed by Brian. And typically in our program, if an issue were to continue through our program, the last stage would be the regulatory assessment stage. Next slide, please.

What is GI-199 about? In simple terms, it's the scientific understanding of earthquakes as advancing and changing. In particular, as this G.I. is entitled, they have changed and increased in many locations in central and eastern U.S. In this example curve here, we can see at the Safe Shutdown Earthquake level, which is where plants are designed to be safe and important safety systems are expected to withstand the earthquake and remain functional, we can see that these on the left, these curves all converge at about the same point: at about 4.5 times 10 to the minus fourth per year. Or another way of saying that is we expect an earthquake great than -- for this example plan, of greater than 0.1 G about every 2,200 years.

What GI-199 is really about is if we go out to the right on this curve, I picked a point at 0.7 Gs to illustrate the older IPEEE-era curves produced values of about four E to the minus six, or that is saying that about once every 250,000 years, we expected an earthquake greater than 0.7 Gs at this point. The more recent curves in this picture, the yellow curve at that same 0.7 G level is about two E to the minus five per year, or about once every 50,000 years we'd expect an earthquake at that level or exceeding that.

Now, we all recognize that nuclear power plants have a 40 to 60 year lifetime. So what do these changes mean? How important are they? What, if anything, should be done about them? That is the gist of what GI-199 is about and what we try to answer in the safety/risk assessment. Next slide, please.

In a little more formal terms, in the safety/risk assessment, Marty and Jon and the panel were tasked with two items, and that was basically to determine on a generic basis the risk associated with this and whether it warrants further investigation or possible imposition of [unintelligible] and provide a recommendation for going forward. And as it's indicated on the slides, it could be to go to regulatory assessment, it could be to drop the issue due to low risk, or it could have other actions taken outside the generic issues program.

And with that, Jon Ake is going to talk about the technical work that was done to try and answer the question of, what is the risk of this issue?

MR. AKE: Thanks, John. Yeah, I'd like to start out with a few slides that walk through a little bit of the background for this generic issue and then Marty and I will sort of tag [inaudible] a step through our technical approach that we developed to try and perform the evaluations for this generic issue during the safety and risk assessment stage of the generic issues program.

The map we show in this slide illustrates a couple of points we'd like to make. First of all, to reiterate, this is -- the title of the generic issue is given on the slide and it's the implications of updated seismic hazard estimates in the central and eastern United States. So the scope of this particular investigation was limited to those plants that are in what we refer to as the central and eastern United States, which is approximately east of the longitude of Denver. And of the 104 operating reactors, 96 of the reactors fall into this category. So that provided one of the challenges that we had to deal with in working on this generic issue was the vast majority of the plants fell under the scope of this. However, explicitly, those plants on the West Coast were excluded because of the way the generic issue was written in the first place.

Secondly, this deals exclusively with existing power plants, the operating reactor fleet. So any of the -- any questions anyone might have with respect to the relevance of this for the early site permits or COL applications that are currently being reviewed, those are being reviewed explicitly by the Office of New Reactors under a different regulatory framework and this generic issue doesn't really impact those proposed plants at this point in time.

The other thing that this slide illustrates is the differences in earthquake potential across the continental United States. You can see there is a plot of operating reactor fleet as well as felt and damaging earthquakes, the earthquake locations given by the small dots on this figure. You can see the majority of the earthquake activity is confined to the western third of the continental United States. That, again, provides unfortunately some challenges here for us in that the earthquake genesis and the mechanism for earthquake genesis in the central and eastern United States are not as well understood as they are in the more active regions of the western U.S. So, with that, let's go to the next slide.

As we said a moment ago, a current -- this generic issue applies to the operating reactors and the applicable regulations; all of those reactors were licensed prior to 1997 and the applicable regulations are in 10 CFR 100.1 and Appendix A, that's where they -- at least with respect to the seismic design basis for the plants. And in blue on this slide are a couple of relevant facts and then language down below as well from the Appendix A and Part 100. It's important to point out here that prior to 1997, the approach taken to develop the design basis for the existing reactor fleet was a deterministic approach. By that, we mean there is no explicit specification of the frequency of occurrence or how often the design basis events might occur. And that's important when we now move to post-1997 and the approaches that we're taking today; that is an important difference between the existing reactor fleet and the next generation of reactors. Also, the regulations in Appendix A and Part 100 are based on a review of earthquakes that have occurred near the site. And that, again, has -- we'll discuss that again in just a moment.

Within Appendix A and General Design Criteria 2, as Jon mentioned a moment ago, the structure, systems, and components that are important to safety are designed -- must be designed to withstand the effects of natural phenomenon, that includes earthquakes in this case, without the loss of the capability to perform their intended safety functions. The language from the -- Appendix A is in blue on this slide -- and it's taken, I think, verbatim or very close to it, appropriate consideration of the most severe of the natural phenomenon that have been historically reported for this site and surrounding area. And the phrase "historically reported" provides a little bit of context in terms of approximately how often the design basis events that were developed -- [break in audio] -- Appendix A were expected to occur. And also, an important -- another bit of important language from the regulations is that the design basis must include sufficient margin for the limit accuracy, quantity, and period of time in which the historical data have been accumulated. And we again point out that the -- there's no requirement for periodic reassessment or the seismic design basis in the current regulations for the operating reactor fleet.

