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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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574TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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THURSDAY

JULY 15, 2010

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ROCKVILLE, MARYLAND

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The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:30 a.m., Said Abdel-Khalid, Chairman, presiding.

COMMITTEE MEMBERS:

SAID ABDEL-KHALIK, Chairman

J. SAM ARMIJO, Vice Chairman

JOHN W. STETKAR, Member-At-Large

DENNIS C. BLEY, Member

MARIO V. BONACA, Member

CHARLES H. BROWN, Member

MICHAEL L. CORRADINI, Member

DANA A. POWERS, Member

COMMITTEE MEMBERS: (cont.)

HAROLD B. RAY, Member

MICHAEL T. RYAN, Member

WILLIAM J. SHACK, Member

JOHN D. SIEBER, Member

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

8:29 a.m.

CHAIRMAN ABDEL-KHALIK: The meeting will now come to order. This is the second day of the 574th meeting of the Advisory Committee on Reactor Safeguards. During today's meeting, the committee will consider the following. One, Interim Staff Guidance ISG-17, ensuring hazard-consistent seismic input for site response and soil structure interaction analyses.

Two, Interim Staff Guidance ISG-20, implementation of seismic margin analysis for new reactors based on PRA. Three, future ACRS activities, report of the Planning and Procedures Subcommittee. Four, reconciliation of ACRS comments and recommendations. Five, assessment of quality of selected NRC research projects, and six, preparation of ACRS reports.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Derek Widmayer is the Designated Federal Official for the initial portion of the meeting. We have received no written comments or requests for time to make oral statements from members of the public regarding today's sessions. There will be several people from Westinghouse on the VTC during the sessions on ISG-17 and ISG-20.

There will also be a phone bridge line. To preclude the interruption of the meeting, the phone will be placed in a listen-in mode during the presentations and committee discussions. A transcript of portions of the meeting is being kept, and it is requested that speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume so that they can be readily heard.

We will now proceed with item number seven on the agenda, ISG-17, Ensuring Hazard-Consistent Input for Site Response and Soil Structure Interaction Analyses, and Dr. Shack will lead us through that discussion.

MEMBER SHACK: Just before I start, I want to mention that the ISG has been issued, so we're not expected to write a letter, although of course we always can choose to do so. But the staff is not looking for a letter from us. We had a briefing some time ago on the development of probabilistic seismic hazard for a site.

And you will recall, this involved investigation of seismicity, seismic source models, paleo seismic activity, and ground motion attenuation, based typically on updates of the FPRI Probabilistic Seismic Hazard Studies. And such studies typically give you the seismic spectrum on hard rock layers deep beneath the site.

In the case of South Texas, this layer is more than thirty thousand feet below the ground surface. The spectrum that you get from that can't be directly compared to the Certified Seismic Design Response Spectra that we were familiar with from the design certifications, which typically represents the motions at the free surface, or some elevation corresponding to the foundation elevation of the structure.

To compute the ground motion, site amplification factors that result from the transmission of the seismic waves through the thick soil column must be determined. The elevation typically of interest is the foundation elevation, naturally enough. The spectra determined from the seismic analyses must be modified not only by the soil characteristics, but by an additional factor if we are to obtain a risk-consistent seismic spectrum.

This second factor accounts for the fact that the amplitude of motion at 1 hertz that produces a probability of failure, say, of ten to the minus fifth, is not the same as the amplitude of motion at ten hertz that produces that same probability of failure.

And so you adjust the spectrum to get something like a risk-consistent spectrum. And there is an acceptable process, or a process acceptable to staff for producing such a risk-consistent foundation response motion, or FIRS, given in reg guide 208. The ISG gives additional guidance on how the site-specific FIRS can be compared with the Certified Seismic Design Response Spectra.

And if the FIRS is not bounded by the design response spectra, then you need to do a site-specific soil structure interaction, and the ISG also provides two acceptable methods for determining the site-specific soil structure interaction input motion.

And with that introduction, I will turn it over to Kimberly Hawkins, who will start it off for the staff.

MEMBER RAY: Bill, before you turn it over, can I ask you a question about what you just said?

MEMBER SHACK: Sure.

MEMBER RAY: Is there an assumed relationship -- I mean, you explained a lot, but raised a question in my mind, between horizontal and vertical -- I assume you're talking horizontal here.

MEMBER SHACK: Yes. There is a relationship. I mean, you have to develop both, but there is an acceptable process for coming up with the vertical and horizontal motions.

MEMBER RAY: Which is site-specific?

MEMBER SHACK: Which is site-specific.

MEMBER RAY: Yes.

DR. HAWKINS: Okay, good morning. And thank you for inviting us to talk with you about these two ISGs. My name is Kim Hawkins, I am the chief of the Structural Engineering Branch II in NRO's Division of Engineering, and the presentations this morning represent the culmination of a lot of hard work by the staff in the Division of Engineering, and also by the staff in NRO's Division of Siting and Environmental Reviews, as well as significant stakeholder involvement.

As Bill had mentioned, these ISGs are final, and they were made final back in the spring, I think March or April timeframe. At the front table is Mr. Goutam Bagchi, he is a senior level scientist in DSER, and Dr. Jim Xu, a senior structural reviewer in my branch.

And also here with me at the table is Dr. Nilesh Chokshi, the deputy director of DSER. The purpose of our presentations this morning is to give you an idea about why we developed the staff guidance, since SRP was updated in 2007, and also to describe the positions in the ISGs.

At the end of the presentations, we hope that you will be in a good position to provide any feedback that you have on the ISGs. And given the technical complexity of the topics that Goutam and Jim are going to discuss, I'm going to just turn it over to them immediately -- unless Nilesh, do you have any comments or introductions?

Okay. So with that, why don't we have Goutam start his presentation.

DR. BAGCHI: Good morning everyone. As was introduced by Dr. Shack, it's an excellent introductory summary of how things developed in the hazard and seismic demand determination area. Now I'm going to go into some of the details of how this interim staff guidance developed. Next slide, please.

MEMBER SHACK: You have to do it.

DR. BAGCHI: Oh, I have to do it.

MEMBER SHACK: We need a voice-controlled computer.

DR. BAGCHI: It is important for me to acknowledge right at the beginning how much of an effort it took to get here, both on the side of NRC and the stakeholders. Dr. Chokshi has given a very significant amount of technical leadership, and stayed with the issues very closely, and his guidance and leadership has made it possible for us to get here and make substantial progress.

It is not only just in this area, but initiatives with respect to seismic safety -- you know, hazard determines how things are going to be designed and executed later on, so it's a very important factor. It goes without saying.

And some of the folks within the NRC helped us. Dr. Hawkins, of course, provided a great deal of support, and Mr. Brian Thomas, Brian, chief of SEB1, his staff did a detailed review of the ISG and provided very constructive comments.

And Dr. Clifford Munson, he is a staff member, he is now a senior level scientist in DSER, he also initially came up with those supporting ideas with respect to performance-based, fully performance-based foundation input spectra, and then the surface response spectrum.

And Dr. Jim Xu and I have been working

pretty closely. Dr. Constantino is our consultant, he has been doing detailed soil structure interaction reviews, and very close to the issues. He is the one who conducted the study that went into option two in ISG-17.

On the industry side, Dr. Kennedy and Dr. Ostadan, they came up with the idea -- and when we were in the public meeting, we were surprised to see how much of a coincidence there was within the concept of performance-based foundation input response spectra.

So, that much for acknowlegement. Next one, please.

Now, my outline of the presentation is not going to be belaboring on a whole bunch of details with respect to the technical issues of it. Dr. Shack summarized it wonderfully. What I'm going to go through is "What is the ISG-17?" Some of the key background concepts -- this is not for Dr. Shack, but some of the others like us who might have a fuzzy acquaintance with some of the terms and ideas.

Key issues that are addrssed in the ISG and its technical positions. There are really three key technical positions, and they are comparisons of the Certified Seismic Design Response Spectrum, CDS --

actually, that is wrong. CSDRS. I beg your pardon, that was wrong. That was why I was unable to get through it -- CSDRS, Certified Seismic Design Response Spectrum, with the site-specific seismic demand.

When we take that certified design and put it in a specific site, does it envelop the site demand or does it not? That is a very important aspect of determining the acceptability of a combined operating license at a specific site.

As you know, even though the .3g Reg Guide 160 type of spectrum for the CSDRS is conservative, but nevertheless because the deep ground acceleration now becomes asymptotic at about 100 hertz, the high-frequency end of the site-specific demand at rock sites tend to become higher than .3g.

So, there are other ISGs that address that issue, but those -- it is not an unimportant issue, so you don't just go to a site and say "Oh, there is no contest", like in South Texas or Florida. These specific sites may have some strange demands in the high-frequency end. So it is an effort that one has to go through.

MEMBER RAY: Could I ask you the same question I asked Dr. Shack, which is at the site also, of course, the vertical to horizontal ratio is site specific.

DR. BAGCHI: This is an important concept. I think your experience may well be from the west coast.

MEMBER RAY: It is.

DR. BAGCHI: And there, of course, the vertical to horizontal ratio cannot be fixed. In the eastern United States, central and eastern United States, we find that there is a ratio between vertical and horizontal spectra.

MEMBER RAY: It's strike-slip versus thrust faulting that makes a lot of the difference, and I assume that would be not unique to the west coast.

DR. BAGCHI: Well, supposedly there are uniform hazard sources in the east coast, and mostly the very distant sources would be associated with some kind of fault mechanism. And many of those things are not well-determined yet. For example, in the Madrid zone --

MEMBER RAY: I don't mean to divert you, I am just trying to understand what was assumed. You are assuming, I take it, then, that it's two thirds, or something of the sort.

DR. BAGCHI: It is in the regulatory guide, but aside from that it may well be site-specific based on the seismic hazard.

MEMBER RAY: Yes, because it is a current issue at --

DR. BAGCHI: Our staff reviews it very carefully, and we really have one of the best staff in the geophysics and seismology area.

MEMBER RAY: I am just trying to learn.

DR. BAGCHI: No, I take a little bit of pride in that. We have high quality staff people. Including research.

MEMBER POWERS: You have a good staff.

DR. BAGCHI: Yes.

MEMBER SIEBER: Does soil structure influence the ratio between horizontal and vertical in a big way, or a minor way, or not at all?

DR. BAGCHI: That ratio at the rock level generally transmits to the surface, as you well know, perhaps. And as you know, the soil transmission for the vertical waves and vertically propagating horizontal waves have different qualities, p-wave versus s-wave and so on. Those amplification ratios can be different and are different.

MEMBER SIEBER: Okay.

DR. BAGCHI: But I draw a little bit of uncertainty here. I think that it is the horizontal spectrum at the surface GMRS. Once that's developed, the vertical is determined on the basis of the ratio of that spectrum. And unless it is driven by specific source orientation for that particular site, whereas they would have to do an amplification for the p-wave. But that I have not encountered in any of the applications that I recall.

But this is not a complete answer. To really address your issue, the point is that p-wave amplifications are different. They would have to use a different model. It can be done, and often is done.

MEMBER SIEBER: Okay. Thank you.

DR. BAGCHI: How do we compare the CSDRS versus site-specific? Here is an interesting thing, and at the end of my presentation I am going to make, certainly, the question of observation. We do this highly sophisticated performance-based probabilistic seismic demand, but when it comes to actually designing the structures, we go through the soil structure interaction, which is completely deterministic.

Three soil properties. And in the PSHA, we use 60 randomized soil properties, and really exhaustively follow through what kind of site amplification we might get, but soil structure interaction, in fact, is different. But that is not the focus of my presentation, and I will come back to it later.

Minimum foundation input is required in the regulation itself, Appendix S2, Part 50. And I will explain that as it proceeds. Next slide, please.
So, what is the ISG-17? It supplements the standard review plan section 3.7.1.

As I was just a few minutes ago trying to say, it is completely deterministic based on the use of three soil properties, best-tested, and upper bound, and lower bound, and so forth.

And ISG-17 really bridges the gap between the probabilistic ground motion analysis, and the deterministic way the soil structure analysis is done. And then site-specific design response spectra, and certified design spectra, how they are compared. The ISG is based on an extensive interaction with the stakeholders. There was an industry white paper, it is all referenced in the ISG and I am sure Dr. Shack will be happy.

There was also the NRC study authored by Dr. Carl Constantino. The draft was issued on August

31st, the final was issued on March 24th, but in between there were lots of public meetings and so forth. There was very significant interaction with the stakeholders.

