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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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SUBCOMMITTEE ON REGULATORY POLICIES AND PROCEDURES

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WEDNESDAY

MAY 19, 2010

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ROCKVILLE, MARYLAND

The Subcommittee convened at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 1:00 p.m., Dr. William Shack, Chairman, presiding.

SUBCOMMITTEE MEMBERS PRESENT:

WILLIAM J, SHACK, Chair

SAID ABDEL-KHALIK

J. SAM ARMIJO

MARIO V. BONACA

MICHAEL CORRADINI

MICHAEL T. RYAN

JOHN D. SIEBER

CONSULTANTS TO THE SUBCOMMITTEE PRESENT:

BOZIDAR STOJADINOVIC

NRC STAFF PRESENT:

ZENA ABDULLAHI, Designated Federal Official

ROBERT ROCHE-RIVERA

JOSE PIRES

GOUTAM BAGCHI

DON DUBE

SYED ALI

ALSO PRESENT:

RICH MORANTE (via teleconference)

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

1:00 p.m.

CHAIRMAN SHACK: The meeting will now come to order. This is a meeting of the Regulatory Policy and Practices Subcommittee.

I am William Shack, the Chairman of this Subcommittee meeting. ACRS members in attendance are Said Abdel-Khalik, Mike Ryan, Mario Bonaca, Sam Armijo, Jack Sieber. Our ACRS Consultant for this review is Professor Bozidar Stojadinovic. Zena Abdulah of the ACRS Staff is the Designated Federal Official for this meeting.

In today's meeting, we will be discussing Regulatory Guide 1.216, Containment Structural Integrity Evaluation for Internal Pressure Loading Above Design Basis Pressure. This is a new regulatory guide that was issued for public comment and subsequently revised in order to address some of the public comments.

As you know, the version of the Reg Guide that we started to review has been revised somewhat further.

The Reg Guide is intended for new light water reactive mines. It deals only with design basis conditions and describes methods the staff finds acceptable for predicting the internal pressure capacity for containment structures above the design basis accident pressure, demonstrating containment structural integrity related to combustible gas control, and demonstrating containment structural integrity to meet the Commission's performance goals related to the prevention of mitigations to their accidents.

We have received no requests from the public to make a statement at today's meeting. The meeting will be open to the public. The rules for participation in the meeting have been announced as part of the notice of this meeting previously published in the Federal Register.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register Notice. Therefore, we request that participants in the meeting use the microphones located throughout the meeting room when addressing the Subcommittee.

The participants should first identify themselves and speak with sufficient clarity and volume so they may be readily heard.

We will receive requests for telephone participation. We asked that telephone participants identify themselves before the start of the meeting. Is anybody on?

Please mute your phone so that you participate by listening only.

We will now proceed with the meeting, and I will call upon Mr. Robert Roche-Rivera of the NRC Office of Research to begin.

MR. ROCHE-RIVERA: Thank you.

My name is Robert Roche-Rivera, and this afternoon we are going to be presenting on Reg Guide 1.216 on Containment Structural Integrity Evaluation for Internal Pressure Loading Beyond Design Basis Pressure.

Here with me today is Jose Pires. We are both from the Office of Research, Division of Engineering, Structural, Technical and Seismic Engineering Branch.

On the line -- I think here they identified themselves, but on the line I believe we should have our contractors from BNL, Rich Morante and Joseph Braverman.

So, today's agenda for the presentation consists of background, objective, description, and we have the public comments available as background, and we are proposing going over the presentation slides, which provide an overview of the Regulatory Guide, and then we propose moving forward with the discussion of the ACRS observations.

As far as the background for this Regulatory Guide, it is intended to ensure appropriate and consistent implementation of regulatory criteria related to structural integrity of the containment for beyond design basis pressure loading.

One key aspect of the Reg Guide is the evaluations are of a deterministic nature, and I would like to mention that motivations that resulted in this Reg Guide were to consolidate and complement available guidance related to three regulatory positions presented in the Reg Guide in one document.

Examples of documents that included this guidance include Reg Guide 1.136, 1.157, 1.7, and 1.206. That was one of the motivations.

A second motivation was to address the issues identified during recent license review.

MEMBER SIEBER: Does that mean that those four Reg Guides will then be withdrawn, once this is approved, or will they still be there, and the effort is duplicated?

MR. ROCHE-RIVERA: They will still be there. Our intention is to complement, provide additional guidance. We decided -- these three different loading cases, what they have in common is that the loading are above the same basis pressure, for our three different loading cases, and the staff decided that this -- including these three cases in one regulatory guide, a different one, a new one, was a good approach for others in that need.

But, the other Regulatory Guide is still remaining in place.

MEMBER SIEBER: Okay.

MEMBER CORRADINI: So, the other guides have different purposes?

MR. ROCHE-RIVERA: Yes, the other Regulatory Guides have other topics besides the topics addressed in this Regulatory Guide.

CHAIRMAN SHACK: One sense, a lot of them provide the loads that you have to deal with in this kind of thing.

MR. ROCHE-RIVERA: Yes.

CHAIR SHACK: You know, they sort of set the boundary conditions on the structural problem.

MEMBER CORRADINI: Okay.

MR. ROCHE-RIVERA: Moving forward.

As far as the motivation, we indicated there were some issues identified during recent licensing reviews.

Some examples of these issues include the use of internal pressure loading for the combustible gas generation, that containment, equal to 45 psig, without the consideration of the pressures generated by 100 percent fuel cladding-water reaction.

When we get to Regulatory Position No. 2, our discussion on Regulatory Position No. 2 will address how we are providing clarity regarding this issue.

And also, there were questions from the Applicant regarding what were the severe accidents that needed to be considered for the evaluation. And, we also provide some guidance in that regard, Regulatory Position No. 3.

Here for reference and information, we present the timeline for the regulatory guide. One comment I would like to say regarding this timeline is that submitting by the date of when the public comments were received, February, 2009, to when we proceed to have a public meeting, where we discussed every solutions to these comments, there were many, many staff interactions, many meetings regarding this Regulatory Guide, to achieve consistency, and to reach consensus, and I think we succeeded in that regard.

Now, our projection is to -- respecting the interoffice concurrence, in this case the Office of New Reactors by this month, and we are having the first Subcommittee briefing today, and we'll have the Full Committee briefing on June, 2010, and it is our expectation that the Regulatory Guide will be publicly available by July.

Overall, as I mentioned, the Regulatory Guide includes three regulatory positions, and the purpose is to provide guidance on what is acceptable to the NRC staff, and we list here the three regulatory positions, a description of the three regulatory positions, and that is -- the first one is the purpose is to predict internal pressure capacity for containment structures of a design basis accident pressure, we'll list the related regulations as well.

We also provide the guidance for demonstrating containment structural integrity related to combustible gas control, and in addition, the third guide, the third regulatory position is related to demonstrating containment structural integrity for an analysis versus Commission's performance goals for the prevention and mitigation of severe accidents.

Now, this is Regulatory Position No. 1. We have mentioned previously the purpose of these regulatory positions, to provide an acceptable method for predicting the internal pressure capacity for containment structures above the internal pressure for the design basis LOCA.

We highlight that this is a pressure capacity at which the structural integrity switching, and a failure leading to a significant release of fission products does not occur.

One thing we'd like to mention is that the Regulatory Guide is consistent with the Standard Review Plan, the applicable SRP sections, and also some of the items -- a summary, an overview of the items that we are addressing in our Regulatory Guide 1.216 with the staff, and this is again Regulatory Position 1, are the staff expectations regarding the use of a non-linear finite element analysis to evaluate the containment response, and also we provide the expectations regarding a simplified method of analysis.

Two key items of this simplified methods are the strain limits, specific for the evaluation, and also the concrete failure modes near this continuity.

CHAIRMAN SHACK: On this one, I mean, I read the original draft regulatory guide. There was a section in there on fragility of containments, and that's something that you need, presumably, for your PRA.

It's not so clear to me what this problem is really addressing. I mean, we've, in the past, assumed that for design basis accidents you had sufficient margin when you met the code, and you used conservative methods to compute the pressures and temperatures. This one, actually, seems to follow more from the SRP, and that just seems to me a somewhat strange regulatory basis.

It doesn't become a starting point for the fragility analysis. I mean, it's not a median calculation of anything. It's not a -- would you consider a conservative -- it's not a -- I guess maybe it is a 95th percentile of the containment pressure capacity.

MR. ROCHE-RIVERA: You might want to consider it in that manner. It is also a useful number, as it also puts in the -- provides a quantitative assessment of the margin above the design basis pressure. It is already implicit on the design procedures, but this provides a quantitative value that the staff can use on their assessment.

MEMBER CORRADINI: How would the staff use it? I'm struggling to understand this.

So, there's a design pressure, which this is not, and then there is a pressure leak rate performance for any particular containment design, and is this the pressure at which it leaks such that the dose is above 10 CFR 100? I'm just trying to understand where along the leakage -- pressure leakage curve this pressure is, and how would one use it?

Am I off base? You tell me if I'm off base.

CHAIRMAN SHACK: No, it's a related question to what I was asking.

MEMBER CORRADINI: Oh, I'm worry, then I don't want to -- I want to be related, not unrelated.

CHAIRMAN SHACK: We are related.

MEMBER CORRADINI: Okay.

MEMBER SIEBER: More or less.

MR. ROCHE-RIVERA: You know, originally the requirements for the calculation of these ultimate capacity or motivations for that, would be like to the Three Mile Island. Those are not as explicit today. They are still present in the Standard Review Plan, the Standard Review Plan still asks for an assessment of the ultimate pressure capacity.

We are trying to maintain consistency with that, in the context of three positions that are here. It's also a useful number, because it also can be used to compare with the pressure capacity that are calculated using the limits that are defined in the other two positions.

So, it does help provide also an assessment of whether the limits for the combustible gas with a severe accident are still close, or what is the margin above those.

MR. BAGCHI: Can I -- my name is Goutam Bagchi, I'm with the Office of New Reactors, Division of Site and Environmental Evaluations.

This was a request I always had in mind, and this request went to the Office of REserach, to try to address the Commission's expectation, which was described in a deterministic manner, so that is in Service Level C, and concrete containments, the ultimate strength criterion would be met.

So, there is very little probabalistic thinking that went on with it. This is a reliable estimate of the containment capacity beyond design basis.

The Commission didn't want to go into the probabalistic framework, so the SECY-93-087 and the SRM didn't change anything. The expectation is based on the coding situation.

CHAIRMAN SHACK: You know, that's Regulatory Position 3, I think, though, isn't it? I mean, I understand the clear connection there for 2 and 3 with the position requirements. It's 1 that has me a little puzzled.

MR. BAGCHI: So, really, the regulatory positions cannot be in conflict with each other, although it could be.

My original expectation was that we will provide some methodology for site -- the containment capacity for doing the calculation that would support PRA later on. But, we did not go that far, because the back-up NUREG studies, or something like that, were not available, and there were large public comments with respect to the fragility portion that we wanted to include in the original draft. So, that was taken out.

But, that's why you see a little bit of --

MEMBER CORRADINI: But, if I could just ask my question again, because I don't -- I guess I don't appreciate -- I guess going back historically, so, let's say tomorrow this was published and somebody computed it, or measured it. Historically, what this number would be used for --

CHAIRMAN SHACK: There is not much left of the containment after you measure it.

MR. BAGCHI: -- I mean, this would be used to demonstrate, we have to write the safety evaluation on Chapter 19 on containment capacity. There is a Chapter 19, DCD requirement that describes the containment capacity.

So, the staff evaluation will have to be that it meets the Commission goal based on these evaluations.

MR. PIRES: One result I find useful for these, like you mentioned on the fair leakage or performance of the containment, these really should bound the pressures on the other two positions. So, it can provide a context for the other two margins. not only with regards to the design basis pressure, also with the margins regarding the metal/water interaction, and the severe accident policy, it can provide a margin of the results of the other two.

Also, these provide a method of analysis that's in capacity or loading clarity.

MEMBER CORRADINI: So, let me try historically. So, when they were trying to construct new NUREG 1150 with the five, or, eventually, six plants they used as surrogates, for Surry they used

120 psia as the ultimate capacity of the Surry containment when compared to all the containment loads for the Level 2 analysis for NUREG 1150.

Is it in this context that such a number would be used?

MR. PIRES: There is only one difference, that is, in this number we prefer to use the code base of the property, so it is somewhat smaller, that number.

MEMBER CORRADINI: But, it's of that type, such that in a Chapter 19 analysis, you wouldn't use the design pressure, you'd use this pressure as the thing to compare to for some sort of off-site release analysis?

I'm just trying to get where I use it.

MR. PIRES: The review evaluation is what we use.

MR. DUBE: Don Dube, Office of New Reactors. Maybe I can shed some perspective.

In Commission paper SECY 93-087, which is about 17 years now, the Commission wanted to provide some distinction between prevention of severe accidents and mitigation.

So, this issue addresses the mitigation aspect, and there were two aspects to that. One was a more deterministic, and one was more probabalistic. The probabalistic has to do with for severe accidents leading to core damage, on average the conditional containment failure probability should be, approximately, 0.1, or 10 percent. So, approximately, only 10 percent of core damages could lead to a large release from the containment failure.

The more deterministic nature here, which is specified in that SECY, says, and you probably get to it in slide 13, but it says, "The containment should maintain its role as a reliable leak-tight barrier for, approximately, 24 hours following the onset of core damage under the more likely severe accident challenges." We'll get to that in a second.

"Following the initial 24 hour period, the containment should continue to provide a barrier against the uncontrolled release of fission products."

So, for the purpose of this is to define what is meant by containment capability, and demonstrating that for the more likely severe accidents the containment integrity on a deterministic basis most likely would be maintained for those 24 hours.

So, it's a deterministic aspect.

MEMBER BONACA: In the same context, I'm

still trying to understand the need for this Reg Guide. I'm not denying it, I'm saying -- and what it does, I mean, it says on page three, "Motivation is to complement and consolidate guidance specified in other regulatory guides."