So, I'd like to step through for just a couple minutes -- next slide please -- how that language then was applied in developing the design basis for the existing reactors. The figure of merit, if you will, for this is what termed the "safe shutdown earthquake" or SSE, and in Appendix A, the SSE is defined as the earthquake that provides the maximum vibratory acceleration at the site. The way that was developed in the process were historical events in the area and region around the site of interest, here shown as a big X on the slide here. Earthquakes that occurred in this area were evaluated. The sizes of those earthquakes in terms of magnitudes -- [break in audio] -- based on either macro-sized observations such as types of damage to structures, and then those earthquakes were assumed to occur at the closest point of either the tectonic structure that was producing those earthquakes or in the geological region or regime around the site of interest. The closest approach to those -- of those geologic structures to the site of interest was to find is the distance. So there was some -- in essence, there was some conservatism potentially added to this process in that the location of these earthquakes were -- there was some transposition of the location of these earthquakes to put them -- bring them to the closest approach to the site. Keeping in mind that we don't design engineered structures for earthquake magnitudes -- we design them for ground motions, vibratory ground motions -- those earthquakes then have to be translated into something that we can use. The figure of merit there is something that's referred to as the site acceleration value. And empirical ground motion prediction equations or attenuation relationships are used to determine the site acceleration resulting from these various earthquakes that were evaluated in the process. Next slide please.

Now, since all of our structure systems and components, or at least many of them, are sensitive to different periods or frequencies of vibration, we have to find some way to represent that in our design process and we do that with the safe shutdown earthquake ground motion, and it's shown in the form of what's called a response spectrum. And we show the -- illustrate the definition of a response spectrum on this slide. It's the peak response of a series of single degree of freedom oscillators of varying natural frequencies at a constant damping all plotted on the same plot. And the important thing here is this -- the site acceleration value that we described in the previous slide is used as an anchor point to anchor this spectral shape, this response spectral shape. And this is what's used in the design process subsequently.

Another point that we'd like to bring up about this response spectral shape is this is what's referred to as a standardized response spectral shape. It was derived from the analysis of observed recordings. There are several different vintages of this that were used for the existing fleet of reactors. Typically what was done with those suites of recordings that were analyzed is 84th percentile values of the spectral -- of the various spectral ordinates were defined -- used to define the spectral shapes. So there are some additional conservatisms that probably added to the design process by this approach.

And a couple of things that -- two points to keep in mind here -- one is this is a determinist as we alluded to a couple slides ago -- this is a deterministic process. There is no specific frequency of occurrence for the SSE, and that the SSE is derived by the methodology in Appendix A, then become plant-specific. And in fact, they are plant-specific to the extent that even for co-located [spelled phonetically] reactors in some cases, the neighboring reactors have different SSEs assigned to them, which again, provided some challenges as we moved forward through the process and Marty will touch on that a little bit later. Next slide please.

This slide summarizes a little bit about what led to the genesis of Generic Issue 199. And this provides a comparison of response spectra again. In this case, it's what's referred to as a uniform hazard response spectrum; the definition is given on the slide on the left. Uniform hazard spectrum represents -- all the spectral ordinates represent a constant annual frequency of probability of exceedance. So it enables us to then make apples to apples comparisons between response spectra in this way. And this shows a comparison for the Vogtle site. The results from the initial early site permit at a particular annual exceedance frequency compared to results from the late '80s vintage electric power research or EPRI study at the same annual exceedance frequency level. And you can see that the blue curve here is the ESP result. You can see it envelopes the earlier EPRI vintage results at all spectral frequencies. And noting that this plot is in log-log space, we would note that the exceedances are not trivial in this case. The SSE is plotted for reference here as well. Keeping in mind that the SSE, you know, is not an apples to apples comparison in this case because it's not a specified annual exceedance frequency associated with that. These types of observations are what -- of reviewing the early site permits is what led the NRR staff at that time to submit what is now Generic Issue 199 to the Generic Issues Program. This was accepted given that designation G.I. 199 and subsequently screened [conference call interference] assessment phase of the Generic Issues Program. Next slide.

So once this generic issue came in to the program and began -- we began to work on [conference call interference] assessment phase --

[conference call interference]

MALE SPEAKER: Okay.

MR. AKE: Once this issue entered the safety and risk assessment phase, we had to make some choices about how we were going to approach the problem. And in terms of the seismic hazard portion of the assessment process, we recognize that we had a number of different requirements that we had to do, as we alluded to in the first slide about -- the maps [spelled phonetically] slide a few moments ago. We needed to evaluate 96 different plants in the central and eastern United States. They happened to be located at 68 different sites. Co-located plants, for this part of the assessment, were the seismic hazard part of the assessment were treated as a single entity. We felt that the hazard didn't vary significantly from plant to plant. So we needed to be able to find a process that we could apply across the inventory of operating reactors in the central and eastern United States.

We felt it was important to incorporate site-specific geological information about near-surface geological conditions to the maximum extent we could. The approach that we took was the following: the solution that we came up with was we decided to perform a probabilistic seismic hazard analysis for each of those 68 sites and we decided to use the software that was developed by the United States Geological Survey to produce the national seismic hazard maps which are used in the national building codes in the international and national building codes. This was pretty well-vetted and we could apply it systematically across the entire operating fleet. At the time we began this, there were only a handful of existing updated assessments in terms of the ESPs and COLs that were available in-house. And so we looked at those, but we didn't have those systematically across the entire inventory, so we used the USGS software recompiled with minor modifications for our uses. And the way we decided to do this was we calculated these specifically for each site for rock site conditions and then we made some adjustments which I'll discuss briefly in a moment, to make those as site-specific as we could.

So the output of this was the following: it was a set of seismic hazard curves for four spectral frequencies for each of the 68 sites that we looked at. And then taking those results, there were two things we needed to produce. One was the hazard curves themselves, which Marty will describe how those were used in a moment, as well as something called the ground motion response spectrum that is sort of the basic building block for the SSE as we would do it today following Regulatory Guide 1.208. So there were really two things that we developed as an output of the seismic hazard assessment here. Next slide please.