Now I will go through some acronyms. One, I already stumbled on, and you probably know most of these by now. CSDRS, I won't go over that. GMRS, Ground -- it is a performance-based, site-specific Ground Motion Response Spectrum. Reg Guide 1.208, we had a gread deal of desire to call it an SSC, but we didn't. And I'm glad we didn't, it is Ground Motion Response Spectrum.

Now, if we are --

MEMBER BLEY: In this definition, Goutam, what does "performance-based" imply?

DR. BAGCHI: That's really a very intriguing question, and a very important question. This performance-based criterion came from AEC 43, it was developed for DOE applications, and then this national standard, AEC 43 reviewed this, and it went through the committee, and it was accepted.

The basis of it is that, for a specific site, hazard is determined at several exceedance frequencies, let's say ten to the power of minus five and ten the power of minus four. And then the actual design is targeted towards, in this case, one decade higher than that, ten to the power of minus four, is the expected design response spectrum.

And as Bill explained, there is this disconsistent design factor that is used to come up with the performance basis. Performance basis assures that there is very low probability of getting significant exceedance of elastic response. Frequency of significant elastic deformation is at the level of ten to the power of minus five.

When the demand is set at ten to the power of minus four, this is because of the acceptantce criteria that are used in the engineering design. And in the determination of those design factors there were other considerations. And that was that in conventional engineering design you get almost like a factor of 1.5.

So those design factors are adjusted such that the demand using ten to the power of minus four produces a design which will not produce any elastic deformation greater than ten to the power of minus five per year.

MEMBER BLEY: So it's something about margin things.

DR. CHOKSHI: If you have a target, a

performance target that is certain, you know your design process, what conditional properties you get, what is my design level. So it's going from the performance, backward, to define your design. So, it's performance-based design.

MEMBER CORRADINI: Can I make sure -- this is what you said, and what you said, I'm trying to make sure that they're the same. So, I'm trying to get back through all of your ten to the minus fourths and all. So are you telling me that the way you're doing it is, you have the plant, and you have this source term, and the procedure to connect the source term spectra to the plant response is going to require that it meets the response with a --

DR. BAGCHI: With a target from ten --

MEMBER CORRADINI: Whatever. And one in ten times it may not? You said ten to the minus fourth it's going to have to be --

DR. BAGCHI: No, it does not mean that. That is -- the principle that's involved in that standard is this, that there is only one percent -- because it's a high-confidence performance. One, there is only one percent probability of failure at ten to the power of minus five. And there is also another requirement, that at 1.5 times the seismic demand, the probability of failure will only be ten percent.

Both probabilities are maintained.

DR. CHOKSHI: The next presentation is going to address that question of what are the design margins. It's a very important question.

MEMBER CORRADINI: Okay, but I just wanted to be sure, when Dennis asked about performance-based, I was trying to listen carefully, because with something like this, I have to be blunt, I don't get it. So I'm trying to get it.

DR. XU: If you look at the design approach, there's two way of looking at it with this aspect. Traditional approach to the design is you define the loading aspect first, right? You use seismics, you define seismic hazard. And then you design the structural system component to withstand that hazard. That's the traditional approach.

Okay. In a performance-based approach, you will work backwards. You define the level of the performance first, okay? In this case, it is the performance goal that you define in terms of the probability of the structural system failing to perform its safety functions.

Okay, you define that goal first. And

then you work backwards. So you work backwards, to decide what kind of hazard I would need to meet that goal, with the fragility of the structural system components.

MEMBER CORRADINI: Well, I mean -- and we're going off topic a bit, but all design is iterative. So I look upon it as a circle, and you start out at a different point on the circle, but I still go around and around until everything iterates -- until I iterate, and everything matches, right?

DR. XU: That is right.

DR. BAGCHI: One other concept that needs to be brought in here, particularly for those who are close to thermal hydraulics issues -- I know your background, sir, so I wanted to use that.

MEMBER CORRADINI: Don't assume I know much. I just want to understand -- no, I understand now what you mean by performance-based, at least.

DR. BAGCHI: Let's suppose I'm going to design a steel structure. And from the seismic loading I have a bending moment, I have shear, and I have tension, and I have all of those things. And they determine that the tensile load is 15 pounds per square inch. But the code is such that it will say that you have to have an allowable stress, you cannot exceed the allowable stress.

So if I have a design demand of 15 psi, that thing is not going to withstand 32, 36 psi. Or ksi, I'm sorry. Fifteen thousand psi, and thirty-six thousand psi. So what kind of margin do we have there. Just because the design process has these kinds of traditional factors of safety. The national standards are cited in our SRP. That's how we base our design.

MEMBER CORRADINI: Okay.

DR. BAGCHI: So, because these factors are there, we are able to say that we are going to target this performance. And now we're going to work backwards to get to the seismic kind of load that it can withstand.

MEMBER BLEY: May I try something, and see if I hit it right? The traditional approach adds fixed factors to give you some conservatism in margin. The performance-based approach is actually trying to reach some level of performance, it's effectively trying to quantify what factors are needed to get you to that performance, rather than having them just be kind of conservative factors.

DR. XU: That is exactly it. And the one feature of that is that you will have a uniform risk, versus the approach we always use, where you define the hazard and then you design the structure to withstand that hazard. Then you wind up having various levels of risk.

DR. CHOKSHI: The concept that Dr. Xu defined, is one that we use a little bit differently. We have our design process, so we have built into our design process a way to work now without those margins, okay, currently existing. And if I use those margins, all design levels I need to design to meet that performance goal.

And that is why there is all this, why all this difficulty regarding this probablilistic issue has come up. Because the design process is still deterministic.

MEMBER SIEBER: And the overall object is to keep every component of the structure in the essentially elastic range.

DR. BAGCHI: Essentially elastic. One more thing, if you would allow me, I'd really like to get to this one. Because it was a transition from the AEC 43 standard and the way that all nuclear power plants have to be designed with very high margins, and ten to the power of minus four at that time didn't look all that good to me, anyway.

And so we said, what would be the core damage frequency with these kinds of things. And then a study was done by the industry, and based on that study it was determined that the average core damage frequency was expected to be, for 68 sites in the central and eastern United States, was expected to be five times ten to the power of minus six.

So we felt comfortable with this design, performance basis. And so we wrote a letter to the committee, and it was not a commission paper, but a letter informing them that we are using this performance-based seismic approach. And since then, it has been used.

DR. HAWKINS: Excuse me, with all due respect to the important dialogue, I'm also sensitive to your busy schedule, and I'm wondering if we should go through the rest of the slides, so that we can try to keep on time, because we're only on the acronym stage, and there's a significant amount of material left to cover.

DR. BAGCHI: Now, this one is the old way of doing things. We did, repeat, have an SSE. We had an earthquake, a magnitude earthquake for which this plant was designed. If you go to the regulation, you will still find an SSE, a particular earthquake.

What do we have now? Ground motion. So it just goes into some of the details of how we go through this SSI analysis, Soil Structure Interaction analysis. And I don't think I need to go into the details of this, unless there is a quesion, and I can explain that.

MEMBER SHACK: Well, if you do, we'll end up in the same place we did with the performance-based, so --

DR. BAGCHI: Well, I will give it a couple of seconds. A few more seconds. Okay. Next one, please. Here is how we do it today. We compute the hazard, as was pointed out, the uniform hazard spectrum at the rock outcrop, and we use randomized soil properties developed for ten to the power of minus five and ten to the power of minus four non-exceedance uniform hazard at the free surface. Actually, our staff members sometimes want to see much lower frequency hazard at the site, in order to determine how the seismic sources might or might not change.

So difficult questions are asked at that level. I think that we do a very thorough review. Then we determine the performance-based design spectra. These we explained earlier; I won't go into that.

At the time of the hazard analysis, it is based on the information that is obtained from site exploration. It is relatively early. Many of the locations of the structures and so forth are not known at that time.

So when it comes to a specific structure, we require under our regulatory -- we do not require, but we recommend under our Regulatory Guide 1.132, I believe, or some other Reg Guide like that, that there has to be so many drilled holes and so forth depending on the structure and its dimensions.

So a lot more detailed information is known about the foundation area of important structures. And so the local information is a lot more detailed. And since we did the foundation input spectrum, the approach -- this new twist, new approach, has been particularly developed for ISGs in this case, has been to develop the performance-based input response spectrum.

Instead of starting with the GMRS and deconvolving, we did the performance-based FIRS right away for this design. And then the comparison point -- no, no. Given that foundation input response spectrum, SSI analysis is done with deterministic properties, only three soil columns.

So the soil column is used to propagate FIRS up to the surface, and then there is a check made against the surface requirement of the performance-based surface response spectrum. And if it doesn't match, then there are several ways to deal with that. I think slides later on will go into that.

This type of a comparison, in a nutshell, in the past approach there's only one defining SSE, surface, and that is always the starting point of all subsequent analyses, and SSE produces the design motion. SSE response spectra are not site-specific, because you take the PGA, and then scale up the standard spectrum to the PGA, so how can you be site-specific?

Then the SSE will be a relationship; it used to be straightforward, and it still is. It doesn't have to be more than a third unless the hazard for that particular site is such that it might demand some other ratio.

In the current approach, we always start with the uniform hazard spectrum at the hard rock. This is unique. This is based on derivation of motion at the rock from the source, based on predicted ground motion attenuation, with predictive ground motion equations.

And design input motion varies with site conditions, site soil condition is extremely important. That can modify results very substantially, it can amplify. GMRS is, of course, a site-specific spectrum, but the CSDRS is generic. Because all the standard designs seem to use something like a .30 guide spectrum at .3g. .3g is the PGA.

MEMBER CORRADINI: Can you just unravel those two acronyms? The GMRS is the local ground motion that the plant has to meet with all the criteria we just talked about, and the --

DR. BAGCHI: And the CSDRS is the Certified Seismic Design Response Spectrum that was used in the design of the standard certified reactor.

MEMBER CORRADINI: Okay, fine. Thank you.

DR. BAGCHI: I think I'm done with this slide. These issues. Hardware compare the site-specific spectrum at the time of combined operating license application. And to determine whether or not the standard design is okay for this site. And then the issues are what do we compare, and how do we compare it?

Next slide, please.

MEMBER CORRADINI: Can I ask one other

question?

DR. BAGCHI: Yes, sir.

MEMBER CORRADINI: Don't go back. So the past approach, the SSC, was not site-specific, but it was applied to the surface motion at the starting point of analysis?

DR. BAGCHI: Yes, sir.

MEMBER CORRADINI: That would imply that since you're now taking a more complex, more rigorous, thorough analysis where the starting point is a defined UHS, far away from the surface, and then doing all this analysis to find the site-specific GMRS, that there was a lot of margin in the SSCs for current plans that now, if you were to do this analysis with current plans, you would find the margin. You would know the margin.

DR. BAGCHI: That's my inner belief. I have not done that analysis lately.

MEMBER CORRADINI: Has it been done for any of the existing plants ot validate your inner belief?

DR. BAGCHI: To some extent, it has been. For example, IPEEE. We tried to find IPEEE, Individual Plant Examination for External Events.

MEMBER CORRADINI: I see.

DR. BAGCHI: At that time, it was reviewed, all the plants were reviewed. And some were screened out because the hazard was so low. We didn't even have to look at those.

So all of the rest of the plants were examined for margins. And this is one big difference. We did that, when, in the mid-eighties. And we were very forward-looking then.

MEMBER CORRADINI: That's fine. I just wanted to understand the connection from the standpoint of the past versus the current. Thank you.

DR. BAGCHI: I think the two points. The next presentation is going to talk about margins.

DR. CHOKSHI: But the second thing I think, the current SSC is site-specific in the sense that the deep-ground exploration is based on site-specific. The spectral shape itself is not site-specific. So that is an important distinction, it is.

And the second thing is that --

MEMBER CORRADINI: So the shape function is not site-specific, but the amplitude is?

DR. CHOKSHI: That is correct, right.

And the second point is that the design process, the analyzed design and the past designs are the same, essentially. You can get a very strong margin, and I'll let Dr. Xu explain the strong design, because it's a product of higher demand.

DR. BAGCHI: Dr. Corradini's question really was quite relevant. What are we doing with the existing plants, and do they have the same kind of margins? To address that, I could even tell you that we identified generic issue 199, we've argued about that, had presentations about that.

So we are looking at those things.