It seems to me that there are additions in this reg guide here that make the other reg guides obsolete, or is it true; I mean I don't know. It seems to have combined all these reg guides into a new reg guide, which is the one we are reviewing now, and then you are saying that you address different issues and et cetera. What happens to the other reg guides, are they still applicable to existing plants, and what's the difference with the new reg guide, it's only tied to the defined reactors?

MR. PIRES: There is one position in the Regulatory Guide that is not available in the others, that is Regulatory Position 3 that addresses the Commission's performance goals. That is not available in any of the other regulatory guides. So, that's a new aspect.

The other positions that have parts of it are already addressed in other regulatory guides. What this does primarily is provide what is the method of -- they focus more on the criteria. This one complements them by providing the methods of analyses that the staff considers acceptable.

So, that is the major new aspect on this.

The other consideration was that it was deemed useful to have these topics together in a single regulatory guide, because they are all the deterministic methods that are used to deal with the beyond design basis pressure.

MEMBER BONACA: Would expect that some of the requirements, you know, the computer codes, et cetera, would still be applicable to the existing plants?

MR. PIRES: Most of these approaches here are also applicable to the existing plants, but there was an intention behind the Reg Guide that would address mostly those that followed the process of Part 52.

MR. ALI: Excuse me. My name is Syed Ali from Office of Research. Maybe I can add something to clarify, I think, two questions.

One was about the other reg guides. If you have the Reg Guide, if you look at the references, you will see, and I will just read the titles quickly, that those reg guides go to a lot more than just what is in this site. For example, 1.136 is titled, Design

Limits, Loading Combination Materials, Construction and Testing of Concrete Containments. That's a much broader scope.

Reg Guide 1.57 is Design Limits and Loading Combinations For Metal Primary Reactor Containment System Components.

Regulatory Guide 1.7 is composed of Combustible Gas Concentrations In Containments.

And, I think 1.7 is just the format.

So, this Reg Guide only takes portions of those reg guides and kind of consolidates portions that are related to the capacity beyond design.

The other thing I want to get back to, on Dr. Shack's point, if you want to clarify or want to say what kind of a capacity this is, it's a best-estimate capacity, because a lot of methodology that you will see later on in this presentation is based on a lot of test specs, and when they did those tests they find certain strains in the free field or away from the discontinuities, at the time that the containments failed. So, it's really based on some tests and just a best estimate, it's not -- it's very difficult to put in probability, because it's not based on a lot of studies where you can say what is median or 95 percent.

MEMBER BONACA: I have one last question which is, does Reg Guide 1.216 stands alone, I mean, can you go through it and without any reference to the other reg guides?

MR. PIRES: It stands alone for the most part. It is the type of reg guide that deals with the context of applications, and in many ways it mirrors the Standard Review Plan. So, it does stand alone, but some of the guidance there is very, very limited.

For instance, with respect to the severe accident policy, all it does is just a simple reference to the SECY paper 93-087. We tried to provide some more guidance here that the Applicants have found have been -- you know, the review of the application, the staff concluded that a bit more guidance would be useful.

MEMBER BONACA: Okay.

MR. PIRES: We took lots of pains to be consistent with what exists already. So, no changes are needed to the previous regulatory guides.

MR. ROCHE-RIVERA: Moving forward?

CHAIRMAN SHACK: Yes.

MR. ROCHE-RIVERA: Going back to the discussion on the Regulatory Position 1, as I say, we provide guidance for non-linear finite element analysis, and also for simplifying that, and highlights of the simplifying methods are the strain limits specified for the evaluation, and also concrete failure modes near this containment.

Questions regarding this use of a simplified method, as I mentioned previously, again, this position is consistent with the criteria percent in the SRP sections, with addition and clarification.

Such as, a new position regarding the verification of concrete shear and actual failure modes, actual compression failure modes, and also a clarification on the limits for pre-stress concrete containment, and that is the limits for the free-field hoop strain in the present standards apply to the total strain, which is the strain for initial pre-stressing, plus the strain from pressurization.

And also, we clarify, we add and defined, a global-free field hoop strain limit for pre-stressed concrete containments, something in addition as compared to the SRP.

We indicated where the information needs to be provided as part of the FSAR, that is in Section 3.8.

Now moving to Regulatory Position 2, this is the one that relates to combustible gas control inside containment. We present here the regulations related to this regulatory position, and 52.47(a)(12), and 52.79(a)(8), requiring an unofficial description of the equipment and system for combustible gas control, as required by 10 CFR 50.44. Now 50.44 requires that the analysis must address an accident that releases hydrogen generated from 100 percent fuel clad coolant reaction, accompanied by hydrogen burning.

So, the purpose of the Regulatory Guide is to present a method acceptable to analysis of containment structural integrity to this type of load.

This regulatory guide is consistent with other regulatory guides, as we had mentioned previously. In this case is Regulatory Guide 1.7, and in agreement with the Regulatory Position 5 in Regulatory Guide 1.7, our Regulatory Guide 1.126 provides the acceptance criteria for the analysis, which is that service level see and factor low category requirements of the ASME code for steel and concrete containments, respectively. This is the allowable criteria, acceptance criteria.

And also, we provide this clarification of the loading combination, and this is where we address that issue that was found during recent licensings review, where we clarify that the appropriate combination for this case to be comprised of that load and the highest of these other two loading conditions that are represented here in these two bullets. That is, again, the pressure rising from in cladding water reaction and hydrogen burning and post-accident inerting, probably goes to all 45 psig.

Now, the issue mainly was that some of the applicants were just using the 45 psig, even if the -- without the consideration of this other case.

So again, this regulatory position is related to the one, just by referencing it, referencing the method of analysis, which is, we say that the finite element model presented in Regulatory Position 1, it's acceptable with some limitations.

And then, we also say where the information should be submitted, and that is in Section 3.8 of the FSAR.

Now moving to Regulatory Position No. 3, that's Commission's severe accident performance goal, and we list the appropriate regulations.

Now, these regulations require a description and an analysis of the same features for the provisional mitigation of severe accidents. In relation to these regulations, we have SECY 93-87, and the respective SRM, which provides guidance regarding the allowable criteria for the analysis involving severe accident.

Now, this SECY 93-87, is endorsed by reference in Regulatory Guide 1.206. And Regulatory Guide 1.206, basically, says that the review related to meeting the regulations 52.47 and 52.79 listed above should specifically address the issues identified in SECY 90-16 and SECY 93.87, of course, with respect to the SRM.

MEMBER BONACA: Now does it address also LOLAs, large fires and explosions?

MR. ROCHE-RIVERA: Do you mean the Regulatory Position No. 3 if it address?

MEMBER BONACA: Well, the description and analysis of design features to prevent and mitigate severe accidents.

MR. ROCHE-RIVERA: Yes.

MEMBER BONACA: And, you know, there have been lots of work done under B.5.b to look at the severe accidents due to large fires and explosions?

MR. ROCHE-RIVERA: Well, we go into some details, we are going to go into some details regarding what accident sequences should be selected.

MEMBER BONACA: Okay.

MR. ROCHE-RIVERA: We don't specify specific data, but we just present some criteria that would lead to the section of those severe accident sequence.

MR. PIRES: And they are a part of the Reg Guide.

MEMBER BONACA: Okay.

MR. ROCHE-RIVERA: So again, the purpose for this regulatory position, Regulatory Position 3, is to provide an acceptable method for an analysis that specifically addresses the performance goals, identifies the SECY 90-16 and SECY 93-87, for containment structure in nuclear power plants under severe accident conditions.

MEMBER CORRADINI: So, what is the time limit? Don quoted from the 93 SECY, I thought he quoted from the 93 SECY.

MR. ROCHE-RIVERA: Yes.

MEMBER CORRADINI: Which was 24 hours. But, 24 hours has now transitioned to 72 hours. So, is it 72 hours or is it 24 hours? What is the time limit, or is it to understand the range of accidents and analysis so that deterministically you know you fall below best estimate calculations? So I'm struggling to -- is there a time window here since there's not a probability?

In the SECY paper, you either took a probabalistic one out of ten approach, or you said that it must hold for 24 hours.

MR. ROCHE-RIVERA: There's still time frames presented in the SECY. First, we have the initial 24 hours right after the onset of core damage, and then we just have time after those initial 24 hours.

Now, there's acceptance criteria for those two time frames. And well the reg guide, actually, will present what is the proposed acceptance criteria for those two time frames.

MEMBER CORRADINI: Okay.

MR. ROCHE-RIVERA: In Regulatory Position No. 3, so two of the items that we want to highlight in this Regulatory Position No. 3, which, actually, resulted in changes in the regulatory guide as compared to the draft guide version, both due to public comments and NRC staff comments, are the identification of more likely severe accident challenges, and also the criteria for that time frame after the initial 24 hours.

MEMBER CORRADINI: "More likely severe accidents."

MR. ROCHE-RIVERA: Yes.

MEMBER CORRADINI: That's an interesting set of words.

MR. ROCHE-RIVERA: Yes, they are.

MR. PIRES: That is what it is in the SECY paper, and we are trying to help people interpret that.

MEMBER CORRADINI: So, you will help us in following slides, right?

MR. PIRES: I don't know. I hope, yes.

MR. ROCHE-RIVERA: We are trying.

MEMBER CORRADINI: The criterion, and a fairly precise one, I see.

MR. ROCHE-RIVERA: It was a concern, of course, from the public as well.

MEMBER ABDEL-KHALIK: Excuse me, I'm not a concrete person, but how do you define failure?

MR. PIRES: For the --

MEMBER ABDEL-KHALIK: For the analysis.

MR. PIRES: -- containment?

You are talking regarding the position 1 or position 2, or position 3?

MEMBER ABDEL-KHALIK: Take your pick.

MR. PIRES: Well, for instance, I would take for proposition 2, it's an easy one, I guess. In position 2 that is related to the combustible gas controls, I mean, our limit state. It's really more our limit state than failure, is to meet the limits that are already specified in some design codes, they are referred to as the level C limits. These limits allow for stresses that are higher that are essentially the onset of yield.

So, that is our failure specified in that case.

MEMBER ABDEL-KHALIK: So, the definition of failure --

MR. PIRES: In that particular case.

MEMBER ABDEL-KHALIK: -- depends on which position you are talking about, whether 1, 2 or 3?

MR. PIRES: Yes, yes. And so this is a--

MEMBER ABDEL-KHALIK: Perhaps you can enlighten us as to how much difference is there between the definitions of failure in those three positions.

MR. PIRES: Yes, yes, I think I can try it, at least.

It is in the Position 2 and 3, it's, in a sense, using the words that I used before, is that the containment must hold in terms of being leak-tight. And so these criteria more strict because the onset of yield, essentially provides a guarantee that you are not trying to have free flow of deformations up to that pressure.

In the Position 1, you allow more deformation. The deformation, you can go beyond the yield point of the steel liner, for instance, in a concrete containment or up to the steel plates themselves in a steel containment.

So, you allowed the pressure to be such that will induce deformation beyond yield. Now the point there is that how far can you go beyond yield before you get either a rupture of the containment, the containment ruptures itself, or leakage becomes excessive --

MR. BAGCHI: Can I try to address your question about the reinforce time?

MEMBER ABDEL-KHALIK: Please do.

MR. BAGCHI: My name is Goutam Bagchi.

It's a very simple declaration that the ultimate capacity, as determined by the code equation, is equal to the value that you come up with there.

You have a pressure, and you calculate the maximum bending moment, or the maximum shear, or whatever governing failure forces might be, and then you compare it to the ultimate capacity of the section to develop that strength. If it doesn't, then there is a failure.

MEMBER CORRADINI: That may have helped Said, but that didn't help me at all. I'm sorry.

Can I try to restate his question?

I guess I thought when you were answering him, I apologize because I'm not attacking this in a structural manner --

MR. BAGCHI: Sure. Sure.

MEMBER CORRADINI: -- I'm attacking it from a response standpoint. I think you guys are -- every time we ask it this way, you answer it in a structural manner. So, that's probably where my disconnect is.

But, I think of pressure and leakage, right? And what I thought you told me, or at least what I heard you say was, that along that curve as I continue to pressurize, and let's use the Sandia test as an example, there was some sort of various ways in which the structure starts deforming, but at any point there's a leakage rate. When I cross the design point, I'm absolutely, positively sure with high confidence and a lot of conservatism that I won't essentially get beyond the leak rate that I designed the plant and licensed the plant to.

Now, I proceed up that curve, and now I start leaking a bit, bit not much, and I'm still not violating 10 CFR 100 site limits, but I'm leaking.

Then at some point I start leaking more, and then I thought your answer was, Regulatory Positions 1, 2 and 3 are different points on this curve.

MR. PIRES: Exactly.

MEMBER CORRADINI: Okay. So, just from a visual standpoint, I'm looking for some sort of curve that says dink, donk, dink, here are the three points, and relative to the design one, so that it all fits together in some form.

MR. PIRES: Regulatory Position 2 is one point on that curve. Regulatory Position 2 is what we are asking for is what the applicant considers to be the last point on curve.

MEMBER CORRADINI: Regulatory Position?

MR. PIRES: 1, on the ultimate capacity, what, in the opinion of the applicant, is the last point on that curve. The end point.

MEMBER CORRADINI: Before you get a catastrophic -- before you get such a large radioactivity release, we don't satisfy 10 CFR 100?

MR. PIRES: Or, maybe it might even be

beyond that.

MEMBER CORRADINI: Well, that's what I'm trying to understand.

MR. PIRES: We are not putting a specific criteria there on what the leakage rate is. We let the applicant make their proposal, and it is assessed on a case-by-case basis.

MEMBER CORRADINI: Okay, thank you.

MR. BAGCHI: Radiation leakage response really is not amenable to a code type of verification, because when you reach the ultimate strength of a reinforced concrete code there is still some margin.

And, when you did the test, when we did the Sandia test, how did you determine failure? Because we couldn't pressurize anymore. So, it's really not linked to pressure versus leakage rate.