This slide illustrates results for one site and we produced these for each of the 68 sites. On the left are the four different spectral frequencies that we developed seismic estimates for and this is -- the results for rock are shown on the left. And we did a -- we produced results for peak ground acceleration: 10 hertz, five hertz and one hertz. We also recognized that the type and thickness of near-surface geological materials will have a very pronounced influence and effect on the strength and characteristics of the ground shaking at any given site. So for those sites that weren't located on rock -- for those nuclear power plant sites that were not located on rock, we made adjustments to those. An example is shown on the right here, the two blue curves -- the dashed curves in each case show the modified or adjusted seismic hazard curves after we've applied the appropriate amplification factors for deep-soil site, in this case. The output then that will go to -- forward to be used in the safety and risk assessment are the final adjusted seismic hazard curves as well as the ground motion response spectrum for each of the different locations. I should point out that the area of interest for developing the ground motion response spectrum; if you look at the Y-axis on these two graphs, is in the range of 10 to the minus four to 10 to the minus five per year. And a different way to think about that is that 10 to the minus four, given a 50 year exposure period or life of a facility, 10 to the minus four is approximately one percent probability of exceedance in that 50 year exposure period. Next slide please.

Additional information that we used in the safety and risk assessment came from the Individual Plant Examination of External Advance or IPEEE program. The IPEEE -- one of the external events that was considered under the IPEEE program was seismic. And fortunately for us, the IPEEE program also considered the implications of beyond design basis ground motions in their assessments as well. As part of the IPEEE program, a review level earthquake, or RLE, was defined for each of the plants. The spectra of the RLE exceeded or equaled the SSE and was used in the IPEEE assessment. Each of the plants demonstrated plant safety either by calculating low core damage frequency or high seismic margin. The core damage frequency was computed as part of a seismic PRA. The seismic margins approach was used for the remainder of the plants. Approximately a third of the plants did PRAs and two-thirds, roughly, did SMAs. For us, it would have been nice if more explicit consideration of developing -- you know, in hindsight, it would have been helpful to have more explicit development of PRA-type results, but it’s important to note that the emphasis of the IPEEE program was on developing risk insights rather than on computing specific risk values. And within the IPEEE approach, there were two different sets of seismic hazard information that were used by the different plants. Some used the results of the 1989 EPRI study, and others used the results of the NRC-sponsored Lawrence Livermore National Lab study. An important point to keep in mind here that we’ll touch on in a moment is that the results for these two different sets of seismic hazard -- these two different seismic hazard studies are different at most plants. Next slide please.

So our assessment really stepped -- really had two phases to it, and we stepped through things in a somewhat orderly fashion, we thought in hindsight, although, at times it didn’t seem orderly when we were going through it. The first part was to develop, as I said before, our GMRS using our USGS seismic hazard model, following the Guidance and Regulatory Guide 1.208. And then once we had defined that GMRS, we made a series of tests for each of the different plants. First we tested against the SSE and the question we were asking was if we were develop -- to develop for an individual plant a new SSE today, would it equal or exceed the previously developed SSE. And for approximately two-thirds of the plants, the answer was yes, we did produce a GMRS that exceeded the SSE. Then recognizing that most of the plants had been evaluated for a review level earthquake that exceeded the SSE in the IPEEE program, we tested against the previous review level earthquake, and we found about a third of the plants exceeded the GMRS that we calculated with the new hazard model -- exceeded the previous review level earthquake.

And then recognizing that the estimation of seismic hazards intrinsically has significant uncertainty associated with it, we tested against the earlier seismic hazard results produced by EPRI in 1989 and the 1994 version of the Lawrence Livermore study. And the question we asked there was does the new GMRS we computed with the updated seismic hazard model exceed both the older GMRS computed using the older seismic hazard results, and the answer was at about a little less than 25 percent of the plants, that was the case. So at the end of that, the seismic hazards at certainly some of the plants has demonstratively increased. So this certainly appeared to validate the judgment of the NRR staff who originally wrote the generic issue, but one is still left with the question of is there any real risk significance to that, and that's the part that Marty's going to touch on and go over in just a moment.

One last slide that we wanted to discuss a little bit is the concept of seismic margin. And, just briefly, the total seismic margin within any existing plant is due to several -- a number of different factors. The figure we show here -- [break in audio] -- it's this concept. As we described previously, the initial development of the design basis ground motions was based on the most significant earthquake to have occurred in the area in historical times, so that provides at least a little bit of context for, perhaps some conservatism. Also, we noted that the earthquakes were essentially moved, if you will, to a location closer to the site of interest during the development of the SSE. Also, in the development of the spectral shapes that we talked about a moment ago, we noted that those were 84th percentile ground motions that were used in the development of those spectral shapes where there was clearly some additional margin included in the process there. Also, in the analysis process, the SSE is a surface ground motion. We have to translate that to in-structure motions, and the analysis procedures used to do that generally involve an enveloping approach. Some additional conservatism is incorporated in the process there as well.

And finally, once we arrive at those in-structure design motions, those are used in an engineering design process. At that design level, we're not designing anything to fail -- specifically, we are designing things not to fail there. So through the process of utilizing the appropriate codes and standards, there is clearly some additional margin added into the process there as well. The challenge really ends up -- in the end, there is some seismic margin in all of the existing plants -- [break in audio] -- to these processes used. And the challenge comes in trying to estimate the magnitude of this margin for a specific plant and also its context relative to any increases in seismic loads that we may postulate due to new and evolving earth science information.

So with that, I'd like to turn it over to Marty and he will describe how we use this.

MR. STUTZKE: Thanks, Jon. Morning. One way to look at -- to assess the implications of the increased seismic hazard is to compare the risk. One can compute risk using various seismic hazard curves and then from that, determine a change in the risk metric. As Jon had pointed out, we have curves that were developed under the IPEEE era [spelled phonetically] -- [break in audio] -- the Electric Power Research Institute Seismic Owners Group issued EPRI NP-6395 [spelled phonetically] that provided seismic estimates for many of the plants in the country. Be aware that not every plant is an EPRI member or participated in the subjects, so in some cases, there aren't any EPRI sub-curves [spelled phonetically]. In '94, Lawrence Livermore National Laboratory, at the request of NRC, developed a set of seismic hazard curves. These are documented in new reg [spelled phonetically] 1488 and all the plants are addressed there.