MEMBER CORRADINI: Okay. Thank you.

DR. BAGCHI: Next one. Wait, did I finish everything? No, I didn't. So then, actually, it makes enormous sense to compare the FIRS, but since what was used at the foundation level --

CHAIRMAN ABDEL-KHALIK: Go ahead, please.

DR. BAGCHI: For the certified design. So in some cases the certified design had assumed a surface-founded structure with no embedment, sometimes it assumed embedded structure but analyzed it as surface-founded. And then, lastly, the third category, embedded structure analyzed as embedded. Next one, please.

This picture give you an example of what to compare. This is the certified design, with the foundation input at surface. So you compare the CSDRS versus FIRS. Next one, please.

Now here the design was done with this surface-founded assumption, but actually it is somewhat embedded. Partially embedded. So what do we compare? We compare the CSDRS versus the foundation input spectrum where the foundation will be at this specific site. Next one, please.

And here, of course, is unambiguous, the FIRS, CSDRS versus FIRS. You know, one-to-one comparison. Next one, please.

Next issue. How do we ensure consistency between the site properties at the site on how the seismic hazard of the load was determined versus how it will be used in the deterministic SSI analysis. Because with PSHA we had sixty properties, we varied everything up and down, and did a really rigorous analysis.

Come to SSI, we have only three properties. So we can hardly make that a direct comparison. But we have to be consistent. That's why we require that the site properties are based on the mean value of the sixty properties as determined at the site, and then upper bound and lower bound based on a coefficient of variation of one.

Generous margine, but nevertheless only

three properties. But here we do require that the comparison be made of the FIRS propagated upwards to the surface with those three properties, and determine whether or not they envelop the PBDRS, Performance-Based Design Response Spectrum.

If not, then there are options. One is to develop input motion based on enveloping the surface motion, or throwing additional soil column properties into the spectrum. And as Dr. Shack pointed out earlier, there are two options, and I think I talked mostly about those in the beginning, so to save the committee's time I won't go into the details unless you have a question to ask.

DR. CHOKSHI: Can I just -- I think Dr. Shack -- you know, performance-based is the basic design principle in defining the margin. If you design to that demand, you will meet the performance goals using the current process. We are keeping the current design process, and the standard is that, working with site-specific design.

But in order to implement the design approach, we have to manipulate ground motion. So the key principle is that when you are manipulating that ground motion, is to make it within the performance-based levels.

Otherwise, you are violating the whole overall approach, and that's what this portion does. It is whatever you do to come up with your input for the structural interaction analysis, deterministic analysis, that motion will not violate that performance target. And that's what the whole complicated process is supposed to achieve.

DR. BAGCHI: Thank you. That was really a key point, also. Next slide, please. And this is about the minimum input check. For many COL sites, the minimum input can get below the .1g minimum requirement in the regulation. I wish I had put in that slide of the GMRS of all the COL sites, they have been compared, and we would see that quite a few of those are below .1g.

That's why this minimum foundation requirement is important. And it really doesn't come into play when the design is not for site-specific structures, because there are some site-specific safety structures that would be designed based on the GMRS. In that case the foundation input spectrum would have to ensure that .1g is met

And this can be done in several ways. Make two analyses and envelop the results, or just use an envelope spectrum for .1g and then do the analysis.

So this is a choice that the applicant has.

So, thank you for your time. This is very helpful. I'd like to appeal to you for one thing. As you can see, this dichotomy of probabilistic design versus deterministic, probabilistic seismic demand versus deterministic design, we have to yield the way to the probabilistic approach.

There are other places where they are using this kind of approach. There's a national standard that's going that way. SSC 4 is going to incorporate criteria for probabilistic soil structure interaction analysis, and so on.

MEMBER CORRADINI: So can I ask now a public question? So you're telling me by that last comment that if I want to build a big football stadium in California, the methodology would be no different there? I've got to worry about eighty thousand people watching some tremendous sporting event, and in the future they're going to essentially take the same approach? I'm going to have a hard rock source term, I'm going to have a performance spectrum and the building codes in seismically active areas would be a similar design approach? Is that what you're telling me?

DR. BAGCHI: We are going to design to a

different kind of standard --

MEMBER CORRADINI: Well, not yet about the standard. Forget about the standard, I'm talking performance-based. I'm trying to ask a different question.

I'm saying the methodology you guys are putting forward, I would expect, then, since you are using civil engineering codes, will be for large structures around the U.S., similarly applied. Different performance bases, but the design approach would be the same.

DR. CHOKSHI: No, I think this is because we are talking specifically for nuclear structures. The committee is talking about the SSC, those are for nuclear facilities.

MEMBER CORRADINI: So I should worry more when I go to a football game?

DR. CHOKSHI: I am afraid so, sir.

MEMBER CORRADINI: I mean, I'm only using that because of the 1989 event in the middle of the World Series.

MEMBER POWERS: Mike, the World Series has nothing to do with football.

MEMBER CORRADINI: Same stadium, Dana.

DR. BAGCHI: Yes, but I would give a lot

of credit to my colleagues in California. Seismic safety is a very important goal to them. Many of the designs have been so vastly improved that they don't have the same kind of risk that there used to be.

MEMBER CORRADINI: Okay.

DR. BAGCHI: If you look at the detailed design of the Bay Bridge, you would be really impressed.

MEMBER SIEBER: Maybe I can -- please correct me, because I'm sort of in a learning mode here, but let's say that you defined the response spectrum, the frequency profiles and all that, built the structure so that it will stay in the elastic range all the way through. Now, you really aren't done, because there's piping and vessels, and all kinds of stuff inside there.

DR. BAGCHI: Absolutely.

MEMBER SIEBER: And how do you translate the earthquake spectrum into motion of buildings where you're going to fasten pipe supports and mount tanks and stuff like that? For example, you're going to have a series of --

DR. BAGCHI: Well, I'm going to try to defend my colleagues there, because I used to have some responsibility of reviewing the mechanical installations.

MEMBER SIEBER: I do have a specific question that relates to that. You are going to have a variety of frequencies, and the question is, when you try to determine what force acts on objects inside a seismically qualified structure, do you take the absolue value of the sums of the spectral components, or do you assume that higher frequencies cancel out some of the lower frequencies?

DR. BAGCHI: Let me try to answer some, and those that are not answered will come back.

DR. CHOKSHI: We talked about here 1 SRP Section 3.7.1, which is the seismic SSI analysis. There are 3.7.2, 3.7.3, there is a series of how to design these buildings, these component responses, and each one addresses these specific questions of how do I combine three data, the appropriate consequent, and you know the question, as Goutam said, it depends on what the relationship between the comfortable frequency and the ground motion frequency is.

And so the different approaches, coupled, non-coupled, but all of those are defined in our SRP, in the regulation guides.

DR. BAGCHI: I would really like to give you a rather simple way that I look at it, and this was a great answer, but what determines the design of structures, and systems mounted on structures. Those use in-structure response spectra.

MEMBER SIEBER: Okay.

DR. BAGCHI: We do the analysis of the structures, and we determine the complete time history of the response at specific locations of interest. So these are the pipe supports, these would be locations of water control centers or battery racks, and things like that.

So you don't just use one envelope type of parameter to design your systems and components, you actually use the response parameters to define them. And how are these response parameters conservative? You broaden the peak. You make sure that the uncertainty in the way the structure responds is considered in the structure response spectra.

And these are developed in the Reg Guide 100, and 1.122, and so forth. There's lots of detailed guidance here, and when it comes to piping design, there may be two or three, or four, or five supports.

MEMBER CORRADINI: Yes.

DR. BAGCHI: So how do you determine which support is to be used for the design? Now, there are time history analysis processes that allow you to use different time histories and different supports. Those are complicated analysis processes. They are rather of more recent vintage, but another way is to take those response spectra, those sets of response spectra, four or five of them, and make an envelope of all the response spectra.

You design to that. So the piping design is so robust --

MEMBER SIEBER: Do you assume that there are peaks in there that are absolute values of various frequencies, or do you try to figure out what the spectrum really looks like?

DR. BAGCHI: Again, it depends what you are trying to do. In some cases, just the peak response is necessary, in that case they take the highest spectral demand --

MEMBER SIEBER: Absolute value?

DR. BAGCHI: From the response spectra. Spectrum is absolute value anyway, since it has no negative ordinates.

MEMBER SIEBER: If you had multiple frequencies, you have to do one or the other.

DR. BAGCHI: Yes, multiple frequencies. You take the highest spectral demand, it could be at 2 hertz, it could be at 10 hertz, it could be at 40 hertz, because there is some resonant frequency of the structure that is raising that demand.

MEMBER SIEBER: Yes, that is true.

DR. BAGCHI: So there are so many conservative factors into those designs, that I worry much less about that. Look at Kashiwazaki. What happened? Nothing.

MEMBER RAY: He is right. Because in California they are asking the question to reconcile methodologies with experience. Have you done that with this, or with any of the other things, to evaluate, validate, determine?

DR. BAGCHI: Well, we do have a generic issue that is supposed to look at some of these things, but we haven't. Not that I know of.

DR. CHOKSHI: I think that the Japanese, that Pepco has gone through very extensive, evaluating all their plans with Kashiwazaki's specific input. And that information is available, and they show good correlation of some of the observed with what was the predicted response.

MEMBER RAY: Well, I don't want to get off on a tangent, but in any event that's getting a lot more consideration in California than I think --

DR. BAGCHI: And I think it will. Because there are -- not only are you changing your method, there are different sources that are coming up because of detailed geological studies and so forth. So that's a much more complex issue, and in a short time it's --

MEMBER RAY: That's why I'm asking about vertical versus horizontal, because you go from strike-slip to --

DR. BAGCHI: Yes, vertical could be much higher than horizontal.

MEMBER RAY: That makes a big difference.

DR. BAGCHI: I am not unfamiliar with some of those concepts, sir.

MEMBER SHACK: Okay, I think we'll have to stop here. We may have to schedule more discussions of seismic issues for later meetings, but I think for the most part --

MEMBER POWERS: I have one question. The issue of seismics has particular poignancy because we look at the more advanced light water reactor designs, where it's really the risk dominantly associated with those plans

MEMBER RAY: But then there's always the issue which comes up here when I ask a question, "Oh, you're from the west, this is just for the middle and eastern part of the country." But the people in the west are left wondering how we are going to address siting in the west, which we --

MEMBER POWERS: They don't even have dome reactors anymore, so what the hell do we care?

(Laughter.)

Seriously, though, that's not the case.

CHAIRMAN ABDEL-KHALIK: But let's just proceed, if you don't mind. At this time, let's proceed to the next item on the agenda, which is ISG-20, Implementation of Seismic Margin Analysis for New Reactors, based on PRA, and Dr. Bley will lead us through this discussion.

MEMBER BLEY: Okay, and all the same things are going to come up again. But where we're going here is, what can we do with what we just heard about. And Jim Xu is going to take us through this, but basically, this is, to me, a pretty interesting ISG. Part 52 required design-specific PRAs. Reg Guide 1.206, and we'll go through this again, but 1.206 requires level one and level two PRAs that includes seismic.

And later staff, I'm quoting from the Reg Guide, recognized that it's not practical for a DC applicant to perform seismic PRA, and proposed a seismic margins approach, a PRA-based seismic margins approach. And the interesting thing of this one is that it preserves the design-related aspects of a seismic PRA.

The fragility analysis, and the plant response analysis, which is essentially laying those fragilities into the PRA model, which connects failures of different pieces of the plant together to come up with an overall plant fragility, or a sequence-by-sequence fragility, or a plant state fragility, however you actually do that.

As you go through it, I have one question that I'll sneak in ahead of time. It makes sense to me with the SRM, that this is the right thing to do before you have the local information. When you get to the COL stage, you could go further, and you bring up the plant-specific aspects of the plant, but we're still staying with the plant.

And before startup, I would assume you've got to get back to the full seismic PRA, so if you'd address that before you finish -- but that wasn't clear to me reading through this, so why don't you go ahead, because anything I would say, you already have in your slides.

DR. XU: Okay. So maybe I will address that issue when --

MEMBER BLEY: When you come to it, yes.

DR. XU: Good morning again, and thank you very much for giving us the opportunity to brief you on the ISGs, and for the very interesting discussions you have here. My presentation will be on the ISG-20, and this is on the implementation of PRA-based seismic margin analysis.

And you can put the phrases in different ways, some of them will say seismic margin analysis based on PRA insight, but I prefer PRA-based. I'll explain why some slides later.