MR. STOJADINOVIC: This is Bozidar Stojadinovic. If I can also chime in.

There is very, very, very few tests, maybe two or three, that attempted to assess the leakage through a cracked concrete wall, which is essentially what we are talking about.

The missing link here, between your position, your question about what is the pressure versus leakage, is the data on how much are you actually leaking through a partially yielded, or semi-cracked wall, and how does that leakage rate increase with increasing cracking, or yielding, or some kind of a through-crack failure formation in the steel kind of containment.

And, in some sense we really do not have an ability to link the two yet. And so, the Commission, what I understand, because over time they have taken a very conservative view in this sense; that the code equations for reinforced concrete, which are aiming at failure of the members, and those that are they used here by ASTM are not even named at cracking and breaking of the members, they are aimed at onset of yielding.

Those are very conservative estimates of a member that is fairly lightly cracked, and in that sense there is an assumption that the leakage rates through the kind of sort of kind of global shell that this containment represents are going to be low.

MEMBER CORRADINI: Okay.

So, above the design, but definitely not at a point where you'd have massive leakage or a substantially noticeable leak?

MR. STOJADINOVIC: Well, my thinking here is that the Positions 2 and 3 are essentially controlled as stated in this reg guide by the same limits.

MEMBER CORRADINI: Okay.

MR. STOJADINOVIC: Which is very low. It is very -- it is there is always going to be leakage. The liner will prevent it, but you could always assume there's going to be just a little bit, and that is still going to be okay.

And then in Position 1, the way I understand it is, the next operative point on the fragility curve.

Now, it is very, again, not difficult, it's not impossible, but it is unsupported by tests, the tests of the actual things were not done. The Sandia tests were beautiful in the sense that they are already there, but it was cold water and the pressure couldn't be pumped up all the way, and some of them broke, and it was very difficult to measure what happened. And, there is a lot of things going on.

So, it is useful to have a best estimate. It is useful to have a best estimate position, but what the leakage rate is at the best estimate conditions, as suggested by this reg guide, is an open question.

MEMBER CORRADINI: Okay.

MR. STOJADINOVIC: We do not know. It is larger than in Positions 2 and 3.

MEMBER CORRADINI: Just larger?

MR. STOJADINOVIC: Larger. But we can't really tell whether that will be a CFR 50 violation on the perimeter of the plant or not.

MEMBER CORRADINI: Okay, that helps. Thank you very much.

MR. PIRES: And, essentially, what we are trying to do is put in the structural engineering terms, the type that you mentioned.

MEMBER CORRADINI: Okay.

MR. STOJADINOVIC: But you are missing the very fundamental link, because no normal conventional structural engineering was interested in leakage off of radiation. There is leakage of water, there is leakage of some liquid natural gas, and things like that have been tried, and there are some ideas as to what the crack sizes are.

There are some French tests that have attempted to do this, and there are a couple of analyses in San Diego has attempted to do this. But, say the San Diego stuff is based on computer modeling, not on the actual test, and then pressurize both sides.

So, there is room to find out more, but this is, I think, a fairly conservative estimate of what happens.

And, just to make it clear, I don't think in Positions 2 or 3 anything is going to be close to failing. It's going to look really good. I mean, the surface is going to look fine, and it is going to be just yielding. So, in that sense I think the structure will be quite safe.

For Position 1, that's based on Sandia test and we can take a look at the pictures of what that looks like.

MR. PIRES: Yes, we have some additional data. We are reluctant to put their leakage criteria. There is test data, and there are measurements in it the precision of tests and measurements that show, for instance, what is the nominal leak-rate curve up to the design basis pressure, and that's normally a very small percentage of the voluntary --

MR. BAGCHI: That really was an excellent characterization. I completely agree with your characterization, that the surfaces might look just fine, even though it has failed.

MR. STOJADINOVIC: Yes, and the leak rate may be very small, but the lack of exact understanding of the leak rate is what forces us, I think, what forces us into this position. If we had a better view of the leak rate, we could speculate more, we could --

MR. PIRES: The general estimate for the for the hole for the nominal leak rate is a very small hole, like this. So it's very visually not detectable on the entire surface face. So that can be --

MR. PIRES: That's an allowable leak rate, the nominal leak rate.

MR. BAGCHI: That's the nominal allowable leak rate, but that would certainly be a lot lower than the limit acceptable.

MR. PIRES: Yes, certainly, yes.

MR. STOJADINOVIC: And, I would like to hear more, especially, not so much about the global, but when we get to dealing with penetrations and the different changes in the shell that are made to let pipes through, or at the foundation level, and so to see how those discontinuities will be treated. I'd like to hear more about that.

MR. PIRES: Yes, we have our second part will address the comments that we have received before. We would like to go one-by-one on those comments if time allows.

MR. ROCHE-RIVERA: Moving on?

So, in Regulatory Position 3, the criteria we are proposing for the more likely severe accident challenges, for defining those sequences, is as follows.

The applicant provides technical basis for the identification of more likely severe accident challenges to be reviewed by the staff on a case-by-case basis.

And, an example of an acceptable way would be to identify the more likely severe accident challenges of identifying the more likely severe accident challenges if to consider the sequences or plant damage states, which when ordered by percent contribution represents 90 percent or more of the core damage frequency.

MR. DUBE: This is Don Dube. If there any risk-informed aspect to this Reg Guide, it's in this one sentence or paragraph.

MR. ROCHE-RIVERA: Yes.

MR. DUBE: But, the 90 percent figure wasn't pulled out of the air. We wanted to make sure that it was consistent with previous design certifications that have been approved or significantly --

CHAIRMAN SHACK: It's sort of like the 10 percent failure.

MR. DUBE: -- review, yes. And when we looked at what was done for two of the design certifications, one used 90 percent and one used 95 percent. So, we felt comfortable using a value like 90 percent based on precedents.

Obviously, 50 percent is too low, and 99 percent is too high. So, you know, the out here is there is the opportunity for the applicant to come up with some other criteria which the staff would review.

Again, this is just guidance, not regulation.

MEMBER CORRADINI: So, the only reason that this is not the same as the other part of the SECY memo is the fact there may be a chance that the final 10 percent, some of those would survive, the containment would survive?

Otherwise, if you pick 90 percent, you've simply got a one in ten probability that you'd bust the containment based on criteria 3 definition.

MR. PIRES: The probability, if I may say, might be a little bit less than 10 percent. Because even if that occurs, the containment rate is stronger than what he is talking about.

MEMBER CORRADINI: Sure, no, I understand that.

MR. PIRES: So, probably it would be less.

MEMBER CORRADINI: I understand that. But I'm saying by this example, which I would suspect you give an example, the licensees will gladly accept your example, you've linked in some indirect way Part A of the SECY and Part B of the SECY.

MR. DUBE: Yes.

MR. STOJADINOVIC: This, I thought, was a very interesting statement, and I like to think -- I mean, I agree, this is the way towards risk information.

But, one thing that I don't know is -- there are two things. One is, what was done in the past? Is this consistent with what was approved by ACRS before?

And, the second one is, in this stacking graph, these events that may lead to core damage frequency, you are going to say this event provides 37 percent, and the other one 17, and the other three, and they add up to 90.

Within those events, is there a possibility that the pressure and temperature outcomes from those events will be different, in the sense that maybe the one that provides half of the 90 percent produces pressures that are lower, and temperatures that are lower than the other value produces the last 3 percent that keel you over.

And so, my fear is that, unless we focus in some sense or try to make sure that the applicants don't take an out here and they designate the very high pressure temperature event as the one that is falling out of this category, that we eliminate that option and that we kind of sort of include really the most severe events in this group.

There is the statement now the ordering is fine, but it may not include -- it doesn't distinguish between the severity of core damage events.

MEMBER CORRADINI: So, what I think you just asked was, do you take the worst of the best, or the best of the best?

MR. STOJADINOVIC: Yes.

MEMBER CORRADINI: In terms of the loading pattern?

MR. STOJADINOVIC: And so, here, the applicant may could be considering the best of the best, and they declare then to be 90 percent of everything. And the worst of the worst may truly be 1 percent, but that may be out.

MEMBER CORRADINI: But that fence-sitter, the worst of the best might be the one you have to use to do your calculations?

MR. STOJADINOVIC: Yes, so how would we deal with this?

MR. BAGCHI: This is a good time, again, may I offer my structural insight to this?

The most important driving mechanism for containment failure is, really, direct pressure.

MR. STOJADINOVIC: Yes.

MR. BAGCHI: Temperature sometimes causes additional pressure, but that's far less important than the pressure itself.

So, we do capture the accident, severe accidents that produce the highest pressure. And there is coordination between the reactor systems folks and the accident analysis folks, and the people who do the structural audit. I've done a few in my life. And I don't think we'll let go of a severe pressure phenomenon that may really trigger the failure initiation.

MR. STOJADINOVIC: Well then, maybe if I can add a little bit of dissent and saying that within this 90 percent, the severe pressure accident must be included, or something like that.

So, you know, there is absolutely no --

CHAIRMAN SHACK: Isn't that what they are trying to do with their second bullet?

MR. STOJADINOVIC: Well, maybe.

MR. BAGCHI: I really wanted to have that kind of statement in the guide itself, but somehow, because of revision or whatever, it might have been taken out.

MR. STOJADINOVIC: Maybe it's in the second bullet.

MR. PIRES: Don, do you want to make a comment?

MR. DUBE: Yes, I mean, we looked at this pretty carefully. I understand what you are saying.

We are taking a quote directly from a Commission policy paper which the Commission endorsed or approved.

If the words of the Commission had chosen said the most limiting severe accident challenges, then I would agree with you. But, that's not what the words say.

The more likely severe accident challenges, which means, in my opinion, that means the most likely core damage sequences and then look at the most likely severe accidents core damage sequences. As I said before, one way to do it is a rank order it, make sure that the containment can take the pressure temperature envelope for the top 90 percent.

Otherwise, where does one draw the line, 95 percent, 99 percent? You are starting to get away from the words "more likely," and getting to be "most bounding."

CHAIRMAN SHACK: But, he is enveloping the 90 percent.

MR. STOJADINOVIC: Yes, I mean, as long as -- my fear is that I do not know what the pressure -- whether core damage accidents can cause different pressures.

If they don't, then this is not a problem, but if they do cause severely different pressures, then I think that the wording should be stated such that within those 90 percent that are emulated by a counting the pressure should be included.

MR. PIRES: We consulted with PRA folks, and with severe accidents people in NRO, and I think the work that they did is more likely severe accident challenges, I think that's very critical in this case.

Even the probability criteria is only on 10 percent conditional probability of failure. So here, if we pick up 90 percent of the sequences, and then even if the containment failure probability is one, we are still below the 10 percent of the conditional.

So, this seemed to be sufficient with the intention of the Commission in their SECY paper. I think we are consistent with that. My understanding also is that there are a few sequences that contribute to these 90 percent, and most of the others are very low probability of occurring. Their probability of occurrence, with the air ducts to add to the last 10 percent, but it is very small for each one of them. So this, in the judgment of the persons in NRO that we dealt with in the severe accidents and with the containment, these appear to be appropriate and consistent with the more likely severe accident definition of the Commission. Is not the most bounding.

MEMBER CORRADINI: So, just to clarify, because I think your explanation satisfies or at least explains. So the second bullet, I interpret the second bullet under pressure temperature demands to mean that if, for example, we were to take your suggested approach and you found 90 percent of all the sequences, and they are the more likely ones, I would look for a pressure temperature response that envelopes that 90 percent, and apply it. That's what

I interpret enveloping means.

Am I interpreting that right?

MR. PIRES: It is that meaning with one exception, that is we also must that they be physically reasonable. Because it could be that there is within those 90 percent the very high pressure, and that may not, really will never co-exist with a very high temperature.

MEMBER CORRADINI: No, no, that I understand.

MR. PIRES: So that if we ask for that--

MEMBER CORRADINI: No, no, that I understand. But let's just pick three possibilities.

So, I have a station blackout sequence. All right. I have a large break LOCA sequence, and I have some sort of something else. Those two are the two that pop in my head.

And based on the core damage or the core and the containment damage state, I might get a series from those six different sequences and six different pressure temperature curves, I would take that pressure temperature pair that envelopes all six of those, all six adding up to 90 percent, I'd use that pressure temperature consistent pair.

That's what I interpret that bullet to

mean.

MR. PIRES: No, no. It is essentially that, but the only small difference from that is essentially that the only small difference is that we think it is acceptable if they judge -- I'm sorry, I think I misunderstood. You are talking about the particular pair, just a single pair.

MEMBER CORRADINI: I'm just trying to figure out what select physically reasonable enveloping pressure temperature demands.

CHAIRMAN SHACK: But, he doesn't take the worst pressure and the worst temperature.

MEMBER CORRADINI: No.

MR. BAGCHI: That word, as it appears in the slide "enveloping," maybe is distorting your view of this.

We are emphasizing --

MEMBER CORRADINI: I'm a basically, distorted person.

MR. BAGCHI: No, sir, I wouldn't say that.

MEMBER SIEBER: I would.

MEMBER CORRADINI: He would.

MR. BAGCHI: The point is that we take the pressure time history that produces the highest pressure load, and then the associated temperature that goes with it.

MEMBER CORRADINI: That's consistent with what I was trying to understand it to be.

MR. BAGCHI: But, not an envelope of all the sequences.

MEMBER CORRADINI: Right.

MR. STOJADINOVIC: But then, this would satisfy what I was wanting to say, that there is a fairly high probability if you'll choose the worst physically consistent combination of pressure and temperature that would happen here, and maybe we'll, through the 90 percent process miss one, but then you are still within the right probabilities.

MEMBER ABDEL-KHALIK: I think, you know, this discussion probably can be clarified if that first sub-bullet in the pressure temperature demand is modified to read, select physically reasonable enveloping pressure demand from the identified sequences and associated temperature, is that what you do?

MR. STOJADINOVIC: Yes, if that's what you do. then that's just exactly it.