As Jon had pointed out, we had seismic hazard curves from the early site permits and the combined license applications for some of the plants that were co-located, and that was the genesis, the origin of generic issue. And of course, we have added applicants as the process of conducting the safety-risk assessment has gone on. We also have a memorandum of understanding what the Electric Power Research Institute for Collaborative Seismic Research. And under that MOU, we have - we were provided information for six sites. It's all good stuff. We had good interactions with EPRI and its contractors. The project manager out there is Bob Cassewora [spelled phonetically]. The difficulty for us is, first of all, we only had six sites' worth of information and the information's proprietary, so it's difficult to use it on a regulatory decision process because we can't release it.

As Jon had pointed out before, the challenge here is the need to assess every plant in the central and eastern United States. Normally, when the staff looks at a generic issue, they pick several representative plants that are relevant to that analysis. For example, if it's an issue that concerns, for example, BWRs with Mark-1 containments, they'll pick one or two Mark-1s and do the risk assessment on that. We don't have that luxury under GI-199 because there's a wide-variability of the seismic hazard across the central and eastern United States, as well as variability in the plant-specific seismic fragilities. I was asked early on in the project, "Can't you just pick a bounding [spelled phonetically] site?" And it's like, yeah, okay, we'll pick the new Madrid [spelled phonetically] seismic hazard and we'll pick fragility of a site down on the Gulf Coast, and everybody's in trouble. Okay, and it's obviously the wrong way to approach the problem. Okay, next slide please.

This map shows you the extent of the variability of seismic hazards. It's courteously of the U.S. Geological Survey's website, which by the way, if you want to learn things about earthquakes, that's the place to go. It's a very, very well-done site. What the map shows you is information like the following. if you look at the green zones up there, what that says is there is a two percent probability that the peak ground acceleration will exceed 0. -- [break in audio] -- next 50 years. When you get to the brown zone, there is two percent probability that the PGA will exceed 1g in the next 50 years.

So, if you just look at the map and focus in on the Central and Eastern United States you see a rather dark band around Southern Missouri [unintelligible] fault region like this. The other one is near Charleston, South Carolina and then some parts up in New England approaching up into Canada. But it gives you an idea, again, of the variability. When you get to, for example, the Florida sites, you know, the figure merits 0.02g's. Okay, so five times slower. I should also point out 0.1g is the minimum in the design basis per part 100 [unintelligible]. Okay, next slide, please.

Management directive 6.4 gives us pretty broad discretion in how we craft an approach to treating a generic issue. The flexibility is provided because each generic issue tends to be unique and so you don't want to run it through a cookbook. At the same time, we are held accountable by our Safety/Risk Assessment Panel shared by Pat Hiland down here who we had to convince we were doing the right things. They made suggestions, so forth and so on.

But when we look at the problem here has Jon had pointed out, we have this issue of generating seismic hazard curves, in order generate some sort of a risk estimate, we need to know something about seismic fragility which is the probability of failure, the probability of core damage given a certain ground motion. For example, peak ground acceleration in one of the spectral accelerations. A good source of that information comes from seismic PRAs. Only 30 percent of the plants through IPEEE did seismic PRAs. The other 70 percent are seismic margins analysis. We will talk about in the next slide how that information was used.

In addition, I'll point out there is very limited information on the seismic containment performance. There was some work done under new reg 1150. The -- [break in audio] -- basically qualitative review like this. Subsequent to the IPEEE, plants have in fact been modified for a variety -- [break in audio] -- directly to fix the vulnerabilities that were identified in the IPEEE. And the other is business as usual in the nuclear industry. People routinely apply for license amendment, changes, tech spec changes, things like this to modify allowed outage times, et cetera, all of which will affect the risk profile of the plant. One of the problems is that we don't know quantitatively the influence of those modifications on seismic fragility in all cases. I would also be remiss if I didn't point out that the IPEEEs were completed before we first had consensus standards on PRA quality. I'm referring to the combined standard developed by the American society of mechanical engineers and the American Nuclear Society that the staff has endorsed in regulatory guide 1.200. Those are relatively recent events. And so there was little or no peer review or [unintelligible] staff review on the results on the IPEEEs like this.

So faced with that, my first inclination is let's go do a seismic PRA at every plant. And since the purpose of the analysis to make a path forward that would a PRA that would be done by the staff. And I got left out of the room by Bryan [spelled phonetically] on that one. So we need some other alternative approach and the approach this way was for each plant in the country, in Central and Eastern U.S., combine the mean hazard curves with the mean fragility curves developed from the I.P. information and estimate seismic core damage frequency. We know that core damage frequency, of course, is the surrogate to the actual public health risk. It’s not a released frequency, but it’s a reasonable approach that’s achievable with the information that we have like that. Next slide, please.

This briefly explains the complexity of competing seismic core damage frequency. This is known as a convolution. Mathematically the idea is that a small range of accelerations, you know the frequency of earthquakes that lie between that ranges. You would also know the probability of core damage. Given that, from the fragility curve you would multiply those two quantities together and then add up the contributions of overall accelerations. Thinking back to your early education, you realize that it’s the definition of integral and therefore, in order to calculate seismic core damage frequency, you need to solve the integrals that are presented up there.

The problem's perhaps even more complex because we are not just solving the integral for peak ground acceleration. We need to do it for one hertz, five hertz, 10 hertz spectral frequencies. We then took a simple average of those numbers. We took a weighted average of those numbers where we use one-seventh of the seismic core damage frequency computed for peak ground acceleration and 2/7th for the remaining one hertz, five hertz, and 10 hertz. We simply use the maximum. And then, not being satisfied with that and pushed a little bit by our panel, we developed what is known as a weakest link model, which is looking at the maximum failure probability across all spectral frequencies at each sliver or each slice of annual exceedance frequency.

