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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

561st MEETING

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FRIDAY,

APRIL 3, 2009

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ROCKVILLE, MARYLAND

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The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., Mario V. Bonaca, Chairman, presiding.

COMMITTEE MEMBERS PRESENT:

| | |
|---|---|
| MARIO V. BONACA | Chairman |
| SAID ABDEL-KHALIK | Vice Chairman |
| J. SAM ARMIJO | Member-at-Large |
| GEORGE E. APOSTOLAKIS | Member |
| SANJOY BANERJEE | Member |
| DENNIS C. BLEY | Member |
| CHARLES H. BROWN, JR. | Member |

MICHAEL CORRADINI Member

COMMITTEE MEMBERS PRESENT: (cont'd)

OTTO L. MAYNARD Member

HAROLD B. RAY Member

MICHAEL T. RYAN Member

WILLIAM J. SHACK Member

JOHN D. SIEBER Member

JOHN W. STETKAR Member

NRC STAFF PRESENT:

DONALD DUBE

CHARLES ADER

HOSSEIN HAMZEHEE

ALSO PRESENT:

DOUG TRUE

BIFF BRADLEY

STANLEY LEVINSON

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

(8:28 a.m.)

CHAIRMAN BONACA: Good morning. The meeting will now come to order.

This is the second day of the 561st meeting of the Advisory Committee on Reactor Safeguards. During today's meeting, the Committee will consider the following: risk metrics for new lightwater reactor risk-informed applications, future ACRS activities, a report of the Planning and Procedures Subcommittee, reconciliation of ACRS comments and recommendations, subcommittee reports, preparation of ACRS reports.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Tanny Santos is the Designated Federal Official for the initial portion of the meeting.

Some members of NEI and NRC staff are on

the phone bridge line to listen to the discussion of risk metrics for new lightwater reactor risk-informed applications. To preclude interruption of the meeting, the phone will be placed in a listening-in mode during the presentations and Committee discussions.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's sessions. A transcript of a portion of the meeting is being kept, and it is requested that speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume so that they can be readily heard.

So the first item on our agenda is the risk metrics for new lightwater reactor risk-informed applications, and Professor Apostolakis will take us through the presentation.

MEMBER APOSTOLAKIS: Thank you, Mr. Chairman.

As some members probably remember, more than 10 years ago the staff worked closely with us on what became Regulatory Guide 1.174, which laid the foundation for risk-informing the regulations. It

identified five principles that every change or request for change in the licensing basis had to satisfy, and also gave numerical values to the change and the core damage frequency and the large early release frequency that would serve as targets in upper bound -- in risk-informed decisions.

Since then, there have been many applications, always invoking the regulatory guide and its guidance. And until recently when we started receiving risk assessments for new reactors everything was fine and the numbers were more or less acceptable. But when these new core damage frequencies started coming in, we realized -- and the staff, of course, realized immediately that the rules of the game probably have changed.

We are now talking about core damage frequencies that are -- may be one or two or three orders of magnitude below the CDFs that we had in mind when the guide was developed for subsequent applications.

So the question is now: does the way -- the current way of doing business in a risk-informed way still apply when somebody reports a core damage frequency, say, on the order of $10^{-7}$? And the Office

of New Reactors has of course identified this as an issue that needs some investigation, and this is the subject of today's meeting.

The title is -- of the presentation, "Implementation of Risk Metrics for New Light-Water Reactor Risk-Informed Applications." We will have a presentation from Mr. Donald Dube of the Office of New Reactors, and then Mr. Bradley and Mr. True of the Nuclear Energy Institute have requested time to make some comments.

So we are back to 1997, as some of you remember, where we are going to have debates what is appropriate, what is not appropriate, how to approach it. And this was an exciting time, and I am sure it will be exciting again.

So without further ado, Mr. Dube.

MR. DUBE: Thank you, Professor Apostolakis. Well said to -- in terms of an introduction. And, Dr. Bonaca, members of the ACRS, the purpose is to brief the ACRS regarding the implementation of risk metrics for new LWRs, specifically risk-informed application, and look at potential paths forward.

We are not looking at a letter at this

time. I envision that this is going to be one of several meetings, and we are engaging stakeholders in public meetings as well. And I should also say at this point the staff does not have a position on which of several options to go forward to sort of the exploratory stage if you will.