CHAIRMAN SHACK: Now, what the actual text says is "which pairs of pressure and corresponding temperature loadings envelope the entire set of pressure and temperature loading." So, that gets very close to where you are at.

MEMBER ABDEL-KHALIK: Right. But that's probably a little confusing, whereas if you say "reasonably enveloping pressure demand from the identified sequences and associated temperature," that would be a more precise --

CHAIRMAN SHACK: Associated rather than corresponding. Okay. You're right. Whatever.

MR. PIRES: It might be more precise, but in the regulatory guide the word that is there, and I think the interpretation of that is you may not just select, necessarily, the pair. You may want to have probably -- you know, it provides a little bit more flexibility than what you say for the applicant. I guess people can see that.

MR. BAGCHI: I have hardly seen in that condition where temperature controls any of the pressure capacity.

The pressure rise is relatively slow. It is even quasi static. Most of the sequences that we evaluate for.

CHAIRMAN SHACK: But, you captured that with the sub-bullet up there for the concrete where you are more or less telling them to just look at the pressure.

Steel is a little bit iffier.

MR. PIRES: Yes, that's the intention of that second bullet was to address exactly that.

MR. ROCHE-RIVERA: Moving on?

Now, for the time frame following the initial 24 hours after the onset of core damage, the regulatory guide provides criteria for addressing this case, and basically we present four options, actually.

And, the first two options relate basically to performing an analysis that shows that the containment structure is strong over the first 24 hours, basically the intent and evaluation.

And if this is not met, then the third one says since this condition or the calculated release for the more-likely severe accident challenges following the initial 24-hour period meets the site-specific design criteria for fission product released from the containment in accordance with the requirements of 10 CFR 100.21 and 10 CFR 50.34.

We also provide the option that the applicants can submit alternate methods, and this will be evaluated by staff on a case-by-case basis.

So, basically, for the two time periods we presented in this Regulatory Position, we quote the method of analysis presented in Regulatory Position No. 1, and we take exceptions in the Reg Guide.

MEMBER CORRADINI: So, can I say it back to you in less words?

So, in the first 24 hours they've got a match up. In the second 24 hours one possibility is, they continue to match up with the load, or they meet the site-specific design criteria for fission product released at the site boundary? I'm trying to remember what the -- in accordance with the requirements, 10 CFR 100.21 are. Is that the site boundary release?

MR. PIRES: Yes.

MEMBER CORRADINI: Okay. Or something else that they can justify?

MR. PIRES: That is -- yes, exactly.

MR. STOJADINOVIC: This CFR 100.21 and 50.34, be the site-specific design criteria for release is key for establishing any space that has confirmed the regulation in this area. This is how it should be done.

We are missing a lot of pieces, but if anyhow possible I would like to keep this in this Reg Guide for the future, for future develops. Because if we had had the ability to compute this, we could do it, this is the way it should be done.

So it is very difficult to do it. It is very difficult to do this, given what we know about reinforced concrete and steel in a containment.

MEMBER CORRADINI: Oh, okay. So you've answered what I was going to ask, which is you told us earlier this is damn hard, if not impossible.

MR. STOJADINOVIC: Yes.

MEMBER CORRADINI: But, you are okay with letting this option in there, even though you know it's very hard.

MR. STOJADINOVIC: Because we will get better. I mean, I personally think we could be doing better right now. But over the years we will get better along these lines. I mean, that's how the CFR 50.61(a), the thermal pressure shock people got there. They are there now.

And, I would like to keep this as a goal for a version of this that is very similar to 50.61(a).

MEMBER CORRADINI: Let me ask on the fourth dash, is there an alternative method the staff has accepted on a case-by-case basis in the past that isn't the second dash and the third dash?

MR. ALI: No.

MEMBER CORRADINI: Okay. I didn't think

so. I was just curious.

MR. STOJADINOVIC: There is one, explode the containment.

MR. ROCHE-RIVERA: And now the information first related to Regulatory Position 3 should be reported in Section 19 of the FSAR.

Going forward?

Basically, we just wanted to be included in this presentation just for reference a tabulation of the public comments that we received, and this is based on the letter from the NEI. The categories were defined by them in the letter, so this is just for reference, the numbers associated with each category.

And, we categorized ourselves these comments on the Regulatory Position. And we formed a working group to work on the resolution of these comments. And, as I have mentioned, over the presentations there were some key changes that were based on those public comments and recommendations from the staff.

Now, I would like to highlight some of those major revisions, and basically it's that the Regulatory Guide scope includes -- it's only applicable for new water reactors.

We received some comments in the line of the organization of the Reg Guide. So we clarified the purpose and also clarified the relationship between the regulation and the regulatory positions.

Also, one thing that was identified by the public was that they wanted more criteria in terms of what was the more likely severe accident challenges, and we are providing that criteria.

And also, they were asking for original criteria; what to do for that period following the initial 24 hours.

And, one of the biggest ones I would say is the removal of the Regulatory Position No. 4, that Dr. Shack has mentioned previously. We think it is that this item may require further development of technical basis and subsequent publication in a report or standard, in that we think that that has to happen first.

And also regarding the intention of this Reg Guide, it's our intention that this Reg Guide should focus on deterministic methods and to subsequent research provides the technical basis for risk-informed performance regulatory guide.

Basically this concludes our presentation. We have here as background slides some examples of key public comments. I leave it up to you if you want to go over these.

The other thing we had planned for this afternoon was to go over the ACRS observations.

CHAIRMAN SHACK: Consultant's observations.

MR. ROCHE-RIVERA: Consultant's observations, and our proposed response to those observations. I think this will be a good time to --

CHAIRMAN SHACK: I just had a question, whether anybody had an alternate suggestion for the criteria for 2 and 3.

MR. PIRES: For Regulatory Position 2 and 3?

CHAIRMAN SHACK: Yes. You know, I assume that the 90 percent was -- I mean, nobody actually proposed anything less than that, did they?

MR. PIRES: There was no specific proposal on the comments. There were requests for proposals from our side.

CHAIRMAN SHACK: Okay.

MR. PIRES: Guidance from our side, but there were no specific requests, as far as I recall.

CHAIRMAN SHACK: You mean all the comments on the choice of the level C, you know, that's already Commission policy. I mean, that's not Reg Guide decisions.

MR. PIRES: But it's a general feeling that the level C, like the consultant said, is strict criteria, but it's not the only. You know, by default on the Reg Guide, it's just one acceptable method, you know, and the applicant can choose another method to be reviewed.

MR. ROCHE-RIVERA: So, we will pass on to the consultant's recommendations and our proposed resolution.

The recommendation here is that, I'll go one-by-one.

MR. PIRES: If I could comment, some of them are very similar, so one sometimes --

CHAIRMAN SHACK: Never ACRS guidance.

MEMBER CORRADINI: Response to ACRS comments?

CHAIRMAN SHACK: No, consultant comments.

MR. ROCHE-RIVERA: Consultant.

CHAIRMAN SHACK: There's no ACRS comments until we write a letter.

MEMBER SIEBER: Delete this slide.

MR. STOJADINOVIC: Yes, I don't know if you want to go through everything, but really, 9, 10, 11 and 12, so if you want to --

MEMBER CORRADINI: Yes, where the money is, yes.

MR. ROCHE-RIVERA: Yes. Well if you prefer just to go on those first.

MR. STOJADINOVIC: Well, just to summarize, I think that the first four or five comments were basically background and just clarification of the scope. And I think -- well, let's go through them anyway because your responses are important to get. Okay, yes.

Okay. So we'll go fast through here.

MR. ROCHE-RIVERA: Okay. So I'll proceed and read the comment and read the response.

Comment No. 1, the objective and the regulatory basis for this Reg Guide are described clearly and in sufficient detail. However, the Regulatory Guide provides the guidelines for a deterministic evaluation of containment structural integrity for internal pressure loads that are above the design basis. The margin of safety, expressed in terms of multiples of design pressure arrived at using these guidelines does not contain sufficient information for probabilistic risk analysis of the containment integrity.

This version of the Regulatory Guide may need to be modified to clearly state its deterministic mission.

Our response is that we concur with the comment and we propose to add a clarification in Section B.

MR. STOJADINOVIC: So, in some sense, according to what we talked about today, we will identify three points along the pressure leakage curve, but those probabilities associated with those points are unknown.

MR. ROCHE-RIVERA: Yes, we don't propose to add a statement to that level of detail. I mean, just a statement saying that the Regulatory Guide addresses deterministic method.

MR. STOJADINOVIC: Yes, that's it, thank you.

MR. ROCHE-RIVERA: Comment 2, statement of a direct link between the three regulatory positions in this Reg Guide and the three tasks stated in the first sentence may help clarify the structure of this Reg Guide.

MR. STOJADINOVIC: Yes, I agree.

MR. ROCHE-RIVERA: Comment No. 3, the scope of applicability is stated to be for light water reactor containment structures using steel reinforced concrete and pre-stressed concrete. However, it is not clear whether the deterministic guidelines of this Regulatory Guide should be applied to non-light water reactor containments using these materials for containment structures, might use other materials.

And, the reason the last sentence of this section may need to be deleted.

So, the staff understands that the comment means that the last sentence in this code section of Part B may indicate that this guidance might be applicable to containments of non-light water reactors constructed of materials other than metal or concrete.

We proposed using two sentences to clarify that this is not the case, basically, made it specific that it is made out of concrete.

MR. STOJADINOVIC: Yes. But hat I would like to avoid is, somebody comes up with a Generation 4 Kevlar containment, something very, very, very different. So, even the principles used here may not work, or some kind of bubble-gummy material. We don't know.

So, we would write the next Reg Guide for that.

MEMBER CORRADINI: You are saying that the analysis -- I just want to make sure I understand just for the sake of my understanding. You are saying that the analysis techniques that are discussed are definitely applicable to metal and concrete.

MR. STOJADINOVIC: Yes.

MEMBER CORRADINI: But, if somebody comes up with something innovative --

MR. STOJADINOVIC: Yes.

MEMBER CORRADINI: -- they may not be applicable.

MR. STOJADINOVIC: Exactly.

MEMBER CORRADINI: Okay.

MR. STOJADINOVIC: Because say something that doesn't leak, even though it's yielding, whatever that is, if somebody comes up with that, we need a new Reg Guide, we cannot throw them into this one.

MR. PIRES: And, that was our intention, but the sentence is awkward.

MEMBER CORRADINI: Okay.

MR. PIRES: And, I think that we will work with the technical editor to clarify that.

MEMBER CORRADINI: I mean, the intent certainly is --

MR. BAGCHI: Not to quibble about this, but if you don't have a national standard, consensus standard, you are not going to build or design any kind of a containment structure the staff will ever accept.

MEMBER CORRADINI: That sounds like something you guys should solve over a beer.

CHAIRMAN SHACK: You know, I mean, you've always said they could have alternate approaches for the position 2 and 3.

MR. ROCHE-RIVERA: Moving forward.

Yes, there is a little bit more than that.

Okay, moving forward.

The glossary of this Regulatory Guide eloquently defines the notions of global and local response. The explanation of the weld hoop strain limits for pre-stressed concrete walls should be augmented by stating that the strength in hoop tendons of typical containments is about 24 percent before pressurization.

Similarly to the statements in Section C.1.f.(2), it may be clearer to express the limiting strengths for pre-stressed containments as increments with respect to the pre-pressurization strength.

We agreed with the first part of the comment, and will augment Part B to state that the strength in hoop tendons of typical containments is about .4 percent before pressurization.

MR. STOJADINOVIC: Just to clarify for everyone, there was an email that accompanied the May 12 version that Ms. Abdullahi sent me, and in that email this was very nicely stated.

MR. ROCHE-RIVERA: Yes.

MR. STOJADINOVIC: So, presenting the Reg Guide, it was nicely stated in the email, that would be really good to have in the Reg Guide.

MR. ROCHE-RIVERA: Thank you, yes.

Comment five, the fairly significant release of fission products should be defined. If the Regulatory Guide opens the door for releases less than significant. One option is to define it in terms of uncontrolled release of fission products is by SECY 93-87. Another option is to place the burden on the applicant to show that a release will not be significant in terms of 10 CFR 50, as seen in approach of lining section C.1.j.

We propose to delete the second part of the first sentence in the first paragraph of Section C.1.

Now, the guidance in the Regulatory Position 1, Section C.1.j, already states that the applicants should consider the potential for containment leakage of pressure levels below the calculated control capacity. A reference to 10 CFR 50 might be construed as a staff position for leakage criteria for ultimate pressures, which instead should be evaluated on a case-by-case basis.

MEMBER CORRADINI: So, you are opting out, you are going to remain silent on this?

MR. PIRES: Well, the concern was that it might be construed to have some other meaning.

MEMBER CORRADINI: I just want to make sure that's what you are doing.

MR. PIRES: Yes.

MR. ALI: This is just to focus on the structure aspects.

MR. STOJADINOVIC: I mean, when I was reading this and other SECYs, there are several terms that are used. And uncontrolled release of fission products was in SECY, and then significant. We want to be very careful about terminology, so as to be either silent or very clear.

MR. PIRES: And, that's why we don't want to use "controlled" here, because it's on the other positions.

MR. ALI: I agree.

MEMBER CORRADINI: Although, you know, as a statement of purpose, I think it's reasonable. And in a sense your simplified criteria, you know, it sort of -- it's like saying level C is what you need to keep it tight in 2 and 3, and so you've got criteria here that can be interpreted as your interpretation of what -- if you meet these, then you are going to have less than a significant one, even if you don't know exactly what it is.

And then if they want to propose anything else, they have to come in and justify it. So, you know, I'm not sure that I have any problems with it, myself.

MR. PIRES: I didn't have problems, though, we were just trying to address the concerns. Because it's always what -- if it is not significant, then what significant is. We don't define significant.

MEMBER CORRADINI: Well, you've sort of got an operational definition of significant, if it meets these structural criteria, you said it doesn't have significant leakage. That's okay. Like I say, it's sort of like leak tight in Level 3.