So in this presentation, I hope I will be able to communicate with you on two issues. First is why we need this ISG. Second is what implementation this ISG relies on that will be consistent with the Part 52 process.

And I will be happy to answer any questions that you have to clarify the issues. Next slide.

Before I go through the outline of the presentation, I just want to acknowledge that the ISG was a product of the close coordination in a broad alignment of the NRO with research at Brookhaven

National Laboratory. And I would just like to acknowledge their contribution to this team effort.

Now, let's look at the outline. I will first go over the timelines, especially the interactions with the key stakeholders during the development of the ISG. And then I will discuss with you on the regulatory framework, and that will answer why we need this particular ISG, to provide guidance on seismic margin assessment.

And then I will describe briefly what is a PRA-based seismic margin analysis, which is a very simple approach, a straightforward analysis of -- there are confusions in the industry and the staff, but there's no mystery to the approach, so I put in one slide on the method, to demonstrate the simplicity of the methodology.

And then I will discuss the implementation process, the policy that we've designed, and that would answer how we will implement the process to ensure in design that you have acceptably low risk from seismics.

And lastly I will discuss positions in the ISG. You probably have read the positions, which include basically two aspects. The first is basically what information the applicants should provide in the application. The applicants should provide information in the application.

Second is what are the acceptance criteria. That will rely on the review of the application to determine the adequacy of the analysis. Next slide, please.

We held a public meeting on September 29th to discuss the implementation strategy and related technical issues to be addressed in this ISG. The meeting received very broad participation, including NEI and the industries which are involved in the DC and COL applications.

On the one hand, we received very positive feedback from the public, and subsequently the draft ISG was issued on October 15th. And we received the three sites of public comments, which included NEI's, which were generally positive. And the industry recognized that we really need this guidance to move forward.

So the ISG was finally published and issued in the Federal Register on March 22nd, 2010, and it is final.

To understand why we need this ISG, we need to look at the regulatory framework for risk assessment of new reactor applications. Part 50 ensures that a new reactor will have acceptably low risk.

So the three requirements. Let's look at the first bullet, 52.47 (a) 27, for the design specification, and 52.79 (a) 46 and 52.79 (b) 1, for the COL applications. 52.47 (a) 27 required that the DC applications must include a description of a PRA and the results.

These are very high level requirements. The 52.79 further required the COL applicants to update the DC's PRA to include site-specific and plant-specific information. Okay, these are the key issues we are going to address in this ISG.

And there are other aspects for PRAs. Upgrades and maintenance for a reactor operation that will transition into a protected space will be governed by the 50.72(h) process. So that is out of the scope of this ISG.

And Reg Guide 1.206 further defines the scope of the PRA assessment, which include also level one and level two, and include both internal and external events at all plant operating levels.

Unfortunately, it is not practical to perform assessments and PRAs for standard design, and this is important, due to lack of site-specific hazard information in the application. They just don't have that information for DC applications.

The SECY 93-087 and associated SRM instructed staff to rely on PRA-based seismic margins for seismic risk insight. Okay, so instead of where we do the full-blown seismic PRA, because we couldn't do it, the Commission said we can use seismic margin assessment, but it had to be PRA-based, to develop the risk insight for seismic events.

MEMBER BLEY: But the SECY, and I assume the SRM, was aimed at the design certification stage, right?

DR. XU: Yes.

However, there was no further guidance on how this analysis would be performed, and what information should be relied on in performing this analysis. And this is the confusion, and this is the area in which industry and staff need guidance.

And this is why the ISG will bridge the gap, and will provide the guidance to specify what information at what stage of the applications the applicant should provide, and how the staff should evaluate the analysis submitted in the application.

MEMBER BLEY: I am just curious as to the history of what led to this ISG. Were you getting analyses that you didn't think were appropriate, or as complete as they should be, or was it just confusion and something you worked out with industry to agree to have a --

DR. XU: Staff had reviewed several analyses submitted by the applicants in a DC applications, and some applicants rely on past seismic margin assessments, such as the one implemented in the IPEEE program for operating plants.

DR. CHOKSHI: The confusion was "What is PRA-based seismic margin?" You know, as you said, in the SRM, you are looking at the full set of event reports, and we are not locating anything. In the traditional seismic margin, as used in operating reactors, it is a truncated or simplified process.

So there was some confusion as to whether those simplified processes are ready for the new designs, and the main role is define what processes you need to apply for the new designs. Otherwise, people will come in making different assumptions which are not right.

MEMBER BLEY: Fair enough. Thanks.

DR. BAGCHI: The reasons why this was driving towards the need for guidance is that we were finished up with the certified designs, and we were getting a lot of COL applications. And at that point, there was no really clear guidance as to what they should do in that part.

DR. XU: And that is probably more important for COL than for DC, because the COL need to establish and incorporate site-specific information, to bring that PRA-based analysis to a more realistic fashion. So to make that fit for their side.

MEMBER BLEY: Just a question. The ISG says it is effective from the date of issuance, and you said it is complete. Is it on the street now?

DR. XU: IT is on the street now, yes.

MEMBER BLEY: And does this apply to the current COLs? We are looking at who have already submitted their -- essentially, passed reviews of the PRA from the --

DR. XU: Well, this is a staff guide. This is a staff guide. This is the guide the staff rely on when reviewing the applications. You know, most applications tend to follow the ISG's approach, but they don't have the guidance.

MEMBER BLEY: I guess I'm not asking the question quite right. There are already a number of COL applications that are in review, people have reviewed the seismic portions of those, and the PRA portions.

Does this now require, before those COLs are completed, that staff now ought to apply this to the ones that we're already looking at, or are they -- is it to the new ones that are coming in?

DR. CHOKSHI: I think there are two things. One thing is that the requirement has always been there. As in that COL has to update their PRAs so that --

MEMBER BLEY: I'll come back to it later, after he tells us what happens at the COL stage.

DR. CHOKSHI: No, I mean the requirement is there, but the guidance wasn't there how to meet this requirement. If somebody wants to propose an alternate approach, they can do that, but I think this is one meeting. And the discussion within the industry is "What do we need to do?"

MEMBER BLEY: I think the alternate approach so far is nothing, at the COL stage.

MEMBER SHACK: Let's try it again. Are the COL applicants being reviewed to this standard.

DR. CHOKSHI: Yes, we are looking at them like that.

DR. XU: But that's in terms of regulation 52.79. Next slide.

This slide summarizes what the PRA-based seismic margin analysis is. We can first look at the five bullets in this slide. The first four bullets are part of the seismic PRA process. To identify seismic-induced initiators and develop associated action sequences, initially to include all transient locals, all sizes, and then base it on the safety features in the design, you can start to plan a logic model and capture seismic falures.

You should also consider non-seismic failures, including human actions. Random equipment failures as well. So the four bullets are the traditional approach we used in seismic PRAs.

So if we have seismic hazard information, we could have performed a convolution of seismic hazards with the sequence-level fragility to develop sequence-level contributions to the core damage frequency.

Narrow it down, then we don't have to do the margin assessment. But as I mentioned before, the design certification does not contain the seismic hazard information, because it is generically designed. So, that's why we use this alternative approach. So what we do with PRA-based SMA is to calculate sequence-level high confidence of low probability of failure capacity, which is HCLPF capacity.

And this capacity will be calculated at the sequence level. And at the lowest sequence-level HCLPF, we can calculate the plant margin. So that's how the margin was calculated. Now we needed to show that the plant-level HCLPF wsa satisfied. The commission approved the staff position on the margin, which was 1.67 times the design-based SSE.

So this is PRA-based margin assessment. So that's why we call it PRA-based, because it started with the PRA, and then you progress to a point where you couldn't continue, to --

MEMBER BLEY: To come up with the HCLPF for a particular SSC, before you combine it to sequence-level, you essentially need the full fragility analysis, don't you?

DR. XU: Yes.

MEMBER BLEY: So you essentially need to do a PRA model --

DR. XU: The fragility analysis is an important element of the model.

MEMBER BLEY: That's the tail end.

DR. XU: That's right.

MEMBER BLEY: So it's a full fragility

analysis.

MEMBER STETKAR: For all structures, systems, and components that are modeled in the PRA.

DR. XU: Right, for all systems, components and sequences.

MEMBER STETKAR: That are modeled in the PRA, right?

DR. XU: Yes, that are modeled in the PRA. That's right.

MEMBER BLEY: For particular sequences you need the whole thing to know which ones --

DR. XU: Yes. That's right.

DR. CHOKSHI: But that is the important point, because the available information is going to change rapidly as you move from design, DC, to COL, to the true build plan. That's why you need to know what you're getting, because what you're getting won't be all the information.

DR. XU: Yes, because the way the fragility for the surfaces and components will calculate is based on whatever information is available. For the DC, the only information you have is generic. You don't have any site-specific or plant-specific information. That is why the fragility calculated at the DC may not be the same as the one calculated for COL. Next slide, please.

To establish the implementation process that is applicable to new reactor applications, first we need to understand what information is available for different applications. A DC application provides a standard design which is based on design specifications only.

So it's generic. A COL will have a site, so a COL should be able to provide site-specific information and plant-specific information, which is the plant's specific structures, such as UHS. All the particular structures.

And the licensee will have to build and construct the plant. So they have responsibility for the whole thing. They are going to build the plant, so they are the ones who have the physical facilities.

So those are the information that we need to recognize at different stages of new reactor applications.

MEMBER STETKAR: Jim?

DR. XU: Yes?

MEMBER STETKAR: I recognize some minor subtleties between the site-specific and the as-built, but at the COL stage there are a large number of ITAAC that specify, theoretically, if they're done correctly, specify how the plant should be built in terms of supports, anchorages.

We certainly know where the equipment's going to be located, so it's not clear to me why, effectively, what you're characterizing as the licensee level of information is not available at the COL stage. We certainly know the site, we certainly know the site-specific structures and components that have been added, like the ultimate heat sinks.

DR. XU: That's correct.

MEMBER STETKAR: And we have all of the ITAAC specifications, such that if they are followed, indeed the as-built structures are --

DR. BAGCHI: There is an important difference there. Because even at the COL stage, the COL is being reviewed as to the details for that particular site, nothing has started. No design drawings have been made for piping.

MEMBER STETKAR: Right.

DR. BAGCHI: And piping is conceptual.

MEMBER STETKAR: No, no, no. That's why I'm saying, if it's that conceptual, then the ITAAC can't work. So you have to be careful, the ITAAC specify, DAC and ITAAC, I'm rolling DAC into ITAAC, they're supposed to be specific enough so that, indeed, when they construct the plant, the staff can construct a safety evaluation and say yes, if it's constructed and verified according to these criteria, then inded the plant is licensable.

DR. CHOKSHI: I think that we are doing risk assessment here, so that the plant is safely designed, but the risk is --

MEMBER STETKAR: My question is why can't you do the risk assessment at the COL stage.

DR. CHOKSHI: You can't, there are factors you cannot determine. No. The important thing in the seismic risk is in terms of the interactions. So designs are done, people design the beginning of consistent equipment design. The physical interactions, for example the seismic-induced flow. That is why you get a complete picture when you look at the whole plan all together. And these are not the CRMS, it's not a safety -- but if you want to know --

MEMBER STETKAR: What don't I know at the COL stage? In terms of the design, the DAC, and the ITAAC.

DR. XU: I think that I will address your question from a different angle. You are right. COL has lots of design information in order to comply with ITAAC. So the licenseee will have to verify the ITAAC to get approved.

MEMBER STETKAR: They can't design the supports any less rigid than the ITAAC.

DR. XU: But they could design, they could build it more conservative than the actual design. So when you do seismic PRA, or you do any other PRA, you will rely on the actual, as-built condition, which may have more margins than --

MEMBER STETKAR: I understand that the risk could be slightly lower after it's built than at the COL. But I don't know anything about the risk at the COL stage yet.

DR. BAGCHI: Aside from that, you cannot do a plant walkdown for your event sequence details. It is required by the GRS standards.

DR. XU: You could, in the ideal situation, you should be able to do PRA in the COL stage. However, looking at the COL applications we have received to date, most of them don't have the detailed information to simply incorporate the DC level FIRS.

MEMBER RAY: John, let me try again.

MEMBER STETKAR: No, let's keep on schedule. I've made my point.