We will discuss briefly the near and long-term needs to have some resolution on this issue. We will briefly describe the background, what some of the implementation issues are, the options. I won't go into too much detail, because there is some backup information, and advantages and disadvantages are discussed in the white paper, which I believe you have.

And then, the status, where we are in terms of engaging the stakeholders. So the time is now. There is at least one application for risk-managed technical specifications in the combined license application for risk-informed completion times and surveillance frequency control program.

And in the longer term -- and longer term is not too long, but it is probably post combined license issuance, EPRI, on behalf of several design centered working groups and perhaps several

applicants, has a research program on extending risk-informed in-service inspection of piping to new reactors. And also, kind of unofficially there is interest in perhaps special treatment requirements under 50.69 as well, and that is not too far down the road.

So the time is upon us, and in the not-too-distant future we must come to some resolution if you will.

For operating reactors, I am sure you are aware -- and a lot of this background is in Reg. Guide 1.174 and associated quantitative health objectives of the Commission's safety goal. The core damage frequency goes $10^{-4}$ per year. It is a surrogate for latent cancer fatalities in the QHO.

In other words, if a powerplant -- a nuclear powerplant meets $10^{-4}$ per year, or lower, there is reasonable assurance with a degree of -- good degree of margin that the Commission's QHO for latent cancer fatality can be met.

And, likewise, if one works backwards from the Commission's policy on QHO for prompt fatalities, with a good degree of margin, there is a good assurance that if a powerplant meets large early

release frequency, less than $10^{-5}$, it will meet the QHO for prompt fatalities. And so these are the sort of metrics you use for operating reactors.

MEMBER APOSTOLAKIS: I need some clarification here.

MR. DUBE: Sure.

MEMBER APOSTOLAKIS: I remember that the original policy statement of the Commission -- feel free to jump in any time -- that it stated -- in fact, it is in italics as I remember -- that the frequency of releases should be less than $10^{-6}$.

MR. DUBE: Right. Large release.

MEMBER APOSTOLAKIS: Is there a document somewhere that says, "No, it should be $10^{-5}$"? When did it change by an order of magnitude?

MR. DUBE: I am not aware too much of the history, maybe some members in the audience, but there are several papers that -- including what used to be called the technology-neutral framework, as well as I believe some NUREGs and Brookhaven reports that did a separate series of calculations that show -- actually, one doesn't need to be as low as $10^{-6}$ to meet the prompt fatality objective.

That, you know, looking at typical sites

with typical population densities and -- although this is an individual risk, but typical sites and typical meteorology. And while one would expect for release fractions and timing one could meet 10 -- the QHO for prompt fatalities at as high a level as $10^{-5}$ per year. But you will not find that $10^{-5}$ per year explicitly as a goal.

MEMBER APOSTOLAKIS: Well, the thing that bothers me a little bit is that, you know, a policy statement is an official statement from the Commission. And then, to change that because there have been some NUREG reports that show that it would be relaxed without going through a formal process, bothers me a little bit. So that is why I am asking the question.

I mean, a NUREG, as we all know, is just a report reporting research findings. It is not an official document from the Commission. So if anyone can help with that and point me to a place where there is an official statement, not necessarily from the Commission but with the blessings of the Commission from NRR or somebody that says that LERF could be $10^{-5}$, I would appreciate that.

MEMBER CORRADINI: But can I just

clarify? I mean, you were talking about I thought two different things, large release versus large early release. And I thought -- I think the second one has just been not spoken anymore of the large release, and large early release has some time delay relative to containment failure along with frequency, or am I misunderstanding?

MR. DUBE: Correct. That's right.

MEMBER APOSTOLAKIS: Isn't the --

MR. ADER: George, if I could -- this is Charles Ader with Office of New Reactors. There has been a history -- and we were trying to go back and see if there was a definitive statement that went from LRF to LERF. Staff did a lot of work trying to define the LRF, which was in the safety goal, $10^{-6}$. Back in the early '90s there was a SECY paper, 93-138, recommending to the Commission terminating activities to come up with a definition that was quantitative.

MEMBER APOSTOLAKIS: Right.

MR. ADER: The SECY paper that we found that sent draft 1.174 to the Commission at that time identified the LERF, $10^{-5}$, as the metric they would use. And I don't have it with me, but there was a

statement that said -- and this would be consistent or encompass the Commission's $10^{-6}$ safety goal statement.