MR. PIRES: I mean, we were not divided. We didn't really know what way to choose, and what you just said was something that we thought also about. So we might consider leaving it, too.

MR. STOJADINOVIC: Yes, I mean, I'm open to this as long as there is an understanding among us in some kind of past practice in dealing with similar situations.

MR. PIRES: Yes. The main reason why it was there was to later refer to that position j, so that people will not just bypass it.

MR. STOJADINOVIC: Okay.

MR. PIRES: So, that was the main reason why it was there. So, in that sense, I think it might be useful probably to keep it.

MR. STOJADINOVIC: I'm fine, just as long as we know what we are doing.

MR. ROCHE-RIVERA: Comment 6, the scope of the load effects should be clearly stated. They are effects of internal pressure on temperature, and effects of permanent load. The fact that it affects loads such as seismic loads or impact, and as considered in this Reg Guide, may need to be stated.

Section C.1.c defines the analysis process, which also defines the loads that need to be considered for this evaluation, which do not include the air quick load.

MR. STOJADINOVIC: Okay. So by not saying that they are there, you are meaning that.

MR. PIRES: I think it is normally understood by the people who would make these assessments that these loads are not included. It's just the pressure and the dead loads.

MR. STOJADINOVIC: Yes.

MR. PIRES: I think it normally is -- there has not been confusion on that, as far as I know.

MR. STOJADINOVIC: So, there is no need to do --

MR. PIRES: No, I don't think there is a need to do that.

MR. STOJADINOVIC: The other reason why this is, is really in the ASME code there are impact guidelines which allow significant yielding. And so, just to make absolute -- I mean, this is -- if there hasn't been any confusion before, impact will not be considered together with these things at all ever.

MR. PIRES: No. No. I think because these are already considered events that are unlikely, so that they will not combine it. This version is not to combine with other unlikely event.

MR. STOJADINOVIC: Yes, I agree. Okay.

MR. ROCHE-RIVERA: Comment 7, second paragraph in Section C.1 may be consolidated in items

A and B. Item C.1.a should be expanded to include a statement about appropriate boundary conditions of the model.

The second and third paragraphs in C.1 address the organization of this section, which includes a finite element analysis approach, and approaches using simplified methods, while A and B are specific to finite element analysis approach.

Boundary conditions can be -- this is for the second part of the comment -- boundary conditions can be containment specific and their listing would only address a limited number of designs.

This is a level of detail that is not intended for this Regulatory Guide. Nevertheless, Section C.1.i refers to Appendix A to NUREG/CR-6906, which provides detailed guidance on developing finite element models, including boundary conditions.

MR. STOJADINOVIC: Okay. I mean I said may, if you go along too, that's fine. Either way it okay.

MR. ROCHE-RIVERA: Comment 8, I think d and e should be expanded to include a statement of the initial pre-stress and the residual strains should be accountable. The Appendix to NUREG/CR-6906 contains recommendations that may be identified as acceptable.

So we actually are requesting further clarification of this comment.

MR. STOJADINOVIC: Yes, when I was reading this NUREG, there were, I think in Chapter 4 and in the Appendix, they were talking about how the initial pre-stress and the residual strains -- I mean, the initial pre-stress is already there in the analysis. But the residual strains are very often not. And, there was one statement there saying the residual strains, even though they are difficult to capture, may represent 20-30 percent of the stress capacity of the material and should be included. And they suggested some kind of a pre-stress that is available, it says LS-DYNA now or some other method that's available in ABAQUS.

And so my question here is not so much that -- have there been confusions about this, can you get in trouble with applicants doing this or deliberately not doing this, or is this a problem that should be regulated?

And, if so, I think maybe there's a statement in the modeling part that something like that, pre-stress and residual strain should be modeled.

MR. STOJADINOVIC: Is this part of the

pre-stress containment, concrete containments? It would be part of pre-stress concrete.

MR. ROCHE-RIVERA: Yes, and the residual strains are more so for the steel.

MR. STOJADINOVIC: Steel, okay.

MR. ROCHE-RIVERA: Because when you forge them, or somehow weld them, there are --

MR. PIRES: Yes, normally, in the 6906, they had the modeling considerations. We referred already to those modeling considerations. They expressed those models terms of the residual stresses. They were expressing these modeling terms of the resident stress from the forging and the cold work. And in that case, yes there were some comments there on the Appendix D. They said that for those residual stresses, usually they are not included in -- they were not including them in the analysis and that they were already accounted for in the criteria. The point is the criteria in the ASME already has allowances for the residual stresses.

Also, many of these tend to be of a bending pipe.

MR. STOJADINOVIC: Yes.

MR. PIRES: Instead of being the membrane ones, which typically are the more important one for this case. And so, I guess what we may want to do is discuss further with BNL whether it would lead to a confusion to make a point specifically to those parts on the NUREG.

MR. STOJADINOVIC: Maybe the possible way to make it in the Reg Guide, but not make it very big, is to mention it within the finite element modeling guidelines as one item that is in this appendix.

What I would like to avoid is some kind of a vessel design that is very heavily pre-stressed, or has a large set of residual stresses, that for some manufacturing reason are there, but are not accounted for in the analysis. Because then, you know, we haven't done it before, therefore we will not do it again, ever.

And so, so as to have -- for NRC to have a way of saying, well, you know, in this review we found that residual stresses are high, and here we say but you've got to include them.

MEMBER ARMIJO: Some of those residual stresses could be beneficial, though. Welding stresses could, typically, shrinkage stresses leave you in a compressive state. Is that really what you are looking for?

MEMBER CORRADINI: I mean, typically, when residual stresses are harmful, I mean, you know, the code would require you to anneal the vessel, for example, to get rid of them.

We typically don't calculate residual strains in highly ductile materials, just because they generally don't enter into the -- you know, for whatever role they may play in stress corrosion cracking and such, they don't really enter into the failure kind of criteria.

MR. PIRES: That was the comment also from our contractor, the BNL contractor, that again the one comment he made was that some of these are bending stress, they are not the membrane strengths that we are worried about. Particularly, the other was that normally the criteria is for brittle material, the concern, not for these ductile materials of the containments.

MR. STOJADINOVIC: So, in some sense, what I want to do is to make sure that the NRC has a leg to stand on if you require further analysis of this area. But I do believe that you are right, we are most bending, and most cases they are going to be okay, in some cases they are even going to be okay, more than okay.

MEMBER CORRADINI: In some cases, yes, we put them in.

MR. STOJADINOVIC: We like to have them.

But just so that there is a place where the NRC could say, well, okay, guys, we think that the residual stresses here matter, therefore you've got to analyze it.

MR. PIRES: I understand.

MR. STOJADINOVIC: For pre-stress, or whatever.

MEMBER CORRADINI: Go ahead.

MR. MORANTE: Jose?

MR. PIRES: Yes, can you identify yourself? Can you say your name please.

MR. MORANTE: This is Rich Morante. Can you hear me?

MEMBER CORRADINI: Yes.

MR. MORANTE: Okay. This is a very difficult area to request an applicant to factor into an analysis of capacity in any kind of quantitative way.

Just the prediction of what the residual stress or strain patterns would be is a major task in and of itself.

MR. PIRES: No, I understand, Rich. But I understand, if I may say, that the comment from the consultant is that he's not asking that that analysis is addressed there. He just wants a mechanism in the Regulatory Guide that if there is a particular occasion which we think is important, we'll have the means to invoke it.

So, I think he's in concurrence with you.

MR. MORANTE: I have no problem with that, but I heard mention of LS-DYNA and ABAQUS.

MR. PIRES: No, I don't think we need to go into that detail. It's just a means that we can invoke in the Regulatory Guide.

MR. MORANTE: Okay.

MR. PIRES: Thanks, Rich.

MR. ROCHE-RIVERA: Thanks.

Comment 9, Item f should be expanded to clarify the difference between the simplified method and the more complex methods. For example, it may be assumed that the strain base on the simplified method evaluation is intended to cover the weld strengths away from significant discontinuities.

Conversely, the straining of those discontinuities is to be evaluated on a case-by-case basis, using other more complex methods and models. However, this may not be the intent of this Reg Guide. Therefore, the Reg Guide should clearly state when the simplified method evaluation can be done, and when a more complex method, or more model, is needed.

Our response, it is implicit in Part B that the strain limits for simplified methods are intended to account for weld strengths away from discontinuities.

Where applicable, the simplified method is intended to compensate for local strain effects by using a conservative strain limit on the membrane behavior away from discontinuities.

Paragraph 3 in C.1 indicates that simplified methods are an alternative to the more detailed finite element analysis. In addition, C.1.f lists those containment types and the parts of those containments for which the strain limits for the simplified method are applicable.

MR. STOJADINOVIC: Okay. I mean, what I wanted to make sure here is that no applicant is tempted to use the strain limits near a discontinuity.

MR. PIRES: I think we specifically states for cylindrical containments of reinforced concrete of pre-stress.

MR. STOJADINOVIC: So, just to make sure that you don't get someone saying, well, the strain here, this hole is less than 1 percent, therefore, it's okay.

MR. PIRES: No.

MR. STOJADINOVIC: Okay. So, as long as you can use whatever is in the Reg Guide now to prevent that, I'm fine with it.

MR. PIRES: Okay.

MR. ROCHE-RIVERA: Comment 10, the strains limits specified for reinforced concrete, pre-stressed concrete, and steel in item f are conservative. They're approximately one half of the rupture strength. The strain limits specified for reinforced concrete, pre-stress containment and steel -- oh, sorry.

Given that this Regulatory Guide is deterministic in nature, the choice of such limit strain levels could be acceptable.

It should be noted that these strain levels are well in the non-linear response range of the three materials.

MR. STOJADINOVIC: So, just so that for everybody to be aware that f goes quite a bit along the pressure-leakage curve, but it is about halfway to where the vessels burst according to NUREG/CR-6906.

So, I don't know that this gives us an idea where the next point is going to be, but that's just what I wanted to point out.

And also, I wanted to ask you guys, was there any thinking then along the lines of where the limits were set, or did you just half them, or how did you come up with the numbers?

MR. PIRES: For the pre-stress?

MR. STOJADINOVIC: No, for all three.

MR. PIRES: All three?

MR. STOJADINOVIC: Yes, because, you know, for the pre-stress it's about half, and for the concrete it's about half. For the steel, it's a bit less than half. Any method?

MR. PIRES: It was essentially based on the recommendations, if I recall, in 6906.

MR. STOJADINOVIC: Yes.

MR. PIRES: Yes, and that was, essentially. And the motivation was that there may be strain rises on the actual containments that are most be attenders on the test vessels.

So, that was part of it.

The other motivation is, you know, not to go all the way. To have, like you say, not to be so close to the catastrophic area that it might happen.

But, these recommendations are on 6906.

MR. STOJADINOVIC: Okay. So there is a

basis and you can defend this if an applicant comes in?

MR. PIRES: Yes.

MR. STOJADINOVIC: Okay.

MR. PIRES: And, it is also consistent with the Standard Review Plan that is already in effect. This part is consistent with that Standard Review Plan, so it's already been used by some applicants.

MR. STOJADINOVIC: Okay.

MR. ROCHE-RIVERA: Comment 11, Item f.3 should be modified to specifically state that concrete compression failure modes may occur near discontinuities. For example, out-of-plane bending at the containment structure wall near its foundation may induce concrete crushing at the outside surface, before the concrete wall reaches the membrane strain identified in Item f.1. However, the concrete crushing limits state it will be specified. It may be acceptable to specify that the applicant should conduct an analysis that preserves cross section strain compatibility across different materials to demonstrate that the concrete compression stress is smaller than the nominal concrete compression stress capacity $f^{i}c$, reduce using at 0.9 reduction factor.

Our response, C.1.f.(3) already addresses the failure modes in comments 11 and 12. The first sentence in this section will be modified to refer that these failure modes may occur near discontinuity.

This Regulatory Guide does not address specific limit stated conditions based on code methods for each of these failure modes. And this might already by the first choice of an applicant, while for others such guidance might be construed as unnecessarily prescriptive.

MR. STOJADINOVIC: Okay.

MR. PIRES: And, this is also our response to Comment 12. It's kind of similar to this.

MR. STOJADINOVIC: Yes. Well, I mean, for Comment 11, the strain limit, stress limits that are suggested, the strain limits that were suggested in f, I mean, this is fine, and this was in response to I guess some of your questions more directly where concrete compression may occur.

And, the ASME Code and the ACI 359 Code are applicable in these situations cover these quite well.

And then, for Comment 12, it was referring to basically the same thing as this is for shear. I am personally happy with the fairly conservative approach of the ASME Code and ACI 359, they work together. The shear capacities there are sufficiently low to be pretty conservative, from what I understand.

So, as long as the applicants understand that not only that the f, the Part f that you specify here, that those things cannot be applied in shear, I think I'll be fine with this.

MR. PIRES: I think they will. We hope that they will see that this is separate paragraph, and we were mentioning there that it was specifically not for the cases in which this failure might occur before the hoop failures occur, the tensile membrane failures.

We also, and the one reason why we didn't want to indicate particular methods is because we felt they would do what you suggest, they would go to ASME Code. But that the stated one-quarter scale tests there were some studies done for containment under internal pressure, they might be conservative, very conservative.

So, we don't want to -- there was a study sponsored by the NRC at University of Illinois, it's in NUREG 5674, in the CR. So we want to let them be able to -- if they would like to address other studies, if they thought that it might be necessary.

MR. STOJADINOVIC: Okay. So there will be a very -- I mean, you think there is sufficient clarity in the Regulatory Guide, such that concrete strain of, say, 2 percent is not used in shear.

MR. PIRES: I hope there is. I hope that it will be --

MR. STOJADINOVIC: It's very clearly stated, it's an additional failure mode than the one that we've been talking about.

MR. PIRES: I think it will be.

MR. STOJADINOVIC: As long as it kicks it over to ASME C. ASME C is very particular about shear, that is, I mean I guess half of it is about shear stress limits.