Usually, when I get to this point, I'm all willing to lay out the integrals and the math and all that. I guess we don't have time to do that right now. The details of the weakest link model as well as the other computational details are in appendix A of the safety risk assessment report. What this boils down to then is we have three hazard curves, we have eight estimates, and seismic core damage frequency per plant times roughly 100 plants is a lot of computation. All of this was done in Microsoft Excel with some visual basic macros. And run time is not too bad. You set it to recompute and drink your cup of coffee, and it's basically done. It's not too bad. Okay next slide, 21.

Plant level seismic fragility curves, again, on the idea is that you want to compute the probability of core damage as a function of ground motion. The ground motion can either be peak ground acceleration, it could be at a specific spectral frequency, and it could be over a range, an average of spectral frequency select those. What the curve shows you is the higher the ground motion, the more likely these things are to fail.

You generate these curves directly in seismic PRA for the plants' IPEEE that have done seismic PRAs. I went back to this middle, in some cases, the responses to request for additional information. I was able to reconstruct the curves. For plants that did seismic margins approach, you don't generally generate this type of a curve directly. Seismic margins analysis, the figure of merit of this word is known as the high confidence of low probability of failure, commonly pronounced "HCLPF," that roughly corresponds to our conditional core damage probability of one percent. So if I said the HCLPF is 0.3g's, that means if an earthquake happened that caused the site ground motion at 0.3g's there would be a one percent change of core damage for that.

Standard sumption when using seismic fragility curves is they are log normal in shape. So these look like log normal cumulative distribution function. Those have two parameters, what is known as the medium seismic capacity, the C50 value, that's the scale parameter. The shape parameter is known as Beta C or more formally, the composite logarithmic standard deviation that determines how fast the curve rises up like this. So, given a HCLPF and anchoring that curve. Failure probability of 10 to the minus two and assuming a value of Beta C, I can generate the entire curve from the results of the seismic margins analysis. We picked the value of Beta C of 0.4 for our study. We did sensitivities over the range of 0.25 to 0.55 and the conclusions of the study don't change. It's not sensitive so much to the value of the Beta C like that. All the fragility parameters are actually in appendix C of our safety risk assessment report.

Okay, so much for the approach. Slide 22 will begin to discuss some of the results of the analysis. What you see here are known as box and whisker plots in the statistical literature. Let me explain what we mean by them. The upper whisker represents the maximum. So the idea is I take all of the plants and CS, and I compute their seismic core damage frequencies and I sort them from high to low. The upper whisker is the highest value across the United States. The bottom whisker is the lowest value of course. So that tells you that all of the numbers are between that.

The upper box portion is the 75 percentile. So it means, in this case, 72 plants actually fall below that line and the remaining 24 plants are above that line. Similarly, on the 25 percentile, which is the lower box, the green dot is the main the arithmetic main and the yellow triangle there is the median. So 50 percent of the plants are above that line and below.

So what do you learn out of a chart like this? Well the first thing is you see that there are not a lot of differences between the seismic core frequency estimated using the U.S. Geological Survey data, which is recent compared to the older Lawrence-Livermore data. Beans [spelled phonetically] are the same, the medians are virtually the same, and the maximums and the minimums are virtually the same like this. The D.C. lower estimates coming out of the APRI curve like this.

What the graph doesn't show you is that plants are moving within the distributions here. The plant that had, for example, the maximum using the Lawrence-Livermore sets of curves is not the same plant that is maximum with respect to the U.S. Geological Survey data. Neither are the minimums, okay, so ordering, fleet-wide distribution hasn't changed, but the position of plants within that distribution changed markedly in some cases.

The other thing the chart tells you is, well, the maximum, using USGS, is at 10 to the minus four per year. That lets us decide something about the acceptability of risk, okay? When NRR originally sent the generic issue over to us, they had reached a conclusion that there was not a concern with adequate protection, and this graph tends to confirm that because as you can see, all the plants are below the safety goal and they are certainly below our -- [break in audio] -- our instruction. This is NRR office instruction [unintelligible] 504, the concerns with risk-informed decision making during emergent issues, that office instruction was developed after the Davis-Specy [spelled phonetically] reactor vessel had corrosion problems on a recommendation from the government accounting office. So you can see, we are clearly below that guideline like this.

Now, I'd remind you, guidelines risk numbers like this don't define adequate protection. We are not a risk-based agency, we are risk-informed, but we use these guidelines as tools to help us decide if we have appropriate level adequate protection. Slide 23.

In the Generic Issue Program, we have criteria that are shown here in the red line that divide the range into continue and excludes zone. Those of you that are risk analysts will realize this is the same graph that is used in regulatory guide 1.174 for risk-informed license amendment changes. Along the X-axis is baseline seismic core damage frequency. And that baseline will either be from the older APRI SAG data, or the older Lawrence-Livermore data. Y-axis is the change, actually, the increase in seismic core damage frequency. So that is seismic core damage frequency computed from USGS minus its baseline. The yellow triangles are for the APRI baseline and the blue dots are using the

Livermore -- next slide [unintelligible].

What do you see when you look at this? There is a lot of plants above the line, okay? When we talk about continue, what we mean is continue evaluation of the generic issue and excludes means perhaps, we can drop it. So the first insight here is look at it collectively and there are more than a few plants that fall under [unintelligible] zone like this. Now to be fair, you'll notice these axes are logarithmic. So, it's only possible to show you the increases in risk metrics and seismic core damage frequencies. You don't see the plants, you know, where the seismic core damage frequency has actually gone down. In other words, when we use the USGS curves, we get a lower number than when we use the Livermore curve and the APRI curve. So, it's true that for every -- what you would expect is that for every triangle, there ought to be a dot on the graph but that is not necessarily the case. The other thing is to remember that not all plants have APRI data on this. So, let's flip to slide 24.