It was in the SECY that went forward trying to find the exact time that the decision in 1.174 was to go to $10^{-5}$. There is a lot of history on this, and we are still trying to --

MEMBER APOSTOLAKIS: If you can find that SECY later and send it to us.

MR. ADER: Yes, I have it upstairs.

MEMBER APOSTOLAKIS: I have another comment, though, because -- and it relates also to Mike's comment. Is LERF a subset of LRF? So if LRF is $10^{-6}$, how can a subset be $10^{-5}$?

MR. DUBE: That is a good question. Logically, you would --

MEMBER APOSTOLAKIS: Silence.

MR. DUBE: -- expect if "large" is defined consistently, LERF should be a subset of LRF.

MEMBER APOSTOLAKIS: It should be a subset.

MR. DUBE: But you will find that it may not be.

MEMBER APOSTOLAKIS: Doug?

MR. TRUE: This is Doug True from ERIN. I think we are actually going to talk a little bit about this whole topic in our presentation.

MEMBER APOSTOLAKIS: That's fine.

MR. TRUE: The short answer is it depends how you define it. It depends how you define it.

(Laughter.)

MEMBER APOSTOLAKIS: Yes. But, I mean, you know, some --

MR. TRUE: No. I'm not being facetious. I think that --

MEMBER APOSTOLAKIS: No. I know.

MR. TRUE: -- our track record, which we tried to lay out in our paper, that reconciles those two values.

MEMBER APOSTOLAKIS: Okay. First of all, the reason why I am raising the issue is just to see whether there is a document someplace. And if a SECY exists and the Commission -- I mean, I'm sure it exists -- and the Commission said fine, go ahead, then that is fine with me. But I would like to see.

CHAIRMAN BONACA: But didn't it come as a condition of the containment failure?

MEMBER APOSTOLAKIS: And then, you have

that other problem. But let's talk about LERF first.

MEMBER CORRADINI: Can I just go back to -- if I might, Mr. Chairman?

MEMBER APOSTOLAKIS: Absolutely.

MEMBER CORRADINI: Go back to what Charlie said, because if I remember at the time when this was being discussed, at least somebody on the staff or the Commission was struggling with how long should containment stay together. And so the ad hoc discussion was LERF was a way of trying to show that if I had a damage -- core damage accident, and I then could hold containment together for one, two -- n days, n being less than 10 but more than one -- then I have added another layer of -- I have added another layer. And an order of magnitude was expected.

MEMBER APOSTOLAKIS: Exactly.

MEMBER CORRADINI: And that is how it was left -- at least I remember back in the early '90s -- very empirically.

CHAIRMAN BONACA: There was a condition on probability of containment failure.

MEMBER CORRADINI: But I think you can make -- I am just -- it is more of a question. I might be incorrect about this, but I think the way

Doug -- Don suggested it relative to prompt fatalities it really is a time that I have integrity. And after that, something else may occur.

MR. ADER: I think if you look at the timeline, the new reactors that were going through in the early '90s, the System 80+ and AP-600, and some of the issues that were coming up, the Commission gave the staff guidance. And you will hear a little bit later in Don's presentation -- that is part of the dilemma we have.

The Commission gave staff guidance still using $10^{-6}$ LRF. They also had some other containment performance objectives, 24 hours, not exceeding service level C, .1 containment -- conditional containment failure probability. And that was in the early '90 timeframe.

In '93 is when staff terminated efforts to quantitatively define a large release. We were going down a path to define it in terms of equivalent curies of iodine of some magnitude.

The LERF that came up in 1.174 is where we were trying to go back and see if there was a clear, definitive transition. That was in I think, what, '97? '95, '96, '97 timeframe.

The SECY that I was referring to -- and I will get a reference to it -- it was --

CHAIRMAN SHACK: It is 98-015.

PARTICIPANT: Wow.

CHAIRMAN SHACK: Historian

MR. ADER: The one I found was sending the draft 1.174 documents up for publication.

CHAIRMAN SHACK: Yes, right. It is sending up the draft 10.61.

MEMBER CORRADINI: SECY what?

CHAIRMAN SHACK: 98-015. At least that's what this document says.

MR. ADER: And as I remember it -- and I only read it probably three weeks ago, so -- it has a $10^{-5}$, but it also mentioned the $10^{-6}$ in Commission safety goal policy. And what we have in new reactors, you know, in the guidance is the $10^{-6}$, and that has not changed from the LERF. And that puts us in the dilemma that Don is going to continue to tell you about that we face.