MR. PIRES: Right.

MR. STOJADINOVIC: And, those are quite conservative, and I would use them until we come up with better ones.

MR. PIRES: Yes, we probably -- but I think that there is sufficient clarity there. I think that they are clear it's a different material.

MR. STOJADINOVIC: I mean, underlying this, that was my primary concern that is there sufficient guidance so that people don't go using crazy strains where they should not be used.

MR. PIRES: Yes, and we will put that these are near the discontinuities, so that it will be clear.

MR. STOJADINOVIC: Okay.

MR. ROCHE-RIVERA: Comment 13, item f3 should be expanded to include the steel liner and steel liner anchorage failure modes.

Response, these failure modes are already accounted for in the strain limits for C.1.f.(1) and (2).

MR. STOJADINOVIC: Okay. So people will know there will be no confusion that the strains can be used for the liner, because the ASME Code says the liner should not provide strength.

MR. PIRES: Right, yes.

MR. STOJADINOVIC: No, I think the other designers are aware. They never use the liner strengths for the reinforced concrete for the design.

MR. PIRES: Yes, so for this, same for buckling, same for the next comment. Okay.

MR. ROCHE-RIVERA: Comment 15 is now in Section C.2. This Section is based on the deterministic capacity criteria in Regulatory Guide 1.7, and Regulatory Guide 1.57, and the deterministic load demand criteria in Regulatory Guide 1.57 and

Regulatory Guide 1.136.

This guidance provides an engineering interpretation of the combustible gas containment requirement. The capacity criteria for the containment structure based on ASME Code and essentially elastic response of the steel and concrete containment structures are significantly more stringent that the strain based limits specified in Section C.1.f in this Regulatory Guide.

Comments 15 and 18 are related. We concur with the comments, and no response is necessary.

MR. STOJADINOVIC: Yes, I just wanted to say that, you know, with respect to what we discussed also at the beginning of the meeting, that the limit states 2 and 3, our Regulatory Positions 2 and 3 are going to be much, much more conservative, significantly enveloped by Position 1.

No. 16, Item A.2 should clarify the stress or strain range where the use of an equivalent linear model for concrete response is acceptable, and clarify if it is acceptable to take credit for the tensile strength of concrete. And an acceptable method to evaluate concrete sheer strength could be specified as well.

So, we will clarify in Item A.2 the

tensile strength concrete shouldn't be neglected as in C.1.e.

Now, our Regulatory Position is that the use of an equivalent linear model is acceptable. Any equivalent linear model will have to be adequately justified for the containment and application for which it is used and evaluated in a case-by-case basis.

Genetic of containments and application of genetic prescriptions are not recommended. It is assumed that the finite element analysis and the interpretation of these results will account for concrete shear failure as in Section C.1.

MR. STOJADINOVIC: Yes, okay. In terms of shear I'm okay and they will be held to ASME C, no problem.

The reason why I was asking this is because, depending on how far into the stress or strain range for concrete you could go, people could come up with very different elastic, essentially, secant moduli for that material, and that may become a bone of contention.

And so as long as you are going to develop this on a case-by-case basis, for example, for Regulatory Position 2 and 3, the moduli for concrete are going to be much higher than the secant moduli used in Position 1, and you will be able to argue this. I'm okay with it. But what I wanted to do is to, if there is some thinking to do this, yes, but probably it's best to leave it out of the Reg Guide.

MR. ALI: Can I say something? This is Said Ali.

I think that this part and why it was involved in the review process for this Reg Guide and, actually, I missed that equivalent linear model.

You know, my personal recommendation is to take that out, because this can cause a lot of misinterpretation of how this would be used.

So either that, or it needs more clarification of this. So I think that does need clarification.

MR. PIRES: Somehow I'd like to leave it there, because there have been precedents for people using equivalent linear models in manufactured load category applications. But maybe we could add some of the words that are here, that they would have to be adequately justified and reviewed on a case-by-case basis.

MR. STOJADINOVIC: Well, for reinforced concrete, especially, you know, you are not in elastic range, you are going beyond the elastic range. So the stress block for the concrete, you know, it is modular, it's rectangular, but it's actually some kind of hyperbolic shaped. So, I don't see how anybody can come up with a linear concrete stressed in diagram, beyond elastic range.

MR. PIRES: Well, I think this has been a procedure that has been allowed, I mean acceptable by the NRC, and for it is in earthquake loads people use these secant models for the concrete, what they refer to as crack stiffness and that.

So it has been used, and we would not like to deviate from that practice, provided that the justification is provided.

MR. ALI: Yes, I think this is something that ought to go back and look and hash out.

MR. PIRES: This is only for Positions 2 and 3. And in Position 2 and 3 we are not going very much into non-linear range, we are just going slightly on the non-linear range.

And so --

MR. ALI: If you are not going in the non-linear range, then --

MR. PIRES: No, we still go. We still go. But we are not going there by very large factors. I think it might be --

MR. ALI: Maybe -- were you thinking about something like .5 EIg kind of estimate, or are you thinking about the modulus of concrete, Ec.

MR. PIRES: We are thinking, depending on the analysis, again, that's why we don't want to be very prescriptive here, because it depends on the analysis.

For the hoop strengths, for the most part, it's just tensile, and we are neglecting this.

So, that is the biggest non-linearity in many ways. And then where this is going to appear is under these discontinuities where you are going to have bending, and you are going to point to the basis, the connection. So, you would likely use a stiffness that is not trying to constrain the rest of the containment very much.

So, it's very much a case-by-case application, when are you going to use these equivalent linear approaches? So we don't want to be prescriptive, but we don't want to exclude that, provided it's justified.

MR. ALI: But, I think it came from the SRP, you know, which was written in the '70s, when we did not have the computer codes that we have today and have the ability to model non-linear stress diagrams.

MR. PIRES: But, the goal of the SRP was also was updated recently.

MR. ALI: It was updated also then.

MR. PIRES: And, they still had -- no, you know, I am inclined to suggest that we leave it and if anything, just make it clear that the adequate justification needs to be provided to be evaluated on a case-by-case basis. Because there is experience with that.

MR. STOJADINOVIC: I would be happy with a case-by-case basis statement. I mean, what I really want to protect is somebody cherry picking concrete moduli because they think that this is going to be some kind of a secant, and then saying, well, this is softer than the other thing, without any reference to the actual range in which it is.

So, I'd like the reviewers to be in a position to challenge that selection, rather than to specify what the selection is going to be.

MR. PIRES: I understand. I think I understand better. Maybe even requires some iterative process.

MR. STOJADINOVIC: Whatever is so that you guys can challenge the particular number that was taken by the analyst if you think it is not good enough.

MR. ROCHE-RIVERA: Comment 17, now we are in Section C.3.

This section provides guidance on how the applicant should satisfy the containment performance goals in accordance with SECY 90-16 and SECY 93-87.

The Regulatory Guide provides some engineering interpretation of the containment performance goals following the onset of core damage due to plant damage states, and represents 90 percent or more of the core damage frequency.

MR. STOJADINOVIC: This is what we discussed this morning. I wanted to have it here, but I didn't want to put my interpretations, what I asked about whether within the 90 percent we are going to be taking the worst off the wall or not.

And so, I wanted to have you there so that during the discussion we'd have it, but other than that, I think we covered it very well in the beginning of the meeting.

MR. ROCHE-RIVERA: Comment 18, Section C.3.d prescribes the capacity criteria in ASME code Service Level C, for metal containment, or fracture load category for concrete containments, as a method to demonstrate that the containment continues the role of a reliable leak-tight barrier for the first 24 hours following the onset of core damage.

The selected criteria are conservative, as they stimulate essentially elastic response of the containment to internal pressure on temperature due to core damage during the 24 hour period. However, it is difficult to relax this criteria without substantial, and unethical or experimental basis.

MR. STOJADINOVIC: Now also, we covered this in the morning.

MR. ROCHE-RIVERA: Comment 19, Item C.1 should clarify the stress or strain range for the use of an equivalent linear model for concrete response is acceptable and clarify if it is acceptable to take credit for the tension strength of concrete.

MR. STOJADINOVIC: This is a cut and paste, because this was -- the other one was for Regulatory Position 2, Regulatory Position 3, so the same thing.

MR. PIRES: It is the same that we discussed before.

MEMBER CORRADINI: Same response.

MR. STOJADINOVIC: Right. But the reason why we cut and paste is that I wasn't 100 percent sure whether you want to regulate Position 2 different from Position 3. And if you do, okay. If not, okay again, just that's why I cut and pasted.

MR. PIRES: Okay.

MR. ROCHE-RIVERA: Comment 20, the Regulatory Guide does not allow for an alternative to the ASME code acceptance criteria to demonstrate containment performance goals during the first 24 hours after the onset of core damage.

Item d may be expanded to allow such alternative methods, as we've done in Item A.3 and Item c of Section 3, to Section C.3.2 of this Regulatory Guide.

MR. ALI: Did you mean AISC code here?

MR. STOJADINOVIC: I think I mean the ASME code, yes, ASME.

MR. ROCHE-RIVERA: The reg guide by default allows for alternatives, but it does not provide guidance on what those alternatives can be.

The guidance in C.3.1 is one acceptable approach that is consistent with existing regulatory guidance, and we provide the example.

MR. PIRES: Yes, I think that, if I understand this, we are explicit on the other part, here we are not, So it's a bit --

MR. STOJADINOVIC: Yes.

MR. PIRES: -- but by default really alternatives are always allowed.

MR. STOJADINOVIC: Yes, exactly. That's what I recall now, yes. The other parts you were explicit in here with like within the cutting and pasting of everything, it's like a line was dropped out.

MR. PIRES: And, the motivation somehow for that was that -- on the 3.2, it's a more complex situation, and we felt that we needed to be more explicit, it was really.

MR. STOJADINOVIC: Yes, next comment. I think this is also cut and paste.

MR. ROCHE-RIVERA: Yes, it's the same one as before.

MR. STOJADINOVIC: Because again, I didn't know whether you want to regulate this the same as the other ones or not.

MR. ROCHE-RIVERA: Comment 22, Item C allows the applicant to use alternate methods to demonstrate that their containment design meets the performance goal, that the containment should continue to provide a barrier against the uncontrolled release of fission products after the initial 24 hour period, since the onset of core damage.

This is an important step towards performance based, risk-informed regulation. This item should be expanded by referring to the NRC documents that quantify the extremely low probability for accidents that could result in the release of significant quantities of radioactive fission products said in 10 CFR 50.34.

This item should refer to the Appendix in 10 CR-6906 for recommendations on modeling of confinement structures.

MR. STOJADINOVIC: Containment.

MR. ROCHE-RIVERA: Containment structures.

This regulatory guide focuses on the deterministic method, and invoking this extremely low probability for accidents might lead to confusion in Section C.3.2.c.

The reference to NUREG/CR-6906 is already in C.1.i.

MR. STOJADINOVIC: What I wanted to say here is that if we are to develop a NUREG, something like a statement that we should control the releases and models that build on the ones that are suggested in the Appendix with additional modeling to talk about permeability and leakage should be the basis of the future regulation. I do agree that this may cause further confusion, and maybe the invocation of low probability doesn't take place here right now. But in the future guides my reading is that it is very important to keep statements like this, as we could entice people to analyze more and become more precise, and, hopefully, save money by doing more precise analysis and reducing the margins.

And the way forward is something I guess to determine how they should satisfy the uncontrolled release criteria, and what those probabilities are, and what modeling they should be deploying to prove that they are really meeting those criteria.

But anyway, I do like this particular section a lot.

MR. PIRES: Yes, I understand.

The next comment is about what you already just said.

MR. STOJADINOVIC: Yes.

MR. PIRES: So, that was complete.

MR. STOJADINOVIC: And, yes, the CFR 561a, and the NUREG that accompanies it are very good in terms of providing a roadmap as to how to develop similar regulations for containment. Those are, in my opinion, very well done documents.

MR. ROCHE-RIVERA: Thanks.

So, this, basically, concludes our presentation for this afternoon.

Now, if you have any additional questions.

MEMBER ARMIJO: I have a historical question. In your October public meeting, there were a number of comments from different people. And NEI came out with a general comment that the Reg Guide imposed significant requirements, implication of new requirements, and you commented, no, it doesn't.

But you also removed what had been Regulatory Position 4, which took out a lot -- there were a number of other comments.

I just wanted to know, was the NEI issue focused on what had been Regulatory Position 4, and not really on the other 1, 2 and 3? Because it's kind of -- you know, well, maybe this is just a boilerplate comment to make to any new regulatory guide. But I think I just want to know if they were really being responsible in addressing a real problem that you might have agreed to. You know, why did you remove Regulatory Position 4 from the Reg Guide?

MR. PIRES: The main reason, I think, we can refer to one slide that we had before, that was --

MEMBER ARMIJO: I missed it.

MR. PIRES: -- yes, was slide 20, it was because we eventually concluded -- first of all, it was deemed better that we just concentrate on the deterministic methods, again, not to confuse methods.

The other was that we realized later with our working group that this item might require further development, the technical bases are not yet there. And that was another motivation and the other bullet below that the use of the fragility or probability with the risk-informed performance based guidelines or it ought to be PRA, and we were not quite there yet to provide the guidance in that regard whole the other guidance was absent, and then we could provide it.

MEMBER ARMIJO: Okay. So taking that position out had to do with technically you are not ready to do it, it had nothing to do with whether it was a new regulatory requirement?

MR. PIRES: Exactly. And also, there is not a place where to use that fragility yet, as far as our understanding. Even if the fragility were available, there is not a place where to use it as far as we know, at least according to standards. Maybe an applicant could always provide a use.

MEMBER ARMIJO: Okay. Thank you.

MR. STOJADINOVIC: After hearing all this, I am actually sorry that this was taken out, but I realize there is not enough basis for it just yet.

MR. PIRES: Yes, that is right. I understand that Level 2 PRA standard is still being developed by the ANS.

MR. STOJADINOVIC: But all in all in the end, I mean the real need is fragilities like this, and don't throw away the fire wood when you add this regulatory position.