In an effort to gain some further insight, we generated what we call the "delta delta plot." This is a plot where the X-axis is the change in seismic core damage frequency with respect to the APRI SAG hazard curve and the Y-axis change with respect to the Lawrence-Livermore curve. This plot is on linear scales, it's not logarithmic so you can actually see where seismic core damage frequency estimates have gone down. If I look in, for example, the lower right corner, you'll see a dot there that says there was an increase with respect to the APRI baseline and a decrease with respect to the Livermore indicating the USGS seismic core damage frequency is now bracketed between the two like this.

We have developed a continued zone for this that is based on the Generic Issue Program criteria. The simple way to look at the continued zone on this graph is to say one of the delta CDFs, the changes is above 10 to the minus five and the other one is positive. That means we generated an estimate using the U.S. Geological Survey that is higher than any of the Livermore or the APRI data like this. The 10 to the minus five comes from the previous graph that it shows you. You'll notice there is a notch in the continue zone. That notch is plants where the increases are both small -- [break in audio] -- five. Again, that's consistent with the previous graph from the generic issue criteria like this.

So when you look at this graph, the conclusion remains the same. There are more than a few plants that fall into this continued region like this. The plots that we generated here are based on our -- [break in audio]. You come up with the same conclusion if you use simply the PGA based seismic core damage frequencies. Any one of the individual spectral frequencies, the simple average, the IPEEE average, the conclusion remains the same. You have large numbers of plants here like this.

That being said, at this point in the presentation and realize we have had the benefit to presenting this to management on numerous occasions, everybody wants to know which plant goes with which dot on this graph. And that has caused no small amount of consternation for us as we generated pictures that had all the plant labels on it. And it was decided, no, you're overly focusing on plants like this because our regulatory decision is based on the collective result like this. That being said, I believe a couple of months ago or last month, Eric Leeds was at an industry conference. Eric is the director of NRR, and he actually released the plant names. With that, let's jump to slide 25.

It's probably the one everybody has been waiting for. But actually, there is a good engineering reason to show you this, let alone, the plants are out there like this. The plants that are shown with the circles and the dots are ones where we obtained the plant level fragility estimates using seismic margins. The three plants with the triangles are ones where we estimated fragility using seismic results of PRA. So, what it says to us is, if you look at the proportion of plants, it's roughly the same. There's no great benefit in using SMA or seismic PRA like this.

The other thing that one notices here is there doesn't seem to be that strong a dependence on location. Certainly, clearly plants that are in the southeast part of the country or around the Eastern Tennessee come because that's where the seismic hazard estimates have increased a lot in the last couple of years like this. At the same time, we see some plants that are in relatively small or low seismic hazard zones around the Gulf Coast like this, and they also show up on the graph like that. It's merely a question of, does the seismic hazard match the plant's fragility? That's what determined in the result here. There are 27 plants in the continue zone here based on this. And of those 27 plants, they match very well with the deterministic work that Jon Ake had told you about earlier like this. They line up like that. Again, I urge you to focus on the collective results when you look at this slide; there are plants that are very close to the boarder. Can we flip backwards a slide to slide 24?

If you look at the delta-delta plot, you'll see there are plants that are close to the red line that just barely in the exclude zone. When one begins to consider the uncertainty of the information involved like this, the simplified method of estimating the core damage frequency maybe some of those points should jump from the exclude zone into the continued zone or vice versa like this. Again, we don't have up-to-date fragility information for these plants. We know they have been modified in response to IPEEE vulnerabilities and other modifications like this. That being the case, let's jump on to slide 26.

Do we need considered back fits? That was our charter under the safety risk assessment, and we turn to our screening criteria that are contained in new reg BRR 508, pardon me, that tell us one when we should be thinking about cost justified back fence that provide substantial safety announcements. And we see this table, this color coded table where we have on the X-axis the conditional containment failure probability, and on the Y-axis, the change in core damage frequency that would result from a proposed back filler. The box on the left-hand side, the grey box there is the range of the distribution of values that we calculated using the U.S. Geological Survey for seismic core damage frequency. Since all of those core damage frequency estimates are below 10 to the minus four per year, clearly we are not in the top row of this table of this matrix.

At the same time, we have little information on the seismic conditional containment failure probability. What information we have is somewhat dated, but it suggests that we are closer to the 10 to the minus one, to the right column, versus the left column. So, the results are telling us that we should probably proceed into the regulatory analysis phase. And again, when I talk about that, saying to proceed to the value impact portion, we're talking about all the plants, not just the ones that fell under the continued zone. This will help us answer questions of our uncertainty. Okay, slide 27.

When you begin to think about how to do a regulatory analysis, it became apparent that we don't have the information available right now in order to proceed on that. We would like to have updated sites [unintelligible] seismic hazard curves. In addition to the work from U.S. Geological Survey, there is a effort to build a -- [break in audio] -- seismic hazard curves on some of the participants are of course, U.S. Geological Survey, Department of Energy, APRI are involved at NRC, and I believe those are due next year or so. In addition, we need better frequency dependent, site specific amplification functions to look at the amplification from the hard rock spectrum to adjust to the actual soil conditions. So far, we have used the amp factors that were developed under the APRI SAG because that is what we had available -- [break in audio] -- spectral shape in the likelihood of earthquakes like this. But we need better information. We would also like to have updated information on the plant level fragility and the contributors to seismic risk.

That's the contributors we would used to identify candidate back fits that we could then run through the back fit process. In fact, one could say that is the initial step of doing the back fit analysis, is well, what do you propose to fix like this? The difficulty is that the simplified approach we use generates the seismic core damage frequency, but it doesn't provide incite as to what drives that. We can't tell when we look at the results of whether it is due to the high spectral frequency motions, for example, anchorages or things like this. We can't tell if it's due to the more low frequency motions which are more structurally related like this. We recognize that these are different fixes, may be required at different plants because there all deigned differently like this, and they are subject to this.