CHAIRMAN SHACK: So, George, you've got to also remember they have a policy on the $10^{-6}$. They also have a policy that you shouldn't go beyond the safety goals.

MEMBER APOSTOLAKIS: The safety goals are the foundation.

MR. DUBE: That is our dilemma.

MEMBER APOSTOLAKIS: That is your dilemma.

MR. DUBE: Yes. We wouldn't be here if there weren't that dilemma.

MEMBER APOSTOLAKIS: My question -- I did not call into question the $10^{-5}$. My question was purely administrative. How does a number that is given by the Commission in an official policy statement change? There must be some official document some place?

Now, you tell me there is a SECY. Fine, I am willing to accept that, and I am going to read it. But the $10^{-5}$ I did not dispute. So because some of the discussion had to do with how it is and what it means, that is not the question now. Later there may be other questions.

MR. DUBE: Okay.

MEMBER APOSTOLAKIS: So, please. I am not --

MR. DUBE: Moving on to new reactors, this is what the staff is reviewing, design

certifications, and then subsequently combined license applications against. And this comes from the staff requirements memorandum on SECY 90-016 in the 1990 timeframe.

A core damage frequency of $10^{-4}$ -- in fact, the Commission explicitly states that, you know, the staff had recommended $10^{-5}$, and the Commission said, "No, we'll stay with $10^{-4}$."

A large release frequency, however one wants to define "large," of $10^{-6}$ per year, a deterministic goal that containment integrity be maintained for about 24 hours from the onset of core damage for the more likely severe accident challenges. These are pretty much words verbatim. And then, a conditional containment failure probability less than about 0.1, with some caveats that, you know, give or take that 0.1 value would be -- we are not going to get too concerned about.

MEMBER CORRADINI: There is no time with the 0.1.

MR. DUBE: No.

MEMBER APOSTOLAKIS: Now, if I meet the core damage frequency goal in the conditional containment failure probability, and the

deterministic goal, then I am in good shape. It turned out, though, that I am violating the large release frequency goal?

MR. DUBE: Yes. Yes. It is -- the numbers are -- if you work through, and I think my white paper -- or the white paper I primarily authored --

MEMBER APOSTOLAKIS: Yes.

MR. DUBE: -- mentions they are inconsistent. In fact, assuming design meets .1, and assuming it is $10^{-4}$-ish in core damage frequency, you can meet the $10^{-6}$, which means, really, one has to meet about a $10^{-5}$ or less core damage frequency to be consistent.

Now, in practice that is not too bad, because the Electric Power Research Institute has an advanced lightwater reactor requirements document. And all of the new designs being submitted for certification state that their goal is to meet $10^{-5}$ or better.

So a combination of the EPRI advanced lightwater reactor and the Commission goals, one can get there. But, in practice, it really kind of means they need to meet $10^{-5}$ CDF in order to meet all of the

-- in order for all of these things to fall into place.

There were a number of policy statements on Commission's expectations, and I take selected --

MEMBER APOSTOLAKIS: Excuse me. I had a question. I'm sorry.

MR. DUBE: Sure.

MEMBER APOSTOLAKIS: On the previous one. When it says a "deterministic goal," that means following an accepted set of deterministic calculations, is that what it means?

MR. DUBE: A severe accident analysis, accident progression analysis.

MEMBER APOSTOLAKIS: But not in a PRA space. Well, a deterministic --

MR. DUBE: If you look at Chapter -- Section 19 of the FSARs or design control documents, Section 19.1 is on the PRA, you know, the quantitative PRA Level 1 and Level 2. And then, there is a Section 19.2 on severe accident issues. And that is more or less where this falls in.

So this is an accident progression that follows core damage up to, if necessary, reactor vessel failure, combustible hydrogen control.

MEMBER APOSTOLAKIS: But all of this is done deterministically.

MR. DUBE: Well, you know, a MOX code or a MAPP code.

MEMBER APOSTOLAKIS: Yes.

MR. DUBE: Or not MOX, but MAPP code or MELCOR code or some -- yes, sorry.

MEMBER APOSTOLAKIS: Okay.

MEMBER CORRADINI: So just to drive the point home, so these are the ones I remember, and none of -- this set of four do not apply to current reactors. We are not -- I understand.

MR. DUBE: In new reactors, this is what we are using --

MEMBER CORRADINI: Okay.

MR. DUBE: -- reviewing against.