MEMBER RAY: It's a simple question, the

stiffness for example of particular floors and beams, that wouldn't be in the COL, would it? You wouldn't be able to discern that from the COL application. The stiffness of a floor in the structure. You haven't picked the beams, you --

MEMBER STETKAR: You know, I'm not a structural engineer, so I'm not --

DR. XU: Yes, but that's a part of the standard design, when you have --

MEMBER STETKAR: I would hope so.

DR. XU: But as you build a slab, the stiffness may be different, it could be higher.

MEMBER RAY: Yes, that's what I'm saying.

MEMBER SIEBER: The code requirements really limits how much the structure could move. The components in there, at the COL stage, the foundation for them are designed, in advance and the seismic qualifications of the components is there, but all the interconnection --

DR. XU: I've gone through the first part, now I'm going to go through the second part.

(Multiple speakers overlapping)

DR. XU: Well, based on the information that is available at different stages of the new reactor applications.

CHAIRMAN ABDEL-KHALIK: Please, one discussion at a time. Please continue.

DR. XU: The ISG develops an implementation process based on that distinction of different information available at different stages of the process. So the implementation process to ensure adequate margins for the design of new reactors. For DC applications, the applicants -- we're on the second bullet.

For DC, the applicants will perform the PRA-based margin analysis based on design-specific information, to develop plant-level seismic margin for the design. And this analysis should be performed only based on the design-specific information. They overreached to include anything that includes the particular site, the particular plant design based on past experience that should not be part of the DC analysis.

And that's what we've encountered in the past in our reviews of a large number of DC applications. Someone would say "Oh, we have experience, we'll incorporate that. Therefore we don't need to do certain things."

For COL applications, the applicant will updated the DC analysis to reflect the site-specific and plant-specific information, and to assure that the DC-established margins are applicable to the site. In other words, the COL applicant needs to verify that the assumptions made in the DC are valid and applicable to that site.

So that should be included in a COL application, and the staff will review it to verify those aspects. And again, the licensee, since you have a physical plan, you have the physical structures, you should verify that they have built the plant within seismic margins through a walkdown process, and the staff will have options to perform inspections to verify that the process was carried out adequately.

MEMBER STETKAR: Okay, now I've got the real plant and I, since you say walkdown I can probably walk around and touch things and look at them. Why can't I do the PRA now?

DR. XU: You can do the PRA then. Yes.

MEMBER STETKAR: Okay, why doesn't the staff say you should do the PRA to complete the requirements of the process?

DR. XU: But then you have a transition to a 50.71(h) process. Actually, it's required that the applicants, that the licensee will have to do a PRA of level one and level two.

DR. CHOKSHI: Before the fuel loading, they are required to do a PRA.

DR. XU: They are required to do the PRA, yes.

DR. CHOKSHI: Which will be available for inspection by the staff.

DR. XU: Right.

MEMBER BLEY: Say that again, just so I can get it. It's a transition to part 50?

DR. XU: Part 50 --

MEMBER BLEY: Part 50 something (h).

DR. BAGCHI: 50.71(h).

MEMBER BLEY: Thank you.

DR. CHOKSHI: But before you get to that point, before the fuel load, the licensee is required to have a PRA for both internal and external events.

MEMBER BLEY: And the seismic margins kind of ends at that point.

DR. CHOKSHI: Yes, at that point.

MEMBER BLEY: And that's kind of what I was looking for. Where is that point? And it's before fuel load, it's before the final PRA.

DR. CHOKSHI: And I think we are going to see in the next slide, the basic position was that if you have an available standard to perform the PRA ---

MEMBER BLEY: And just to help me track the rules, because I have trouble with that, what is it that tells one to transition to 50.71(h). Is it a line in Part 52 somewhere?

DR. BAGCHI: It's a line in 10 CFR. A line in 10 Code of Federal Regulations Part 10. That 52 is the combined operating license --

MEMBER BLEY: I understand that, but where if 52 does it tell me we transition back to 50 to do this thing.

DR. CHOKSHI: One of the difficulties in this is 52.103(g).

DR. XU: Once you've done that, you can --

MEMBER BLEY: Thank you, I'll look at that.

DR. XU: And this slide shows the full chart of the switch here in the process where we implement it in the ISG. It's pretty straightforward. And these are the tasks that need to be performed under applications.

So I will walk through them in detail in the next few slides. The staff position in the ISG -- can we go to the next slide, please? The staff position in the ISG was based on Part Five of the ASME and ANS standard, to the extent that it is endorsed by Reg Guide 1.200. Actually, 1.200 practically endorses the entire Part Five.

To ensure that the assumptions used in the analysis performed will be consistent with the information available at the time of the staff review. Next slide, please.

The remaining slides provide the staff position on the information which is needed to be included in an application, and the acceptance criteria the staff will rely on to review and determine the adequacy of the analysis.

This slide indentifies the information that is needed to be provided by DC applicants, and I can just walk through it with you. For the DC applications, you need to provide the description and the results, that's in the regulation, of the following.

The design-specific sequences, and the fragility analysis based on design information. And for components that require casting, the DC applicants will need to provide the criteria of procurement specs to ensure that the goal of the plant-level HCLPF will be met.

And then the DC needs to characterize the plant-level type of capacities, and the most important part, which is in the last bullets, is to provide instructions, because this is a three-tiered approach. To ensure continuity of the processs, the DC applicants should provide clear instructions for the COLA and the licensee, as to what they need to perform to ensure adequate updates by the COLA, and as-built by the licensee.

And these last slides are are lacking or understated by the applicants in the applications we've reviewed so far.

MEMBER STETKAR: Jim, I didn't read, I have to admit, I didn't read the ISG, but --

(Laughter)

MEMBER STETKAR: Can we have a show of hands, or what? No, I didn't read it.

MEMBER BLEY: But you have strong opinions.

MEMBER STETKAR: That has never stopped me in the past. The curiosity I have is, I understand conceptually as you go through the DC, as you go through the COL. Why does the ISG extend staff review of the licensee verification of the seismic margins, when indeed all of that would be folded into, as you characterized it, the licensee requirement to do the

PRA.

In other words, isn't the staff review -- the licensee verification of the seismic margins and the staff review of that process a duplicative effort to the production of the PRA and the staff review of that PRA?

DR. XU: I would characterize it as two separate processes. Because basically this PRA started with the DC, and then we need to have closure. And that's the process that just started with the licensee.

MEMBER STETKAR: Isn't the actual seismic PRA performed by the licencee under whatever it was, 50.71(h)?

DR. XU: Performed by the licensee, yes.

MEMBER STETKAR: The closure of that process, the logical closure of that process.

DR. XU: No, that doesn't provide closure to this process. It's the beginning of another process.

DR. BAGCHI: Can I address this a little bit?

MEMBER STETKAR: Yes.

DR. BAGCHI: This is a Commission expectation under SECY and its SRM, so the margin never goes away. You need to ensure that the margin is in place when you go to a specific site, whether or not certain duct banks or some other pipes flow, go through a liquifiable area, it has some impact on liquifaction potential, and therefore does not meet the seismic margin requirement, and needs to be reviewed by the staff.

MEMBER BLEY: If I could, though, the seismic margin was an alternative to doing the PRA, so you would need to do that under the PRA anyway. I guess I had the same problem. It isn't clear to me why this continues past the COL, if in fact you need to have the PRA to go forward. It just seems a little confusing.

DR. CHOKSHI: Basically, the staff review ends at COL. This just points out that there is an additional requirement for licensee to do before fuel loading.

MEMBER BLEY: And that's no burden, because they have to do it anyway to do the PRA.

DR. CHOKSHI: I want to just say that there is the expectation that if you can go to the site and inspect for the PRA, that this is what we will be looking for, will be how did you perform it, how did you verify it? Did you do the walkdown?

MEMBER BLEY: If those steps --

DR. CHOKSHI: It is not a part of the COL review. Absolutely not.

MEMBER STETKAR: No, but if the inspections that you're talking about -- well, I'll let you get to the next slide. But if the inspections that you're talking about are essentially combined purpose inspections, then that's fine. So long as this isn't a separate line item in an inspection process that --

DR. CHOKSHI: Right.

DR. BAGCHI: May I throw another aspect of my perspective into that? Seismic margin is not just seismic PRA. There is a certain amount of core damage from seismic in any referenced design. Seismic core damage, we can say, will be a dominating contributor. Because you have driven down the internally induced core damage frequencies to such a low level.

Nevertheless, the understanding of seismic hazards at particular sites has been changing very substantially. That was one of the driving reasons for having a seismic margin. So that we can then say that the plant is okay, because it has so much margin.

DR. XU: Can we go back? Let me go back one.

MEMBER BLEY: Yes, let's see if we can get through the rest of them --

DR. XU: I have just a few more slides to go through.

MEMBER BLEY: We've talked about most of them already, I think, but go ahead.

DR. XU: Well, you know. If you think you have all of the information we can skip some of them. Otherwise, let me just go through the whole thing. This slide identifies the information that needs to be provided by COL applications, and the licensee when the plant is built.

There were some questions about what they would do, and they will do seismic PRA, because you need to close this process too. So those two can get done together. I mean, they can go and do the walkdown --

MEMBER STETKAR: I am just concerned about the implication of licensee requirements and staff efforts and inspections.

DR. XU: Actually, if you look at the inside development of the program, there is a connection between the margin and the risk at sites. The higher the margin, the lower the risk. Okay, next slide, please.

The next two slides will provide the acceptance criteria that staff will rely on for the review of the PRA. That's the ASME in support of DC applications. And obviously, we're going to look at the information that the applicant will rely on, design-specific or otherwise.

And we are going to use the -- make sure that the analysis is performed according to capability category 1 requirement of the ASME PRA standard. I know this question came up before in another subcommittee meeting, where some applicants were claiming that the DC application had to perform the PRA comparable to capability level 3 category.

And we obviously would be very troubled with that statement, because DC applications should not contain anything beyond the generic information. So it should be at most capability level category 1, not even 2.

And we would expect that the DC application would include the Seismic Equipment List, SEL, to include and identify all the assets used for the seismic sequences. And the fragility analysis would be performed to a standard consistent with a ASME PRA standard with the following assumptions.

The spectrum shape for analysis should be the DC's CSDRS. If you read the standards, the standards were developed for specific plants, seismically specific plants, so that the spectral shape there would be whatever is applicable to a particular site. And with a DC application, the applicants cannot rely on a particular site's spectral shape, they should use the DC CSDRS. And may applicants fumble with this. Next slide, please.

For components qualified by testing, the applicant can use generic information, but must provide adequate justifications.

And the applicant needs to calculate the sequence-level HCLPF, and make sure that the plant-level HCLPF would be 1.67 times the PGA of CSDRS for that soil that the site is on. And we also expect that the applicant will have someone else who can perform an independent review of the analysis, but as a standard we have the guidance in Part Five to lay down the process.

And the important part, which would be where most of the DCs we have reviewd did not do well, is the instructions to COL and the licensees. So we provide the guidance on what needs to be included within the COL action item to ensure that they continue the process, that it's adequately done by the

COL and licensee.

So also the applicant needs to provide adequate documentation during the DC, so that the staff can perform adequate review. And this is an aspect where most of the applications were lacking. Most of them provide two or three pages and describe it very briefly, and most of the staff has a problem to get the information to deterimine --

MEMBER SHACK: Now, suppose a site is like South Texas, which presumably has a much less aggressive spectrum than the design spectrum. Can they downgrade the equipment?

DR. XU: No.

MEMBER SHACK: They have to meet at least the certified design.

DR. XU: If a site soil failure is a likely issue, they can use the GMRS to determine the capacities. Only the site of --

MEMBER STETKAR: Otherwise, it would be a departure from the certified design.

DR. XU: Right, it would be a departure.

MEMBER STETKAR: I mean, you could, in principle, but then you'd need an amendment.

MEMBER SHACK: Got it.

MEMBER CORRADINI: You gave me the

example, and I didn't understand the example. Could you repeat that, please?

DR. XU: If the failure is site-related, say --

MEMBER STETKAR: They call it ultimate heat sink, cooling towers for example.

DR. XU: Then the fragility for the impact structure, for example, is determined based on the actual GMRS. You are not going to determine the fragility based on our CSDRS, because it would never be qualified to that level.

DR. BAGCHI: Then there is one provision there, hold it right there, there is a problem here also. The applicant cannot reduce the seismic margin for the whole plant. If there is no margin, not an adequate margin, there is a problem, they have to fall back on the alternative, which is core damage frequency.