So it's a bit of a puzzle -- [break in audio] -- our hands on this type of information so we can in fact, produce with this, even if one looks at the results of the seismic margins analysis, which are 70 percent. The bulk of plants that we have information for, there is a natural tendency to say you picked the component, or the systems structure component that has the smallest HCLPF value, it's the smallest high confidence low value, and you fix that one. But if you look at how seismic margins approach is done, you'll realize that there are multiple success paths, two success paths in there; and you pick the highest one. So the SSC, with the smallest HCLPF value, may not necessarily be the one you need to fix. You may need to fix something else. So it's not at all obvious how to get these plant specific contributors like this.

One more thing I would point out is that when one does a value for regulatory analysis, the idea is to compare the monetized inverted risk to the cost of a back fit. Inverted risk means that we are out in what is known as level three space in the PRA. We need to know things like person REMS, fatalities, off-site costs, these sorts of risk estimates. That adds, as you can well imagine, a whole level of complexity to the analysis that we haven't touched yet.

Finally, and not to be neglected, is the last bullet on the slide talks about the need for repeatable approach for evaluating new hazard information and future updates. As Jon had pointed out earlier, there is nothing in our current body of regulations that requires -- [break in audio] -- periodically reassess the seismic design basis. This issue was determined because the people in NRR had sharp eyes, and they began to do some comparisons and realized that there was an issue there. And we would like to address that in the future by some sort of -- [break in audio] -- hazard information and perhaps other natural hazard phenomenon information and deciding what does it mean. With that, I'll turn it over to Pat for the path forward.

MR. HILAND: Well, thank you. For those who may not have been at our first public meeting back in 2008, I want to thank both the Nuclear Energy

Institute, who represented industry at that meeting, and they suggested and we did work with the electric power research institute over the past two years to finalize the safety and the risk assessment report. For those that didn't pick them up, there is a single sheet of paper as you entered into the conference room that lists the pertinent documents and the library number that you can access them too. And for those persons with a technical interest, I would encourage you to download the Safety and Risk Assessment Report and read it. It's one of the best reports I've seen come out of our agency, and I've worked here for 25 years. Maybe it's because I don't have a seismic background, and the fact that I had to learn a whole bunch of new acronyms that I think that. But it is a very well written report. Results are very clear and very well done. That's just a pat on the back for the two authors on that report sitting to my right.

Remember -- I guess I'll start off with why are we here. All of the 96 plants of interest meet their current licensing basis. That is, that the license of each plant was based on a deterministic assessment, and they submitted -- what they evaluated was they are a safe shutdown earthquake limit. In the mid '90s, early '90s actually, we went through this individual plant evaluation of external events. A piece of that was: how much margin do each plant have to a seismic event? We included from that that the margins were there and they were acceptable. Go back a few years, we find that the U.S. Geological Survey, their numbers increased a little bit, but it wasn't insignificant; it wasn't trivial. And how do we assess that? Well, we didn't have a tool back when we license the current fleet nor in the IPEEE study. It wasn't available.

So that's how we got started, and what we were looking at it is what is the probability of exceeding that license condition? That is, the safe shutdown earthquake. And we have a criteria that we established as you heard earlier following our look backwards at Davis-Specy [spelled phonetically] and the advance that occurred there. We wanted to know what are the probability of exceeding the license conditions. We have a criteria that you heard Jon and Marty go through that says if that probability is between 10 to the minus five and 10 to the minus four, you should continue to look to see if we can consider implementing a back fit. That is we would require new conditions placed on individual plants.

But stepping back and looking at it from the beginning is the -- [break in audio] -- is limited. We had to take some mean values. We don't have all of the information for all of the plants. In fact, we only have detailed information for a few. I think APRI was able to provide us six plants out of the 96. So our path forward is we are going to ask for this additional information. There is a number of avenues or -- [break in audio] -- on the slide. I'm considering a -- [break in audio] -- or that could be a generic letter. I skipped over, I'm not looking at the slide I'm -- [break in audio] -- we have issues and information notice. The purpose of that information notice is really just to alert our stakeholders to the Safety and Risk Assessment Report. I think we put in that information that we may consider, or we would be considering a generic communication.

If we go down the generic letter path, we would have to go through our committee to review generic requirements to ensure that that generic letter does not in itself impose an unwanted back fit. We'll have to go through a public comment there. We will send this generic letter out, we'll ask for the public, our stakeholders to comment on this generic letter and what our request would be. I don't have it prepared right now. It's going to take me some time to get there, but the generic letter if we send it out will certainly include the items on the previous slide, slide 27. And I would work with my colleagues to make sure the request is succinct enough that the licensees can respond to the request. You know, there are some plants -- why are we doing this? Well we are looking to assure ourselves that we have not just adequate margin, but there's some simple things that can be done to improve the margin a facility might very well consider those actions.

That's where we're at. We are going to work as you heard with the U.S. Geological Survey. They're the federal agency who is responsible for evaluating the risk from earthquakes across the continental United States. We are working very closely with them as well as Department of Energy, Electric Power Research Institute over the next months -- I think we have early 2011 scheduled to go back and reassess the -- and I'll call it the methodology we can all agree upon for doing this evaluation.

I think that's all I have for the path forward. They gave me 30 minutes and I told them I think I can do it in three. But we would certainly be open to the stakeholders for any other suggestions they might have. Right now, I think generic communications and generic letter that I would send out with a request for the information is the path I see in front of me, but I'm open to other suggestions. Jon?