MEMBER CORRADINI: So you said that one way out of the inconsistency is to drive down the CDF. Another one is to show containment is more robust.

MR. DUBE: Right. In practice, if you look at typical conditional containment failure probabilities -- and I have some values there -- they range from a couple percent, and there are a few

designs in the 10 percent range.

So I think what you find in practice is because the containments are robust, much more robust, than current designs, but you find that there are shared -- there are systems that are shared between the accident prevention and mitigation, like a storage tank of water.

And because of this coupling, core damage prevention and accident mitigation are not completely independent. Do you see what I'm saying? So in practice CCFP -- some of the designs, the new designs, are a couple percent up to a tenth of a percent. But it is very hard to drive that too far down because of this coupling.

MEMBER CORRADINI: So may I say it a different way, just so that I've got it in my head right. Is that if I were talking about equipment availability and various damage states there is some equipment that is shared between prevention and mitigation. And so even if I knew the phenomenology past degraded core, I would still have a non-zero containment failure probability, because other systems have failed --

MR. DUBE: Correct.

MEMBER CORRADINI: -- that got me to this point.

MR. DUBE: That's right.

MEMBER CORRADINI: Okay. So a second question, then, about that is -- it kind of goes to what George was saying about deterministic. So this is not a DBA space, and --

MR. DUBE: No.

MEMBER CORRADINI: -- but there are calculations.

MR. DUBE: Right.

MEMBER CORRADINI: Have computer models of these calculations for their application here been reviewed by staff? Or is it an assumption because I am outside a DBA space that sort of a review of the computer models, since you are only using that to determine this, are not needed?

MR. DUBE: There are others on the NRO staff out there who could answer. I don't know if Ed Fuld is here, but --

MEMBER CORRADINI: You know my --

MR. DUBE: -- typically, the licensees are typically -- or applicants are typically using a code, like an advanced version of MAPP, that has been

developed specifically for advanced new reactor designs. But in a lot of cases the staff has a MELCOR version --

MEMBER CORRADINI: Yes.

MR. DUBE: -- of these and are doing their own -- our own independent calculations. I won't call them confirmatory, because it is not design basis. But we are doing a lot of independent analyses.

MEMBER CORRADINI: I am going beyond your presentation, but just so you can see what some of us are thinking. I'll grant all of this, but when I do -- for bullet 3, how do I have faith that what I am doing I actually believe? So that 24 is not really two or 60? Do you see my question?

MR. DUBE: Well, it could be 60.

MEMBER CORRADINI: Could be. But I guess what I am asking, really, is to satisfy bullet 3, you are doing a deterministic calculation, which means by doing that you put some faith into the number you get.

MR. DUBE: Right.

MEMBER CORRADINI: Has the staff, relative to either their tools or industry tools,

gone through a review of that for this application?

MR. DUBE: Well --

MEMBER CORRADINI: I think I know the answer. I just want to make sure I --

MR. DUBE: I mean, I believe the MAPP code users group has gone through a lot of validation.

MEMBER CORRADINI: Okay.

MEMBER APOSTOLAKIS: The answer is no.

MR. DUBE: I think there is reasonable assurance that --

MEMBER APOSTOLAKIS: The answer is no.

MR. DUBE: -- between the two -- okay. I will say --

MEMBER APOSTOLAKIS: You are saying that the "no" is kind of harsh. That it may not have been a very detailed review, but there are --

MEMBER CORRADINI: Yes. What I hear you say is you have done a lot of empirical calculations, done cross-comparisons, and you feel a warm, fuzzy feeling.

MR. DUBE: Yes.

MEMBER APOSTOLAKIS: Well, I don't know how warm it is, but --

MEMBER CORRADINI: But I guess the reason I'm asking specifically about this, because of all of the three -- of all of the four, this one I can actually see a path, and I want to understand how I got to that path.

MEMBER APOSTOLAKIS: I really have to do some planning here. Mr. Bradley, how much time do you think you are going to need, so I can plan here?

MR. BRADLEY: Well, I guess we will use the time we have allotted.

PARTICIPANT: He expects to have 40 minutes.

MEMBER APOSTOLAKIS: 9:30 to 10:20. Okay. So by 9:30 we should be done.

MR. DUBE: We are doing fine.

So there is a couple of Commission policy statements. You are not going to find the words written. It is somewhat implied. Briefly, the Commission expects vendors to design plants to a higher standard of severe accident safety performance, and expects advanced reactors will provide enhanced margins of safety, so on and so forth.