DR. XU: If you look at our objective, in the end, what is our objective? Our objective is to be sure that the margin exists at certain levels in the as-built plant. You know, that plant had that level of margin --

DR. CHOKSHI: At that site.

DR. XU: At that site. The risk will be

demonstrated to be low, sufficiently low.

MEMBER BLEY: I have two related questions.

DR. XU: You have asked them.

MEMBER BLEY: When I first read this, I didn't even notice that it talks, and your slides talk about building a sequence-level HCLPF, but when you actually read the ISG it tells you how to do the fragility analysis for an SSC. And it has a section on developing a plant-level HCLPF, but it doesn't anywhere talk about developing -- it talks about using sequence-level HCLPFs, but it never talks about how you develop a sequence-level HCLPF.

That's the first thing. Why is that? And the second thing is I'm assuming the EPRI fragility seismic application guide is what tells you how to think about independence and dependence and all that kind of thing to develop --

DR. CHOKSHI: I think all of those questions, the major document that's supposed to be used, ASME/ANS is standard. Which goes through all these steps. So I think that this point, what all the confusion points are not on the critical things.

MEMBER BLEY: So as long as you follow those, you will get these intermediate products that you can use later.

DR. CHOKSHI: You know, I've just finished revising the second round of operational standards.

MEMBER BLEY: Okay, thanks. That's good enough.

DR. XU: Okay, the acceptance criteria take up the next two slides. The acceptance criteria for COL updates, which are that the COL needs to be site-specific, and the principles needed to update both the system aspects and the fragility development. And the applicants again should use the ASME standards and the PRE standard, and that the updates will not be based on an as-build/as-operated plant.

So this again goes with what information will be actually available at this particular stage of the application. And for site-specific fragility analysis, the applicant can use the GMRS instead of CSDRS for capacity calculations.

And again the generic data, they can still use the generic data as support for PRA analysis, but they need to provide justification that the generic data will be consistent and conservative with respect to that particular site, since you have to site all of these.

And to demonstrate the plant-level HCLPF to be 1.67 times the site-specific GMRS. And you look at it here in the DC level, we ask the applicant to demonstrate the margin with respect to CSDRS. At the COL stage, since we already have the site, and since our objective is to the determine the margin for an as-built plant, realistically they should establish the margin with respect to GMRS, which is site-specific. Next slide, please.

What should the applicant do if they can't demonstrate that margin at the COL stage? I mean, this chance is probably remote, but it is still a situation. And we offer two options. The first option would be that the COL will identify whatever it is the weakest SSC that will affect the margin, and update the capacity to ensure the plant-level margin is at that level.

Second, if you don't want to do the upgrade, since you already have the site-specific seismic hazard information at the COL stage, we can perform full convolution. So we have the sequence fragility, and then we can establish the risk matrix, and then we will have to review on a case-by-case basis.

But the COL also needs to provide instructions to the licensee for the verification of as-built plan capacity. And again, the adequate documentation aspects should be included, and this is -- you know, we've found the applications lacking in this aspect. Most of them provide one paragraph. "Our GMRS is enveloped by CSDRS, therefore we don't need to do any analysis further." So that had to be changed. Next slide, please.

MEMBER BLEY: You can leave that one, but I want to ask you something about that. I think you said at the beginning that you had public meetings and discussions on this, and the industry has --

DR. XU: They are fully on board on this one.

MEMBER BLEY: Fully on board.

DR. XU: Yes.

MEMBER BLEY: Okay.

DR. XU: They are fully on board.

MEMBER BLEY: And they've had this for some time, right?

DR. XU: Since September of last year.

DR. CHOKSHI: You know, the origin goes back to the nineties, when we did the first design certification. This concept has been around, and recognition that we need to do the COLs is the stand where we are taking that we need more clarity, I think. In the design certification space, this requirement has been the same, and people have used it.

DR. BAGCHI: As you know, the EPRI documents go back to 2004 and thereabouts, so it's been around for quite some time.

MEMBER BLEY: You are finished?

DR. XU: I think this is the last one. And this is straightforward, the licensee is basically doing the same thing.

DR. BAGCHI: No, this is the last one.

DR. XU: That's the last one, yes. That's already been flipped.

DR. BAGCHI: I know, I went back, which was --

MEMBER STETKAR: This is the last one, now?

DR. XU: This is the last one, yes.

MEMBER BLEY: But you haven't gone through that one yet?

DR. XU: I will go through it, that shouldn't be --

MEMBER STETKAR: Let me short circuit that. I see the transition. What I think about fragility analysis is that you go from the DC to the

COL, the fragilities become somewhat more refined. You specify, at least on your slide, and again I haven't read the ISG, on the slide you say, for the fragility analysis at the COL stage you can use the EPRI report, and use generic fragility data.

And then there's simple line items, at least on your slide, that just refer to a plant-specific HCLPF. Is there more detailed guidance or recommendations in the ISG to clarify what that means? That people really do need to do plant-specific fragility analyses on those structures?

DR. XU: Yes.

MEMBER STETKAR: Okay, following the --

DR. XU: They all need to do plant-specific fragility analysis of all structures, systems, components that are affected by the site conditions.

MEMBER STETKAR: Well, no. They should be --

MEMBER BLEY: At the design cert stage, they should have --

MEMBER STETKAR: Well, but they don't have to do it that way.

DR. CHOKSHI: Yes, they do. I think the simple answer to your question is yes. You know, how do you go from accident sequence level to plant level? It's systemized.

MEMBER BLEY: This is to be a part of the design cert stage, and again at the COL stage.

MEMBER STETKAR: Yes, but as they said earlier, they couldn't do detailed fragility analyses at the design cert stage, because they didn't have all of the complex information available. Or they couldn't unequivocally.

DR. XU: We make assumptions. And then the COL has to verify that assumptions are applicable to the site.

MEMBER STETKAR: Yes, but as you finally get to the as-built plant --

DR. XU: Then they will have to perform more detailed analysis.

DR. BAGCHI: The DC will have to develop instructive response spectra for many locations.

MEMBER SIEBER: I would presume that the starting point for that is the development of the FIRS, F-I-R-S. And then from that, you look at building amplification. That gives you the spectrum and the accelerations for equipment fragility.

MEMBER STETKAR: We still don't have things like pipe hangers and that kind of stuff.

MEMBER SIEBER: No, that comes way at the end, and generally pipes above six inches you design in advance. The other ones, you design as you put the pipes in.

DR. XU: See, what staff is working for is whatever information you include in the application, make sure you state the assumptions clearly, and make sure that that assumption will be verified by the next guy who is going to perform a more detailed analysis.

Okay, so he has some information to rely on, and that he knows what he needs to do to --

MEMBER STETKAR: That was my whole point, the transition from you slide whatever it was, thirteen or fourteen to slide fifteen, to make sure that that's followed through.

DR. XU: The ISG is very clear on what the applicants should do.

MEMBER BLEY: I am assuming, although you don't show it here, that the same thing applies at this stage that applied at the COL stage, but you don't confirm that you have to fix it or do the PRA.

MEMBER STETKAR: Well, you have to do the PRA here, anyway, they said.

MEMBER BLEY: I am sorry. We went through earlier that they have to confirm this as part of complying with this guide.

MEMBER STETKAR: Oh, okay.

MEMBER BLEY: So if they try to confirm it and don't, they have the same two options that they had at the COL stage, I assume.

DR. XU: Yes, yes. Because they need to ensure the margin.

DR. BAGCHI: Nobody had any problem doing that.

MEMBER BLEY: One would hope not.

DR. XU: No, no, no.

MEMBER BLEY: Anything else from the committee?

DR. CHOKSHI: Gentlemen, may I? I think that Dr. Ray asked a question that I wanted to get back to about the western sites, and we have started looking at the mountains, and we are thinking about putting an ISG together that will try to give application guidelines for new western sites.

The regulation and requirements remain a question of how do you get all the necessary information, and we had a presentation at the last ICAAT meeting in June, and trying to reach out and get people to think about that. And maybe they'll start thinking about how we can do it jointly with the industry and DOE, because this is a big issue for everybody.

MEMBER RAY: Well, I've been involved in site locating, the farthest east is New Mexico, and it's hard for people to say, is that the middle of the country or is that in the west? What's going on here?

DR. CHOKSHI: So, anything west of the Rockies is a big question.

MEMBER SIEBER: That's not even in the country.

(Laughter)

MEMBER BLEY: At this point, I'd really like to thank the staff for a very informative discussion. Thank you.

DR. BAGCHI: I would like to say a little bit about what Dr. Ray raised about vertical versus horizontal. Now, the vertical input may be higher with respect to the deep ground acceleration because of the proximity to the fault. But that's in the high frequency area.

And structural margins in the vertical direction are substantially higher. There is hardly any column in a nuclear power plant that would be subject to buckling. So there are some structural systems and components where it could be an issue, but at the high frequency end, that doesn't drive the fragility.

CHAIRMAN ABDEL-KHALIK: Thank you very much. Again, thank you for a very informative presentation. At this time we are scheduled to take a break until 10:45, and at that point we will be off the record.

(Whereupon, the 574th meeting of the ACRS went off the record at 10:26 A.M.)

ACRS Full Committee

ISG 17 - ISG on Ensuring Hazard-Consistent Seismic Input for Site Response and Soil Structure Interaction Analyses

Goutam Bagchi
NRO/DSER

July 15, 2010

Acknowledgement

NRC

Dr. Nilesh Chokshi

Dr. Kimberly Hawkins

Mr. Brian Thomas

Dr. Clifford Munson

Dr. James Xu

Dr. Carl Costantino (Consultant)

Industry

Dr. Robert Kennedy

Dr. Farhang Ostadan

Outline of Presentation

- What is ISG 17?
- Key background concepts
- Key issues addressed in this ISG
- Key Technical positions
  - Comparison of CSRDS with Site-specific Seismic Demand
  - Site-Consistent Seismic Input and Soil Profiles Properties for SSI Analysis
  - Minimum Foundation Input

What is ISG 17?

- ISG 17 supplements SRP Section 3.7.1, "Seismic Design Parameters."
- ISG 17 bridges the gap between:
  - Probabilistic ground motion analysis and deterministic soil-structure interaction analysis
  - Site-specific design response spectra and the certified design spectra
- ISG is based on extensive interactions with the stake holders:
  - Industry white paper
  - NRC sponsored study
- Draft issued August 31, 2009
- Final issued March 24, 2010

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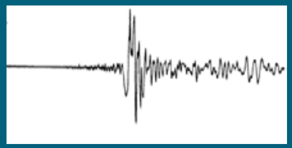
Acronyms

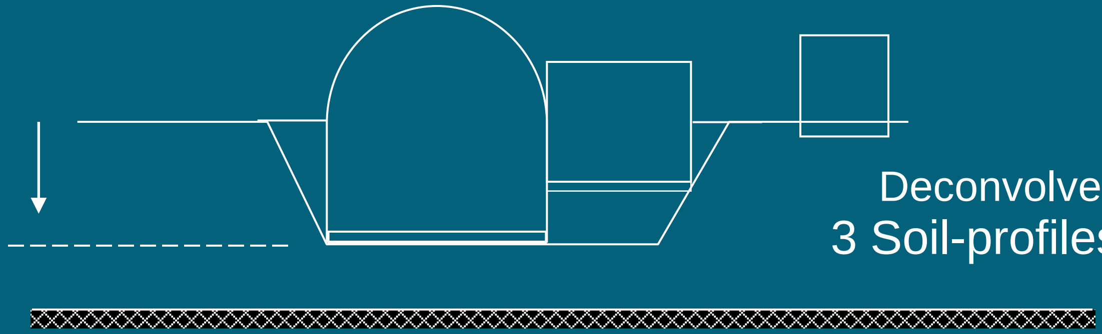
- CSDRS – certified seismic design response spectra - generic response spectra used for certified design (CD)
- GMRS – performance–based site-specific ground motion response spectra
- FIRS – foundation level input response spectrum
- Outcrop – free surface at which the there is no shear stress
  - Produces complete wave reflection
- ISRS – In-structures response spectra
- UHS – uniform hazard spectra
  - Same probability of exceedance at each oscillator frequency
- PBSRS – performance-based surface response spectra

Key Concepts: Past Deterministic Ground Motion & SSI

- Deterministic
- Steps to Determine SSE
  - Identify max. PGA level based on earth-science review (SRP 2.5)
  - Anchor a fixed shape (RG 1.60 for most cases) to max PGA (SRP 3.7.1)
    - – This is SSE
  - SSE is defined at Free Surface
- Application in Subsequent Analysis