MR. AKE: Okay, next slide, please. Oh, you're already there. This is just to wrap up the key points that I would take away from the presentation are: that the operating plants are still safe. Seismic hazards have increased although those increases are -- [break in audio] -- and as they've laid out in great detail, assessment will continue to investigate whether plants can be made safer, and

NRC will continue forward to get the information we need.

With that, that wraps up our part of the presentation. I believe Kimberly Keithline has some remarks she would like to make from NEI.

MS. KEITHLINE: Let's see, this is on? Okay. I'm going to try to make it without making a lot of noise. I'm Kimberly Keithline from the Nuclear Energy Institute. I have very brief remarks so I will get you further ahead of schedule.

I wanted to start by saying that we do, on behalf of the industry, we appreciate the time you have taken this morning to explain, to share with all of us in this room, on the phone, and on the webcast what you have done to evaluate this generic issue. I think that was a very helpful description of the issue itself, the complexity, and the approach you've taken, and we do understand that you've put a lot of effort into evaluating reviewing this generic issue. And we do recognize the complexity of this issue, more so related to how to quantify the remaining margin. We certainly agree with your conclusions that the plants remain safe and that the challenges -- in order to quantify that margin that's built in, or inherent to these methodologies, and ways of evaluating the issue or this technical phenomenon, that there is the challenge.

I did want to mention one thing just to make sure that it's clear. The interactions that have occurred so far between NRC research and APRI, under their memorandum of understanding, have been for the purpose of developing methodologies to use to evaluate this issue. That's really why -- you've mentioned a couple of times that you've only gotten data on a handful of plants, plants specific to data from APRI. The purpose was to use that data to help develop ways of evaluating the issue, not to have APRI under an MOU supply data that would be used in a regulatory assessment. So I just want to make sure for the other people in the room they understand it's not that they were asked to provide information for a regulatory assessment and haven't delivered. But I think from what we have heard the interactions between APRI and NRC research have helped identify some ways to go evaluate this type of an issue, and I think that was the purpose so far.

Clearly, the results of your evaluation lead you to conclude that additional work may be needed. And we on behalf to the NEI industry intend, to the extent that we can and that you would allow us, to help better characterize what information really is needed and helpful in resolving this issue, and to figure out what exactly of that information does currently exist and for the information on that list that you showed us that doesn't currently exist, what would it take to get that information? Some of it -- it's not all just on the shelf somewhere ready to have utilities to hand over to you. So we do want to be sensitive that some of the wish list may be a very large effort to generate. And so we hope we can work with you to find out what you really -- [break in audio] -- of collecting or developing information that might not help solve the problem. So I hope over the next few months, the period of time you have in mind, that we'll be able to work together to make sure that we can identify what's available, what's really needed, and have the right people understand what it will take to get the information that you desire.

And that's about it. I think you have time on the agenda for people to ask questions. I hope they do. I think what you showed us was very helpful, but I'm sure that it generated some follow-up questions to help people better understand what will be required to close out this issue. So with that, that's all I have, but I think that the more knowledgeable seismic folks in the room or on the phone may have some specific questions. Thanks.

MR. AKE: Thank you, Kimberly. Any other industry representatives that would like to comment?

MR. MORRIS: This is Don Morris, Southern Nuclear. I just have one question, Pat, on the path forward. I wrote down that you said go back and reassess. You mentioned the new seismic source re-characterization model. Is that what you meant by that? I was trying to get a clarification go back and reassess.

MR. HILAND: Excuse me. What I currently meant by that is the fact that as we understood, we went back and looked at the individual plant external events and the evaluation of that, the IPEEE. There were plants that recognized some vulnerabilities and made their own internal commitments to go back and install that extra ankle bolt in the tank, or make some modifications of plant. I think that would be the initial expectation I would have is that the licensee when they receive the information -- I have been in several plants that would take an information notice, they would assign this under their engineering department, “Hey, where do we stand?” The information we use to calculate those probabilities that are displayed in the graph is generic -- not generic -- but it’s data that is not up to date. I’ll put it that way, not up to date. It has some uncertainties in it. I would expect the licensees to look at it and see whether they can improve on those uncertainties right now. We may have used a fragility factor at their site that is more conservative than what they believe.

That’s my expectation right now. We’re a long way away from anything further even in generic communications. I’m just requesting information that you have off the shelf as we heard, that would be my initial expectations.

MR. MORRIS: If I understand Pat, what we're talking about is more about fragilities and not the seismic hazard.

MR. HILAND: Correct.

MR. MORRIS: Thank you.

MR. AKE: Any other questions from the audience? We also have the regions form the video teleconference. Any questions from the regions? And we also have people participating by bridge line. Are there any questions form bridge lines?

MR. TALLEY: Yes, good morning. This is Stephen Talley [spelled phonetically] I am a reporter with [unintelligible]. I apologize if I missed this is in Pat's presentation, but I was wondering what's the time frame for the staff's decision on whether to issue a generic communication, and if so, would it be a generic letter?

MR. AKE: Pat, would you take that?

MR. HILAND: Sure. Well, the decision making I would expect certainly by the end of the calendar year to make that decision. But the process to issue a generic letter, I stated in my presentation, I would first take that request for the information in a generic letter form to our committee for review generic requirements. Because I cannot impose an unintended back fit. Then that would be followed by a public comment period on the generic letter. I'd send it out, I think typically for 30 to 60 days for public comment period. Then it would probably take another 30 to 60 days to resolve comments. That's our history. So we're probably looking anywhere between 9 and 12 months to actually get it out on the street.

MR. TALLEY: Nine to 10 months from now, or from when the decision is made?

MR. HILAND: Nine to 12 months from now.

MR. TALLEY: Thank you.

MR. AKE: Any other questions? Hearing none we will close the meeting. There will be a meeting summary that will come out in the next few weeks that will be made publically available. I'd like to thank everyone for their interest and attendance. Thank you very much.

[Whereupon, the proceedings were concluded]