MEMBER APOSTOLAKIS: But -- okay. The

Commission does not say explicitly "use CDF and LERF." I mean, they may have concurred, but -- and all your six options are based on those. Why? I mean, why -- isn't this a good opportunity to think a little bit beyond CDF and LERF? Which have all the problems that you identified.

And what comes to mind is, for example, what you call the formal technology-neutral framework. What is the new name, by the way? Is there a new name? I still know it as the technology-neutral framework.

I know it has not been approved officially, but that doesn't mean it doesn't have some very good ideas in there, and you don't have to accept in its totality. And that would relieve some concerns that some of us have regarding LERF or LRF, because, as you know very well, what is released and how much is not covered by these.

And it seems to me that we have an inconsistency as regulators if we make sure that if somebody requests a change in a risk-informed way delta CDF has to be, you know, $10^{-5}$, delta LERF has to be $10^{-6}$. And then, we turn around and say, "Oh, this application, like an extended power uprate, is not

risk-informed, 20 percent."

I think there is some inconsistency there. So I am wondering whether this is a good time -- and, you know, that is not -- you don't have to answer it now, but whether it is a good --

(Laughter.)

Well, it is not an easy question to answer. To think maybe in terms of other metrics, like the technology-neutral framework goes all the way to dose. Is there an idea there we can use? The first question should be: is it practical? Because I think that is the whole idea of working with CDF and LERF, that, you know, the goals themselves don't have.

But I am wondering whether you have given it some thought, or you think it would be worthwhile giving it some thought in the future.

MR. DUBE: Yes, we could give it some thought. The only other issue here is actually by rule in the latest changes to Part 52, for design certification purposes it has to be site-independent. And they are only required to do a Level 2 PRA, which starts at release and not dose. And, in fact, even at the combined license application phase, they

are not required to do a Level 3, which is offsite consequences.

And the technology-neutral kind of -- I mean, relies on a dose frequency or consequence frequency correlation or set of limits. So we have that issue, that dilemma.

MEMBER APOSTOLAKIS: So all I'm saying is go back and look at it, and see if there are any ideas that may help you. I know that -- again, I repeat, you don't have to say, "Boy, the whole technology-neutral framework is acceptable," because I know that is very hard when it has to go through meetings and approvals and all that.

But there may be some interesting ideas there that will take us out of this CDF, LERF, or LRF framework, which appears to have problems. It is just a suggestion. It is not --

MR. DUBE: My colleague, Hossein Hamzehee, has a --

MR. HAMZEHEE: George, that is a great idea, but we also have to make sure that we are -- we have some technical consistency among operating reactors and new reactors. And if for some reason we decide to look at other metrics for these new

reactors, we have to make sure they are also applicable and used for the operating reactor, and that is a challenge.

MEMBER APOSTOLAKIS: These are the issues that you may want to raise.

MR. HAMZEHEE: Yes.

MEMBER APOSTOLAKIS: I didn't give you an answer. I didn't say, "Do it." I said, you know, "See if there is something outside" -- I really hate to use that word "think outside the box," but it applies here, unfortunately.

MEMBER BLEY: Well, even within the box, if you go back -- and maybe Doug will be doing this -- to when LERF first came about, there was a lot of work and looking at complete PRAs and looking for a summary measure that seemed to cover the consequence side. And for the plants that were examined LERF did a pretty good job.

But now, if we start playing with the surrogates like LERF and LRF, without relating them back to their origins for designs that weren't included in that verification process, it is a little fuzzy that they will apply. So --

MEMBER APOSTOLAKIS: I think these are

the issues that have to be raised. And you mentioned that you will come back to ask presumably also to the subcommittee. I would be very happy to debate these issues and the problems and the challenges. I think that that would be -- this is a briefing today. You know, it is sort of an introduction. But these are the kinds of things that would be really worthwhile to think about, because I am having a problem with LERF and CDF even for the current actions.

MR. ADER: Just to follow on, when staff was looking at a definition of LRF back in the '90s, the Commission's direction was to try to decouple it from having to go out and do dose calculations, to try to find something that would be a surrogate that basically would stop at containment boundary.

As Don mentioned, we have the challenge that nobody is required to do a Level 3 for the new plants now and in the future, and that is -- all of this that we are talking about is really the new plants that we have on our plate today, the AP-1000, the ESBWR. We are not taking this to the advanced reactors, because there is other issues.