MR. PIRES: No, no, I understand. We have studies being done with Sandia and other organizations looking at developing containment fragilities. But for a guideline we need to be very -- for a regulatory guide we need to be very specific on what is the use of what we are providing guidance on.

MEMBER CORRADINI: Any other questions?

Any comments on what things should be presented at the full Committee?

I think, basically, the initial portion -- you know, we don't need to go through all the comments at the full Committee, but, you know, I think your initial position, sort of laying out the big picture, should work reasonably well, I think, for the full Committee.

When in doubt, shorten it.

MEMBER ABDEL-KHALIK: How much time is allotted for that presentation at the full Committee meeting? How much time is allotted? What's their slot.

MS. ABDULLAHI: It should not be more than an hour. I will have to look it up.

MEMBER CORRADINI: Stick to the usual guidelines, but cover the big picture.

MR. PIRES: Okay.

MEMBER CORRADINI: Don't try to address all the details that we've dealt with here in the Subcommittee meeting.

MR. PIRES: Okay.

MEMBER CORRADINI: If there are no additional questions or comments, I'd like to thank the presenters for their endurance and their general responsiveness to questions and issues raised by our consultant and the members.

Thank you very much.

With that, I think we can adjourn.

(Whereupon, the above-entitled matter was concluded at 2:58 p.m.)

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RG 1.216 on Containment Structural Integrity Evaluation for Internal Pressure Loadings Above Design-Basis Pressure (For New Reactors)

Prepared by: Robert Roche and Jose Pires, NRC/RES/DE/SGSEB
Joseph Braverman and Richard Morante, BNL

ACRS Briefing
May 19, 2010
Rockville, MD

Outline:

- Background
- Objective
- Description
- Public Comments

Background:

- This RG is intended to ensure appropriate and consistent implementation of regulatory criteria related to structural integrity of the containment for beyond design-basis pressure loadings.
  - The RG will provide detailed and up-to-date guidance on deterministic methods to evaluate containment structural integrity under pressure loads above design-basis pressures for new light water reactors design.
- Motivation:
  - Complement and consolidate guidance specified in other regulatory guides (i.e. RG 1.136, 1.57, 1.7 and 1.206)
  - Issues identified during licensing reviews

Background (Cont.):

- Example of issues identified during licensing reviews:
  - Use of internal pressure loading for the combustible gas generation inside containment equal to 45 psig, without consideration of pressures generated by a 100% fuel cladding-water reaction.
  - Questions regarding what severe accidents and acceptable structural integrity criteria should be considered for an analysis that addresses NRC's deterministic containment performance goals in SECY-90-16, SECY-93-087, and corresponding SRMs.

Background (Cont.):

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Timeline:

- Dec 2008 – Issued for public comments
- Feb 2009 – Received public comments
- DG revision with staff working group and BNL
- Oct 2009 – Category 2 public meeting
- May 2010 – Interoffice concurrence
- May/June 2010 – ACRS briefing
- July 2010 –RG publication

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Objective:

- To provide guidance on methods acceptable to the NRC staff for:
  - predicting the internal pressure capacity for containment structures above the design-basis accident pressure
    - 10 CFR 50, Appendix A, GDC 50
  - demonstrating containment structural integrity related to combustible gas control
    - 10 CFR 52.47(a)(12), 52.79(a)(8), 50.44(c)5
  - demonstrating containment structural integrity for an analysis that addresses Commission's performance goals for the prevention and mitigation of severe accidents.
    - 10 CFR 52.47(a)(23), 52.79(a)(38).

Regulatory Position 1: Prediction of Containment Internal Pressure Capacity above Design-Basis Pressure

- 10 CFR 50, GDC 50:“Containment design basis. containment heat removal system shall be designed so that the containment structure and its internal compartments can accommodate, without exceeding the design leakage rate and with sufficient margin, the calculated pressure and temperature conditions resulting from any loss-of-coolant accident…”
- **Purpose:** to provide an acceptable access method for predicting the internal pressure capacity for containment structures above the internal pressure for the design-basis LOCA.
  - Internal pressure capacity at which the structural integrity is retained and a failure leading to a significant release of fission products does not occur.

Regulatory Position 1: (Cont.)

- **Related SRP sections**
  - 3.8.1 and 3.8.2, SRP Acceptance Criteria 4.K and 4.D, respectively.
- **Items Addressed:**
  - Staff expectations regarding the use of a nonlinear finite element analysis to evaluate the containment response
  - Staff expectations regarding the use of a "Simplified Method"
    - Strain limits specified for the evaluation
    - Concrete failure modes near discontinuities

Regulatory Position 1: (Cont.)

- Staff expectations regarding the use of a "Simplified Method" (Cont.)
  - The positions are consistent with criteria in SRP sections 3.8.1 and 3.8.2 with addition and clarification such as:
    - new position regarding verification of concrete shear and axial compression failures.
    - limits for the free-field hoop strain in the prestressing tendons apply to the total strain which is the strain from initial prestressing plus the strain from pressurization.
    - Defines global free field hoop strains limits for prestressed concrete containments
  - Information to be submitted in the FSAR and in which sections of the FSAR (i.e. Section 3.8).

Regulatory Position 2: Combustible Gas Control Inside Containment

- 52.47(a)(12) and 52.79(a)(8) for DC and COL applications respectively, require an analysis and description of the equipment and systems for combustible gas control as required by 10 CFR 50.44
- 50.44(c)(5)
  - "Structural analysis. An applicant must perform an analysis that demonstrates containment structural integrity… The analysis must address an accident that releases hydrogen generated from 100 percent fuel clad-coolant reaction accompanied by hydrogen burning…"
- **Purpose:** to provide an acceptable method to evaluate containment structural integrity to pressure loadings associated with hydrogen generation due to the reaction between fuel cladding and the water coolant.

Regulatory Position 2: (Cont.)

- This RG complements the guidance in RP 5 in RG 1.7
- In agreement with RP 5 in RG 1.7 it provides acceptance criteria to meet requirement in 10 CFR 50.44(c)(5).
  - Service Level C and Factored Load Category requirements of the ASME Code for steel and concrete containments respectively.
  - Load combination consisting of dead load and the higher of the following:
    - Pressure arising from fuel cladding-water reaction, hydrogen burning, and post accident inerting (if applicable), or
    - 45 psig.
- Additionally, it references the finite element model described in RP 1 of this RG, with some limitations, as an acceptable method to evaluate the containment structural integrity.
- Information to be submitted in the FSAR should be reported in section 3.8.

Regulatory Position 3: Commission's Severe Accident Performance Goal

- 52.47(a)(23) and 52.79(a)(38) for DC and COL applications respectively, require a description and analysis of design features for the prevention and mitigation of severe accidents.
- Section C.I.19.8 of RG 1.206 provides the following guidance:
  - "The applicant should provide a description and analysis of the design features to prevent and mitigate severe accidents, in accordance with the requirements in 10 CFR 52.47(23) or 10 CFR 52.79(a)(38), for a DC or a COL application, respectively. This review should specifically address the issues identified in SECY-90-016 and SECY-93-087, which the Commission approved in related SRMs dated June 26, 1990, and July 21, 1993, respectively, for prevention (…) and mitigation (…)."

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Regulatory Position 3: Commission's Severe Accident Performance Goal (cont.)

- **Purpose:** to provide an acceptable method for an analysis that specifically addresses the performance goals identified in SECY-90-016 and SECY-93-087 and related SRMs for containment structures in nuclear power plants under severe accident conditions.
- SRM (July 21, 1993) to SECY-93-087 states:
  - "The containment should maintain its role as a reliable, leak-tight barrier (for example, by ensuring that containment stresses do not exceed ASME Service Level C limits for metal containments, or Factored Load Category for concrete containments) for approximately 24 hours following the onset of core damage under the more likely severe accident challenges and, following this period, the containment should continue to provide a barrier against the uncontrolled release of fission products."

Regulatory Position 3: Commission's Severe Accident Performance Goal (cont.)

- Key items:
  - Identification of more likely severe accident challenges
  - Criteria for structural integrity evaluation of the containment for the period after the initial 24 hours following the onset of core damage as it relates to the ability of the containment to continue to provide a barrier against the uncontrolled release of fission products.

More Likely Severe Accident Challenges

- Selection of accident sequences for consideration:
  - "The applicant provides the technical basis for the identification of the more likely severe accident challenges to be reviewed by the staff on a case-by-case basis. An example of an acceptable way to identify the more likely severe accident challenges is, to consider the sequences or plant damage states, which, when ordered by % contribution, represent 90% or more of the core damage frequency."
- Pressure-temperature demands
  - Select physically reasonable enveloping pressure-temperature demands from the identified sequences.
    - These demands define the deterministic loads for the structural analysis.
    - For concrete, it is generally acceptable to analyze the containment for the sequence or damage state with the highest pressure load and its co-existing temperature loading

Period Following Initial 24 hours after the Onset of Core Damage:

- "…the containment should continue to provide a barrier against the uncontrolled release of fission products."
- Acceptable ways for meeting the performance goal:
  - The maximum pressure/temperature demands following the initial 24-hour period is enveloped by the maximum pressure/temperature demands during the initial 24-hour period; or
  - The containment response under the maximum pressure/temperature following the initial 24-hour period meets applicable Level C or Factored Load acceptance criteria (as in the case of the first 24 hour period); or
  - The calculated release for the more likely severe accident challenges, following the initial 24 hour period, meets site-specific design criteria for fission product released from the containment, in accordance with the requirements of 10 CFR 100.21 and 10 CFR 50.34; or
  - Another alternative method if adequate justification is provided.
- For the evaluations to be conducted for the two time periods under consideration, the RG recommends using a finite element model such as that described in Regulatory Position 1.
- Information to be submitted in the FSAR should be reported in Section 19.

Public Comments

- Public comment period: December 9, 2008 to February 9, 2009.
  - 38 comments received by February 9, 2009.
- Comments by category as per NEI submittal:

Purpose	6
Applicability	11
Methodology	3
Acceptable Analysis Codes	2
Definitions	1
Limitations	10
Criteria	5

Public Comments (Cont.):

- Comments by Regulatory Position:

RP 1	4
RP 2	1
RP 3	7
RP 4	12
RP 1 and RP 3	2
RP 1 and RP 4	2
RP 3 and RP 4	1
Other	9

- Staff formed a working group for the resolution of the public comments that resulted in major revisions to the DG.

Public Comments (Cont.):

Major revisions include:

- The DG scope is for new light water reactor designs
- Clarification of the DG purpose and relation to existing requirements and guidance documents.
- Severe accident performance goals (SECY 93-087/SRM)
  - Approach to identify the more likely severe accident challenges.
  - Additional criteria for the period following the initial 24 hours after the onset of core damage.

Public Comments (Cont.):

Major revisions include:

- Removal of Regulatory Position (RP) 4, “Containment Fragility under Pressure Loads”
  - Item may require further development of technical bases and subsequent publication in a NUREG report or a standard.
  - This RG should focus on deterministic methods until subsequent research provides the technical bases for risk-informed performance-based regulatory guidelines.

Background Slides

Resolution of Public Comments on RP 1:

1. **Comment:** "No leakage criteria is identified for C.1 item k."

   Staff Response: Currently there is no regulation or guidance to specify leakage criteria for this purpose. In past licensing review process, the applicants provided their acceptance criteria which were reviewed on a case-by case basis. Presently, it is more productive to continue to review criteria presented by the applicant on a case-by case basis rather than establishing leakage criteria. Therefore, no change was made.

Resolution of Public Comments on RP 1:

2. **Comment:** This comment addresses the acceptable membrane strains in steel and concrete containments to define the ultimate pressure capacity. The comment also addresses leakage failures as opposed to catastrophic failures for concrete containments.

   Staff Response: These strain limits are for use with an alternative "Simplified Method" to the more rigorous nonlinear FEM of analysis. The strain limits incorporate reductions to account for strain risers in actual containments that are more severe than those in the models tested and for results in NUREG/CR-6810 and NUREG/CR-6809. Leakage failures are addressed in comment 1 (slide 20).

Resolution of Public Comments on RP 3:

1. **Comment:** Several terms appear to be in need of definition to effectively use the proposed Regulatory Guide and these include the following:
   - "More Likely Severe Accident Challenges" is not defined. This leads to an open-ended analysis criteria.
   - Containment should maintain "leak-tight barrier" for 24 hours. ("Leak-tight" is not defined.)
   - Containment should continue to provide a barrier against "uncontrolled release" of fission products after 24 hours. ("Uncontrolled release" is not defined.)
   - "Design Basis Accident Temperature" is not defined (See p.7 of DG-1203).

   Staff Response:
   - Selection of the "more likely severe accident challenges" is addressed in the RG (see slide 15).
   - In agreement with the Commission's performance goal the RG guidance is that a reliable "leak-tight" barrier is provided by ensuring that containment stresses do not exceed ASME Service Level C limits for metal containments, or Factored Load Category limits for concrete containments.
   - The RG provides guidance on how to meet the Commission's performance goal related to the "uncontrollable release" of fission products (see slide 16) after 24 hours following the onset of core damage.
   - The "design-basis accident temperature" is the temperature used in the design of the containment for the design-basis loss-of-coolant accident (LOCA) in agreement with General Design Criteria 50 in App. A of 10 CFR part 50.

Resolution of Public Comments on RP 3:

2. **Comment:** Section C.3: For initial 24 hours, linear elastic material properties may be used. This does not appear to allow for use of inelastic material evaluations in a realistic ultimate pressure/temperature calculation.

   Staff Response: RP 3 for the initial 24-hour period is not intended to calculate the ultimate pressure/temperature capacity of containment. It is intended to show that for the "more likely severe accident challenges" a "leak tight barrier" is provided if Service Level C limits in the ASME Code are satisfied for steel containments and the Factored Load Category limits are satisfied for concrete containments (per the Commission's performance goals).