Control on reduction of surface motion



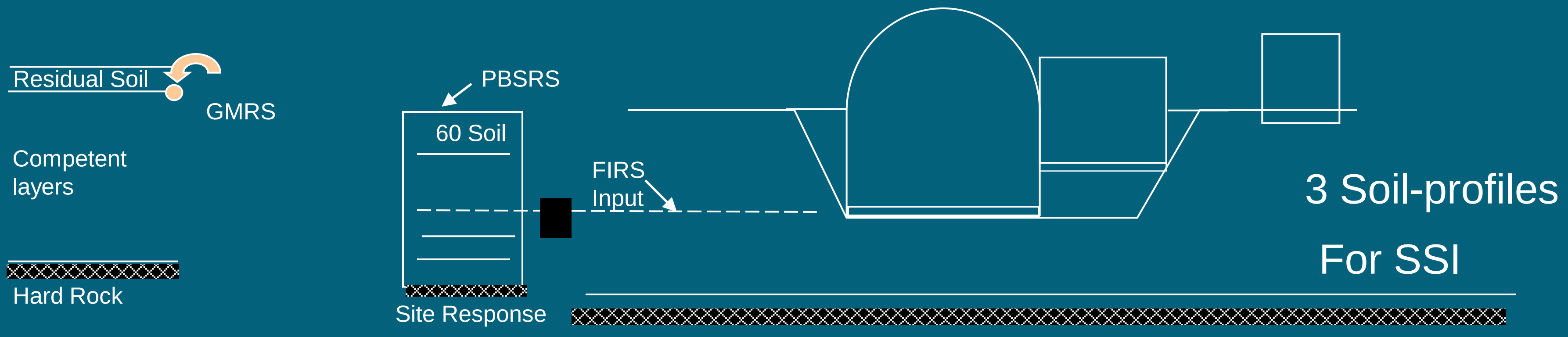
Deconvolve 3 Soil-profiles

– SSE applied at surface in all subsequent analysis
– Deconvolved surface motion
– Deterministic procedure using 3 soil-profiles

From Dr. Nilesh Chokshi

Key Concepts Current Approach: Ground Motion & SSI

- Ground motions probabilistic, performance-based
- Steps to determine ground motion
  - Compute hazard curves and uniform hazard spectra (UHS) at hard rock (9200 ft/s) outcrop
  - Use 60 site-profiles to perform site-response analysis
  - Develop 10^{-4} and 10^{-5} non exceedance UHS at free surface
  - Determine performance-based design response spectra (DRS) by multiplying 10^{-4} surface UHS by design factors derived from two UHS (10^{-4} and 10^{-5}) at free surface



  - In principle starting point for all subsequent analysis – UHS at rock
  - Preserve performance-based approach for the surface motion for actual conditions
  - Use input at the foundation level in free-field (that is compatible with the above) to perform deterministic SSI analysis

From Dr. Nilesh Chokshi

Key Concepts: Past & Present Approach Summary

Past Approach

- No ambiguity in defining SSE
- Surface motion is starting point for all subsequent analysis
- SSE produces design motion
- SSE response spectra are <u>not</u> site-specific
- SSE/OBE relationship straight-forward

Current Approach

UHS at hard rock is unique, site-specific and starting point for analysis

Design input motion varies with site conditions'. Site specific motion used:
-To compare with the DC design
-To design site-specific structures

GMRS is a site-specific spectrum
CSDRS is a generic spectrum

SSE/OBE relationship more complex (e.g., SSCs within DC scope are tied to the OBE for CSDRS)

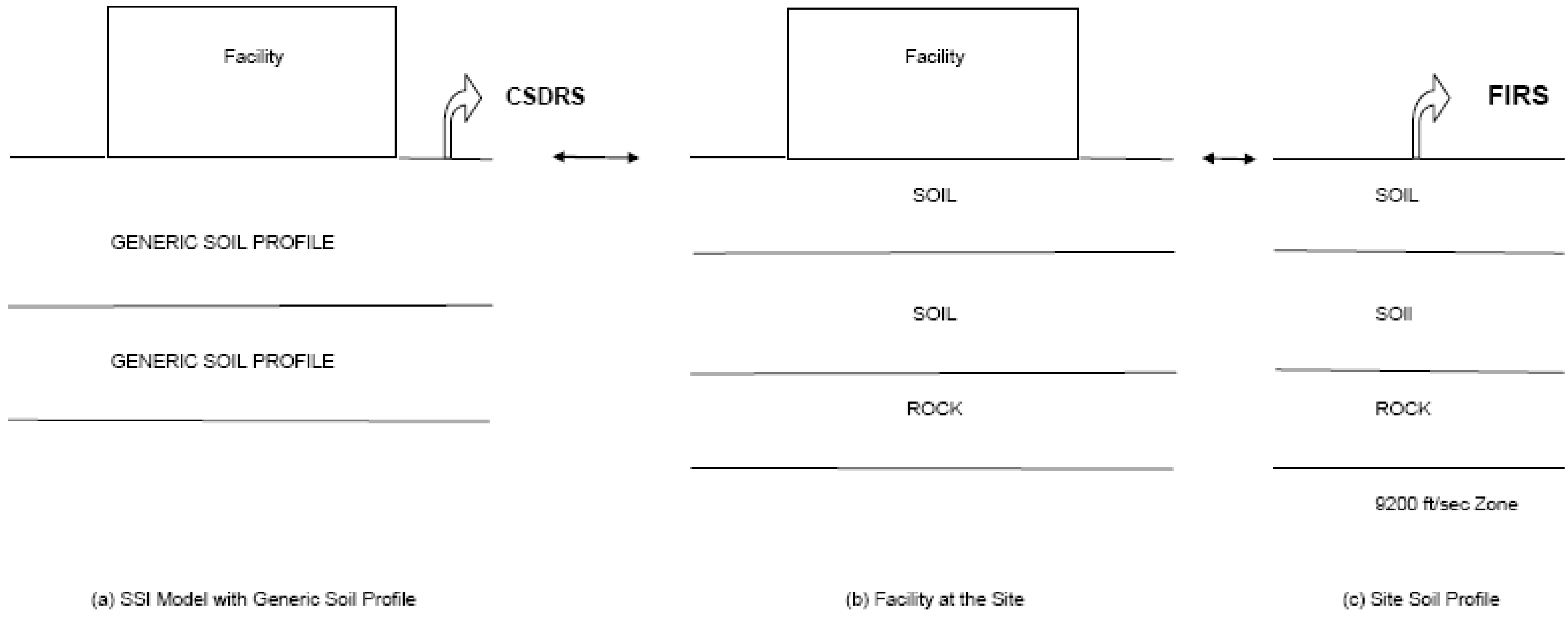
From Dr. Nilesh Chokshi

Key Issue: Comparison Of Site-specific Motion With Certified Design Motion

- Comparing Site-specific spectra (COLA) and the CSDRS to determine if standard design envelopes the site specific motion or additional analyses are needed
  - What do we compare?
  - How do we compare?

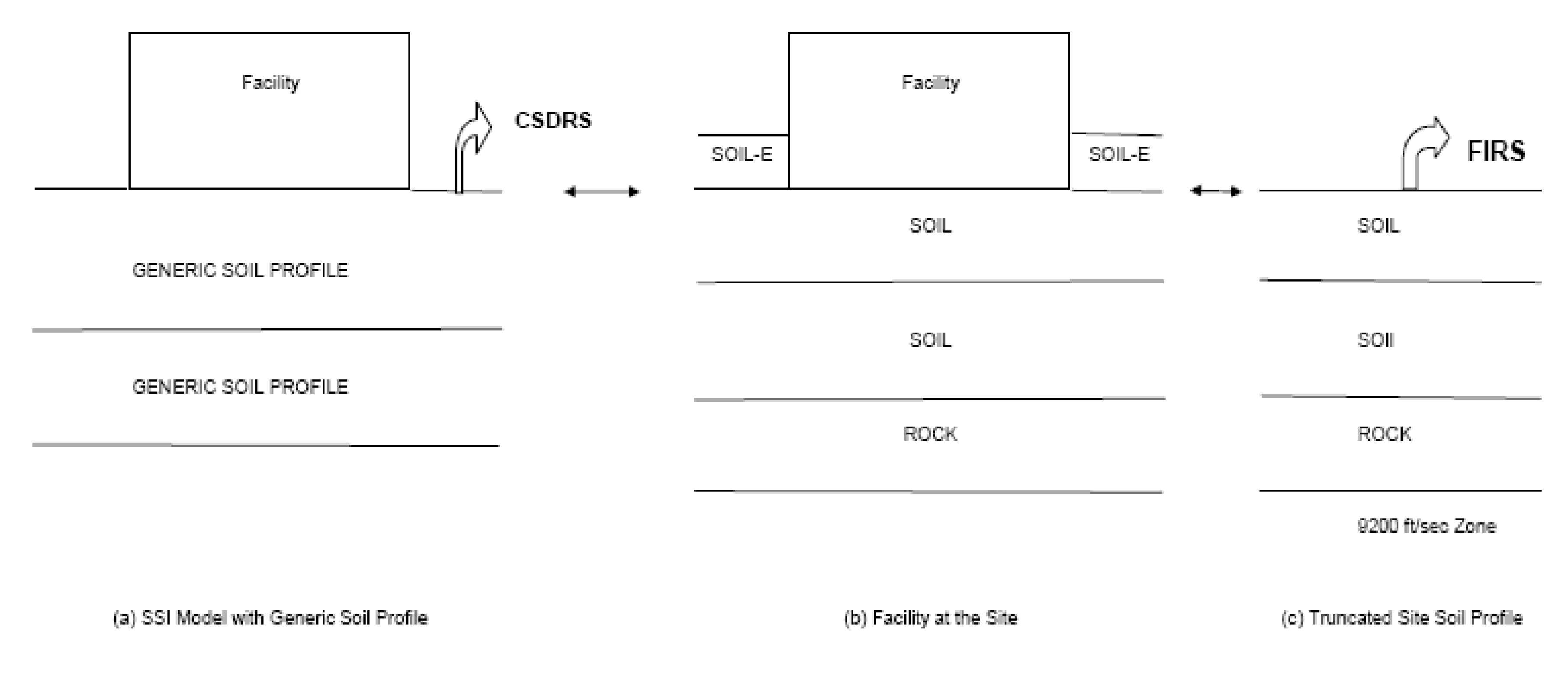
Comparison Of Site-specific Motion With Certified Design Motion – Technical Position 5.1

- Guidance on what to compare - the FIRS for both site-specific conditions and design certification must be compared
- Comparison method driven by seismic design approach used in the certified design
- Guidance on how to develop FIRS - Technical position 5.2 describes how to develop FIRS
- Acceptable procedures for three different situations
  - Surface founded structure with no embedment
  - Embedded structure analyzed as surface founded
  - Embedded structure analyzed as embedded