   In accordance with the ASME Code, Service Level C and Factored Load Category criteria are verified using linear elastic analysis methods.

Acronyms:

ACRS	Advisory Committee on Reactor Safeguards
ASME	American Society of Mechanical Engineers
BNL	Brookhaven National Laboratory
CFR	Code of Federal Regulations
COL	Combined License
DC	Design Certification
DG	Draft Guide
FEM	Finite Element Method
FSAR	Final Safety Analysis Report
GDC	General Design Criterion
LOCA	Loss-of-coolant accident
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission
RG	Regulatory Guide
RP	Regulatory Position
SECY	Secretary of the Commission, Office of the
SRMs	Staff Requirement Memoranda
SRP	Standard Review Plan

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Response to ACRS Guidance to the Staff on RG 1.216

Prepared by: Robert Roche and Jose Pires, NRC/RES/DE/SGSEB
Joseph Braverman and Richard Morante, BNL

ACRS Briefing
May 19, 2010
Rockville, MD

Comment 1

- **(Section A)**
- The objective and the regulatory basis for this RG are described clearly and in sufficient detail. However, the RG provides the guidelines for a deterministic evaluation of containment structural integrity for internal pressure loads that are above the design basis. The margin of safety, expressed in terms of multiples of design pressure, arrived at using these guidelines does not contain sufficient information for probabilistic risk analysis of the containment integrity. This version of the Regulatory Guide may need to be modified to clearly state its deterministic nature.

- **The staff proposes to add that clarification in Section B (scope section).**

Comment 2

- **(Section A)**
- A statement of a direct link between the three Regulatory Positions in this RG and the three tasks stated in the first sentence may help clarify the structure of this RG.

- **The items in the first sentence of Part A are repeated in the remainder of Part A, in Part B (Background) and then again in Part C (Regulatory Positions) to provide the direct link between those three items, the background and the positions.**

Comment 3

- **Section B: Scope)**
- The scope of applicability is stated to be for LWR containment structures, using steel, reinforced concrete and prestressed concrete. However, it not clear whether the deterministic guidelines of this RG should be applied to non-LWR containments, using these materials for containment structures made using other materials. In addition, the last sentence of this section may need to be deleted.

- **The staff understands that the comment means that the last sentence in the scope section of Part B may indicate that this guidance might be applicable to containments of non-LWRs constructed of materials other than metal or concrete. We proposed using two sentences to clarify that this is not the case.**

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Comment 4

- (**Section B: Prediction of Containment Internal Pressure Capacity above Design Pressure)**
- The Glossary of this RG adequately defines the notions of global and local response. The explanation of the wall hoop strain limits for prestressed concrete walls should be augmented by stating that the strain in hoop tendons of typical containments is about 0.4 percent before pressurization, similar to the statements in Section C.1.f.(2). It may be clearer to express the limiting strains for prestressed containments as increments with respect to the pre-pressurization strains.

- **The staff agrees with the first part of the comment, and will augment Part B to state that the strain in hoop tendons of typical containments is about 0.4 percent before pressurization.**

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Comment 5

- **(Section C.1)**
- The term "significant release of fission products" should be defined. As is, the RG opens a door for releases less than significant. One option is to define it in terms of "uncontrolled release of fission products" used by SECY-93-087. Another option is to place the burden on the applicant to show that a release will not be significant in terms of 10 CFR 50, using an approach outlined in Section C.1.(j).

- **We propose to delete the second part of the first sentence in the first paragraph of Section C.1.**
- **The guidance in regulatory position 1, section C.1.j , already states that the applicants should consider the potential for containment leakage at pressure levels below (and up to) the calculated structural capacity. A reference to 10 CFR 50 might be construed as a staff position for leakage criteria for ultimate pressures which instead should be evaluated on a case-by-case basis.**

Comment 6

- **(Section C.1)**
- The scope of the load effects considered should be clearly stated. They are: effects of internal pressure and temperature, and effects of permanent loads. The fact that effects of loads such as seismic loads or impact are not considered in this RG may need to be stated.

- **Section C.1.c defines the analysis process which also defines the loads that need to be considered for this evaluation which do not include the earthquake loads.**

Comment 7

- **(Section C.1)**
- Second and third paragraph may be consolidated in items a. and b. Item C.1.a should be expanded to include a statement about appropriate boundary conditions of the model.

- **The second and third paragraph in C.1 address the organization of this section which includes a finite element analysis approach and approaches using simplified methods, while (a) and (b) are specific to the finite element analysis approach.**
- **Boundary conditions can be containment specific and their listing would only address a limited number of designs. This is a level of detail that is not intended for this Regulatory Guide. Nevertheless, section C.1.i refers to Appendix A to NUREG/CR-6906 which provides detailed guidance on developing finite element models including boundary conditions.**

Comment 8

- **(Section C.1)**
- Items d. and e. should be expanded to include a statement that the initial pre-stress and residual strains should be accounted for. The Appendix to NUREG/CR-6906 contains recommendations that may be identified as acceptable.
- **The staff requests further clarification of this comment.**

Comment 9

- **(Section C.1)**
- Item f. should be expanded to clarify the difference between the simplified method and the more complex methods. For example, it may be assumed that the strain-based on the simplified method evaluation is intended to cover the wall strains away from significant discontinuities. Conversely, the strains near discontinuities need to be evaluated on a case-by-case basis, using other more complex methods and models. However, this may not be the intent of this RG. Therefore, the RG should clearly state, when the simplified (item f. strain based) evaluation can be done, and when a more complex method or model is needed.

- **It is implicit in Part B that the strain limits for simplified methods are intended to account for wall strains away from discontinuities. Where applicable, the simplified method is intended to compensate for local strain effects by using a conservative strain limit on the membrane behavior away from discontinuities.**
- **Paragraph 3 in C.1 indicates that simplified methods are an alternative to the more detailed finite element analysis. In addition,C.1.f lists those containment types, and the parts of those containments, for which the strain limits for the simplified method are applicable.**

Comment 10

- **(Section C.1)**
- The strain limits specified for reinforced concrete, pre-stressed concrete and steel in item f. are conservative. They are approximately one half of the rupture strain The strain limits specified for reinforced concrete, pre-stressed concrete and steel in item f. are conservative. They are approximately one half of the limits identified in NUREG/CR---6906 for the three materials. Given that this RG is deterministic in nature, the choice of such limit strain levels could be acceptable. It should be noted that these strain levels are well in the non-linear response range of the three materials.

- **We concur with the comment and no response is needed.**

Comment 11

- **(Section C.1)**
- Item f.(3) should be modified to explicitly state that concrete compression failure modes may occur near discontinuities. For example, out-of-plane bending of the containment structure wall near its foundation may induce concrete crushing at the outside surface, before the concrete wall reaches the membrane strain identified in item f.(1). However, a concrete crushing limit state should be specified. It may be acceptable to specify that the applicant should conduct an analysis that preserves cross-section strain compatibility across different materials to demonstrate that the concrete compression stress is smaller than nominal concrete compression stress capacity f'c reduced using a 0.9 reduction factor.

- **C.1.f.3 already addresses the failure modes in comments 11 and 12. The first sentence in this section will be modified to refer that these failure modes may occur near discontinuities. This regulatory guide does not address specific limit state conditions based on code methods for each of these failure modes. Some of these might already be the first choice of an applicant while for others such guidance might be construed as unnecessarily prescriptive. (also response to comment 12)**

Comment 12

- **(Section C.1)**
- Item f.(3) should be expanded to include concrete shear failure modes. It can be reasonably expected that out-of-plane wall shears may be high near discontinuities and containment structure boundaries. These locations include the ones where high moments may induce concrete compression failure because it is likely that moment gradients at these locations will also be high. Concrete shear limit state is difficult to define, but the shear strength provisions of ASME Code or ACI 359 Code could be considered as acceptable.

- **See response to comment 11.**

Comment 13

- **(Section C.1)**
- Item f.(3) should be expanded to include the steel liner and steel liner anchorage failure modes.

- **These failure modes are already accounted for in the strain limits for C.1.f.(1) and (2). (also response to comment 14)**

Comment 14

- **(Section C.1)**
- Item f.(4) should be expanded to include the steel liner local and global buckling failure modes. Section C.1.(h) contains appropriate modeling guidance.

- **See response to comment 13.**

Comment 15

- **(Section C.2)**
- This section is based on the deterministic capacity criteria in RG 1.7 and RG 1.57 and deterministic load (demand) criteria in RG 1.57 and RG 1.136. This guidance provides an engineering interpretation of the combustible gas containment requirement. The capacity criteria for the containment structure, based on ASME Code (and essentially elastic response of the steel and concrete containment structures), are significantly more stringent than the strain-based limits specified in Section C.1.f in this RG.

- **Comments 15 and 18 are related. We concur with the comments and no response is necessary.**

Comment 16

- **(Section C.2)**
- Item a.(2) should clarify the stress (or strain) range where the use of an equivalent linear model for concrete response is acceptable, and clarify if it is acceptable to take credit for the tension strength of concrete. An acceptable method to evaluate concrete shear strength could be specified as well.

- **We will clarify in item a(2) that the tensile strength of concrete should be neglected (as in C.1.e). The regulatory position is that the use of an equivalent linear model is acceptable. Any equivalent linear model will have to be adequately justified for the containment and application for which it is used and evaluated in a case by case basis. Given the variety of containments and applications generic prescriptions are not recommended. It is assumed that the finite element analysis and the interpretation of its results will account for concrete shear failure as in section C.1. (similar to response to 19 and 21)**

Comment 17

- **(Section C.3)**
- This section provides guidance on how the applicant should satisfy the containment performance goals in accordance with SECY-90-16 and SECY-93-087. The RG provides an engineering interpretation of the containment performance goals following the onset of core damage due to plant damage states that represent 90 percent or more of the core damage frequency.

- **We concur with the comment and no response is needed.**

Comment 18

- **(Section C.3.1)**
- Section C.3.d. prescribes the capacity criteria in ASME Code Service Level C (for metal containments) or Factored Load Category (for concrete containments) as a method to demonstrate that the containment maintains the role of a reliable, leak-tight barrier for the first 24 hours, following the onset of core damage. The selected criteria are conservative, as they stipulate essentially elastic response of the containment to internal pressure and temperature due to core damage, during the 24 hour period. However, it is difficult to relax these criteria, without substantial analytical or experimental basis.

- **See response to comment 15.**

Comment 19

- **(Section C.3.1)**
- Item c.(1) should clarify the stress (or strain) range where the use of an equivalent linear model for concrete response is acceptable and clarify if it is acceptable to take credit for the tension strength of concrete. An acceptable method to evaluate concrete shear strength needs to be specified.

- **We will clarify in item C.3.1.c(1) that the tensile strength of concrete should be neglected (as in C.1.e). The regulatory position is that the use of an equivalent linear model is acceptable. Any equivalent linear model will have to be adequately justified for the containment and application for which it is used and evaluated in a case by case basis. Given the variety of containments and applications generic prescriptions are not recommended. It is assumed that the finite element analysis and the interpretation of its results will account for concrete shear failure as in section C.1. (similar to response to 16 and 21)**

Comment 20

- **(Section C3.1)**
- The RG does not allow for an alternative to the ASCE Code acceptance criteria to demonstrate containment performance goals, during the first 24 hours after the onset of core damage. Item d. may be expanded to allow such alternate methods, as was done in item a.(3) and item c. of Section C3.2 of this RG.

- **The RG by default allows for alternatives but it does not provide guidance on what those alternatives can be. The guidance in C.3.1 is one acceptable approach that is consistent with existing regulatory guidance (i.e., SECY/SRM 93-087, RG 1.7, RG 1.57 and RG 1.136).**

Comment 21

- **(Section C.3.2)**
- Item b.(1) should clarify the stress (or strain) range, where the use of an equivalent linear model for concrete response is acceptable and clarify if it is acceptable to take credit for the tension strength of concrete. An acceptable method to evaluate concrete shear strength may need to be specified.

- **We will clarify in item C.3.2.b(1) that the tensile strength of concrete should be neglected (as in C.1.e). The regulatory position is that the use of an equivalent linear model is acceptable. Any equivalent linear model will have to be adequately justified for the containment and application for which it is used and evaluated in a case by case basis. Given the variety of containments and applications generic prescriptions are not recommended. It is assumed that the finite element analysis and the interpretation of its results will account for concrete shear failure as in section C.1. (similar to response to 16 and 19)**

Comment 22

- **(Section C3.2)**
- Item c. allows the applicant to use alternate methods to demonstrate that their containment design directly meets the performance goal that “the containment should continue to provide a barrier against the uncontrolled release of fission products” after the initial 24---hour period since the onset of core damage. This is an important step forward towards performance-based risk-informed regulation. This item should be expanded by referring to the NRC documents that quantify “the extremely low probability for accidents that could result in the release of significant quantities of radioactive fission products” stated in 10 CFR 50.34. This item should refer to the Appendix NUREG/CR---6906 for recommendations on modeling of confinement structures.
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- **This RG focuses on deterministic methods and invoking the extremely low probability for accidents might lead to confusion in section C.3.2.c. The reference to NUREG/CR-6906 is already in C.1.i.**

Final Comment

- The staff should be commended for their effort to provide and clarify the guidance for applicants on how to evaluate containment structural integrity for internal pressure loadings above design-basis pressure, and how to demonstrate containment structural integrity to control combustible gases inside the containment and to perform as desired after the onset of core damage in more likely sever accidents. The staff successfully integrated several decades of experience in modeling and testing containment structures (presented in NUREG/CR---6906), relevant NRC requirements and containment design codes. This RG is deterministic in nature. Given the Commissions overarching intent, it is imperative to continue working toward risk-informed performance-based regulatory guidelines.

- Section C.3.2.c of this document is a good start. An example of such risk-informed performance-based regulation is NRC rule 10 CFR 50.61a that provides new Pressurized Thermal Shock requirements. Development of similar new rules and regulatory guidelines for containment integrity may require additional research and advances in modeling and analysis methods to provide containment structure fission product release fragility curves.