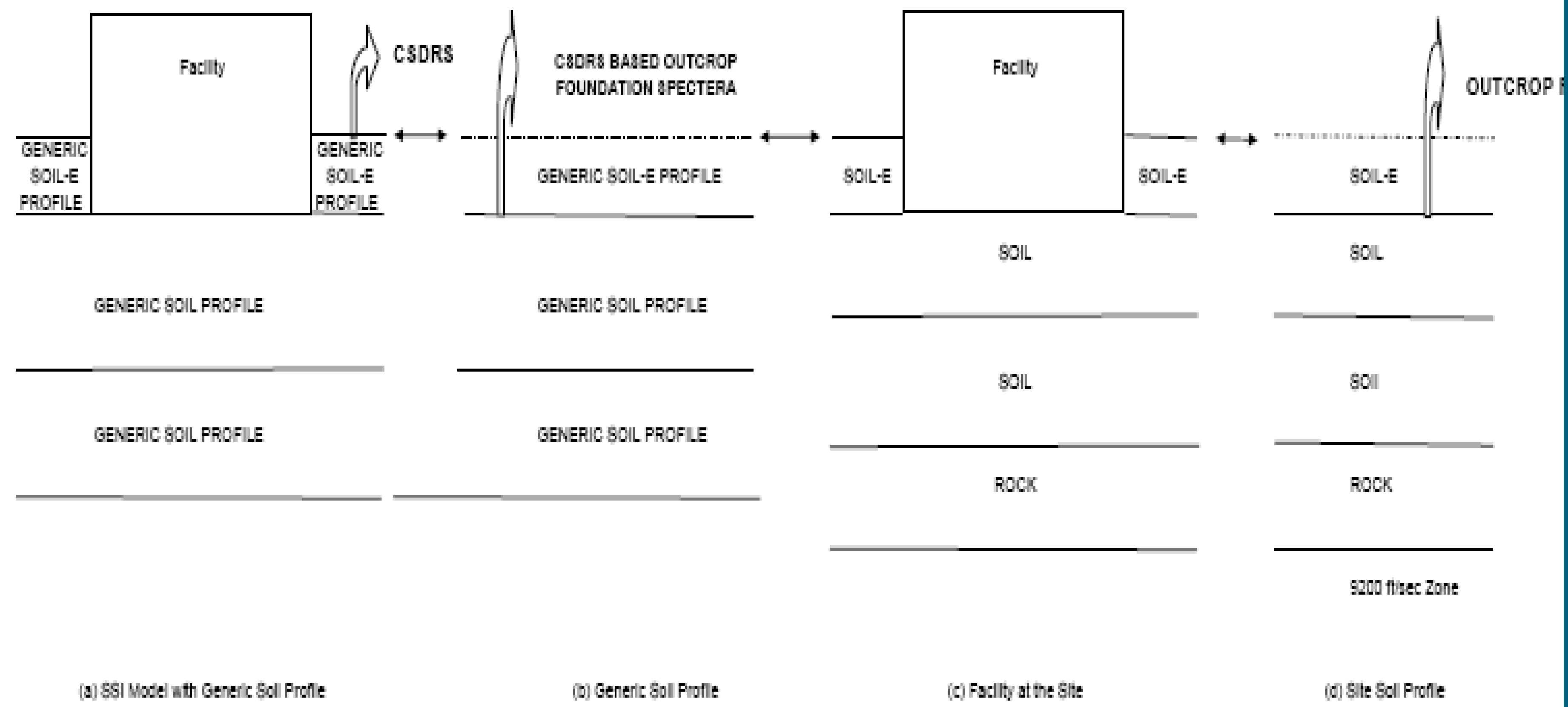
Comparison of CSDRS with FIRS for Surface Structures

Sketch taken from NEI White Paper, Ref 3



Comparison of CSDRS with FIRS for Embedded Structures Analyzed as Surface Structures in Certified Design

Sketch taken from NEI White Paper, Ref 3



Comparison of CSDRS with FIRS for Embedded Structures Analyzed as Embedded Structures in Certified Design

Sketch taken from NEI White Paper, Ref 3

Key Issue – Consistency Between Site-response and SSI Analysis

- How to maintain consistency between the site-response and site-specific SSI analysis considering the following factors
  - Probabilistic site response analysis using sixty site profiles
  - Input motion at rock level in the site response analysis
  - Deterministic SSI using three site profiles
  - Input motion at foundation level in the SSI analysis

Consistency Between Site-response and SSI Analysis – Technical Position 5.2

- Important principle – Maintain integrity of performance-based ground motion when using a deterministic set of SSI analyses
- Two options – one based on an industry white paper and other based on NRC work
- Guidance on how to select three deterministic site profiles from 60 profiles used in the probabilistic site response analysis
- Procedures on how to compute performance-based surface response spectra (PBSRS) and FIRS
- Adequacy check: the surface spectra associated with the FIRS must envelop the PBSRS

Key Issue: Minimum Foundation Input

- 10CFR Part 50, Appendix S Criterion
  – The horizontal component of the Safe Shutdown Earthquake Ground Motion in the free-field at the foundation level of the structures must be an appropriate response spectrum with a peak ground acceleration of at least 0.1g

- How do we assure that site-specific motion meets the requirement
  - What are the options if the site-specific ground motion is less than the minimum

Minimum Input Check – Technical Position 5.3

- Guidance on response spectrum (RG 1.60) to be used with the minimum PGA of 0.1g to satisfy the response spectrum part of the requirement
- Check performed only for horizontal excitation at the foundation level (site-specific FIRS and the above response spectrum with PGA at 0.1g)
- Guidance on associated vertical spectrum with the minimum requirement
- For DCs based on 0.3g PGA broad band spectrum, this check is redundant
- For site-specific SSI analysis, if the site-specific FIRS do not envelop the minimum spectrum, the following options are defined:
  - Use the envelope of site-specific FIRS and the minimum input spectrum.
  - Alternatively, separate analyses using site-specific FIRS and minimum spectrum can be conducted; but design should be based on envelope of responses.

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Thank you

Presentation to the ACRS Full Committee

ISG 20: Implementation of PRA-Based Seismic Margin Analysis for New Reactors

Jim Xu
NRO/DE
July 15, 2010

Outlines

- ISG was developed in close consultation with NRO, RES, and BNL
  - NRO: DE, DSER, DSRA
  - RES: DE, PRA
  - BNL staff
- Chronology
- Regulatory Framework (Why)
- PRA-based seismic margin analysis approach
- ISG 20 Implementation Process (How)
- Staff position

Chronology

- Public meeting on September 29, 2009
- Draft ISG issued on October 15, 2009
- Final ISG issued on March 22, 2010

Regulatory Framework

- Regulation pertaining to PRA assessment of new reactors:
  - 52.47 (a) (27), 52.79(a)(46) and 52.79 (b) (1) establish requirements for DCs and COLs to demonstrate acceptably low risk for standard designs through PRA assessment
  - 50.71 (h) related to PRA upgrade for operation
- RG 1.206 defines scope of PRA assessment:
  - Level 1 & 2
  - Includes internal and external events and all plant operating modes
- SECY-93-087 and SRM
  - PRA-based seismic margin assessment can be used to demonstrate seismic safety by ensuring plant-level margin of 1.67 times SSE
- ISG 20 provides guidance for implementation process for performing PRA-based seismic margin assessment

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PRA-Based Seismic Margin Analysis

- All seismic-induced initiators (transients, LOCA of various sizes, or others appropriate to the standard design)
- Complete logic structures – enhanced from internal event/fault trees to capture seismic failures
- Including non-seismic failures
- Fully developed sequences important for CDF and LRF
- Determination of sequence-level HCLPFs (margins)

ISG 20 Implementation Process

- Information available in new reactor applications:
  - DCs: design-specific, generic
  - COLs: site-specific, plant-specific
  - Licensees: as-built, as-constructed plant
- ISG 20 provides three-tier implementation process to assure adequate seismic margin for standard designs:
  - DCs: perform PRA-based seismic margin analysis based on design-specific information to establish plant-level seismic margin for the design
  - COLs: update DC's analysis to reflect site- and plant-specific information, and to assure DC established margin applicable to the site
  - Licensee: verify as-built plant-level seismic margin through walkdown process

ISG 20 Implementation Process

DC
Design-Specific PRA-Based Seismic Margin Analysis

→

COLA
Plant-Specific Update of DC Analysis Incorporate Site-Specific Failures and Plant-Specific Features

→

Licensee
Verification of As-Built Plant Seismic Margin

- •Design-specific seismic sequences
- •Fragility analysis
- •Equipment qual including procurement specs to ensure the goal for plant-level HCLPF will be met
- •Plant-level/sequence-level HCLPF capacities to satisfy Commission expectation in SECY-93-087 (1.67 times CSDRS)
- •Instructions to COLA and Licensee
- •Staff reviews DCD to ensure information provided address the above items

- •Update DC PRA-based SMA to incorporate site-specific effect and plant-specific features
- •Evaluation of site-specific weak links
- •Establish plant-specific plant-level HCLPF to be 1.67 times GMRS
- •Instruction to Licensee
- •Staff reviews FSAR to ensure information provided address the above items

- •Perform seismic walkdown to verify as-built plant-level seismic margin of 1.67 times GMRS
- •Staff inspections to ensure the verification is adequate

Approach to Developing Staff Position

- Staff positions were developed based on the NRC endorsed industry consensus standard (ASME/ANS Ra-Sa-2009, Part 5) augmented to ensure assumptions used and analyses performed are consistent with information that is available at the time of review

Staff Position

- Information to be provided by applicants:
  - DC applications provide description and results
    - design-specific seismic sequences
    - use of design information for fragility analysis
    - for equipment qualified via testing, measures including procurement specs. are provided to ensure the goal for plant-level HCLPF will be met
    - plant-level/sequence-level High Confidence of Low Probability of Failure (HCLPF) capacities
    - Instructions to COLA and licensee to ensure adequate updates by COLs and as-built margin verification by licensee

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Staff Position (cont'd)

- COL applications provide update of DC SMA:
    - incorporates site-specific effects and plant-specific features
    - evaluate site-specific weak links
    - instruction to licensee to verify as-built plant-level margin
- Licensees:
    - perform walkdowns to establish as-built plant-level seismic margin
    - document results in FSAR
    - staff performs inspections

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Staff Position (cont'd)

- Acceptance criteria for PRA-based seismic margin analysis for DC application
  - Use design-specific information for logic model and fragility development
  - System analysis performed according to Capability Category I requirements of Section 5-2.3 of Part 5 of the ASME/ANS Ra-Sa-2009, to the extent endorsed by RG 1.200, except that the analysis should not be based on site-specific and plant-specific information, as well as reliance on as-built and as-operated plant
  - Develop seismic equipment list (SEL) to include SSCs for seismic sequences
  - Fragility analysis performed according to Capability Category I requirements of Section 5-2.2 of Part 5 of the ASME/ANS Ra-Sa-2009, with the exceptions as for system analysis, and:
    - Can use Separation of Variable or Conservative Deterministic Failure Margin (CDFM)
    - Spectrum shape is defined as DC's CSDRS

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Staff Position (cont'd)

- Generic data can be used with adequate justifications
- Sequence-level HCLPF calculated using mean fragility curve (corresponding to 1% failure probability)
- Plant-level HCLPF shall be the lower bound of the sequence-level HCLPF
- Demonstrate Plant-level HCLPF to be 1.67 times the CSDRS PGA
- Peer review in accordance with Part 5 of ASME/ANS PRA standard
- Instructions to COLs and licensees
  - COL action items to ensure the DC design-specific PRA-based SMA will be updated to incorporate site-specific effects (soil liquefaction, slope failure etc.) and plant-specific features (safety related site-specific structures), to update SEL using the site-specific GMRS scaled by a factor of 1.67, and to demonstrate plant-level HCLPF capacity to be 1.67 times GMRS
  - licensee to verify the plant/sequence level HCLPF capacity based on the as-designed, as-built configuration of the plant prior to the initial loading of fuel
- Adequate documentation in the application

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Staff Position (cont'd)

- Acceptance criteria for COL updates
  - Use site-specific and plant-specific information for updating logic model and fragility development
  - Part 5 of the ASME/ANS Ra-Sa-2009, to the extent endorsed by RG 1.200, except that the updates should not be based on as-built and as-operated plant
  - Site-specific fragility analysis uses GMRS spectrum shape
  - Fragility for seismically-induced liquefaction can use EPRI report - Seismic Fragility Application Guide with the limit state defined in terms of the allowable settlements specified in the referenced DC
  - Generic data can be used to support fragility analysis, but require justifications (consistent or conservative with applicable to the site- and plant-specific information of SSCs)
  - Demonstrate updated sequence-level and plant-level HCLPF to be 1.67 times the site-specific GMRS PGA

Staff Position (cont’d)

- Should plant-level HCLPF be less than 1.67 times GMRS PGA, two options are acceptable:
  - the COL identifies the affected SSCs and upgrade their capacity to ensure the plant level HCLPF capacity be maintained at the level of 1.67 times GMRS PGA or,
  - the COL performs full convolution of sequence fragility for all sequences with the site mean hazard curve to develop risk metrics to demonstrate that the seismic risk is acceptably low for the licensed plant, which will be reviewed and accepted on a case-by-case basis
- Instruction to licensee for verification of as-built plant HCLPF capacity
- Adequate documentation in the FSAR

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Staff Position (cont'd)

- Acceptance criteria for licensee verifications
  - Licensees perform the plant SSC capacity verification:
    - demonstrate that the plant/sequence level HCLPF capacity is consistent with the COL license conditions
    - Using as-designed, as-built plant
    - Walkdown process as described EPRI NP-6041 can be used for the capacity verifications
  - Demonstrate plant-specific HCLPF to be 1.67 times the site SSE
  - Update FSAR

THANK YOU!