We are also, at least right now, we are not looking as part of this effort to go back and

change the current operating metrics. We are trying to get out of the dilemma. We see implementation issues for the new reactors based on the guidance we have to review the reactors, the risk metrics that are kind of tied into a safety goal, raises implementation issues. Don will get into some options; they all have pros and cons. So those are the things we are wrestling with at this point in time.

MR. DUBE: Thank you. If I could move on, the next slide just puts the risk metrics in perspective. These are for operating PWRs and BWRs. These are data that we compiled from the MSPI basis document, so they are about as current as one can get. And, of course, there is uncertainty.

I have also shown the new lightwater reactors with primarily active safeguards, so the EPR for example, APWR, and the passive designs, AP-600, -1000, and ESBWR. And, again, there is uncertainty about this, but depending at what point one compares against another point, as Professor Apostolakis mentioned, there is one, maybe two, maybe three orders of magnitude lower for new reactors, compared to, say, the mean value of -- but there is some

overlap, and we acknowledge that.

And then, the lower right are, as best one could compare, large release frequency as presented in the certification -- the design control documents for new reactors against what we could extract from the IPE reports, that's NUREG-1560, and here they had something called significant early -- I'm not sure I have a lot of confidence in the lower tail of those values, but certainly there is, again, one, two, three, if you want to compare the lowest data point for new lightwater reactor passive against the mean value, or upper bound is three and a half orders of magnitude or lower.

The point of this is that the profile for new reactors are, in general, lower than for currently operating reactors, which poses some issues.

MEMBER APOSTOLAKIS: But there is a question here. If you look at the history over the last 30-some plus years of LWR, I think the estimates of system unavailabilities and then core damage frequency, and so on, have gradually increased as their methods for analysis have become more sophisticated and realistic, as we were collecting

more data, and, most importantly, operating experience.

MEMBER BLEY: Increased?

MEMBER APOSTOLAKIS: Increased. If you go back to the first PRA conference of the American Nuclear Society organized in Newport Beach in 1978, you will see that almost all the papers that reported fault tree analysis of systems had a $10^{-6}$ answer. Yes, Don was not born then.

(Laughter.)

Nobody is going to report something like that today. Okay? So the question is: do you -- is there reasonable expectation that this history will be repeated? Especially for the passive systems. I mean, there may be new failure modes. I believe you mentioned that also in your --

MR. DUBE: Yes.

MEMBER APOSTOLAKIS: -- white paper. If we build them and we start operating them, there will be maybe new insights, new failure modes, somebody does an analysis and finds something. So these numbers I am not sure they will stay there.

MR. DUBE: Well, I can't go all the way back to '78, but I know -- and EPRI has shown this

before the Commissioners -- certainly, since the late '80s/early '90s, and after the IPE days, reactor trip frequencies come down almost an order of magnitude, certainly a factor of three, four.

Unavailability of systems has gone down, reliability of systems has gone way up. And many of the methods now are less conservative -- for example, the reactor coolant pump seal failure model, more realistic. So, since the '90s, CDFs have come down almost a factor of three. So maybe it is --

MEMBER APOSTOLAKIS: I agree.

MR. DUBE: -- an upside-down U-shaped curve in terms of the CDF, but --

MEMBER APOSTOLAKIS: You're right. I didn't want to imply that we have a continuous degradation of safety. The truth of the matter is that if you look at history, there is an evolution of methods, more sophisticated, more data, more operating experience. I would say that something like that probably will happen here, too, so these numbers -- they don't necessarily have to come back up to where the current reactors are, but $10^{-8}$ or -- and I have a hard time --

MR. DUBE: I mean, I would agree with

you, because my experience in the industry is the plants -- these new reactor designs haven't been operating, we don't have operating experiences. There are failure modes that we are not quite aware of yet, and --

MEMBER APOSTOLAKIS: Yes, that is the whole point. Okay.

MEMBER STETKAR: George, I think it is important, just for the record, to recognize that this is internal events only at full power operation. So there is no -- these small numbers are only a fraction of the real total core damage frequency.

MEMBER APOSTOLAKIS: Right.

MEMBER STETKAR: That's why you include fires and seismic events and other operating modes and things like that. And there is no necessary reason a priori, given the long experience on designing against these particular types of events, to presume that that fraction of the total risk might not be a relatively small fraction today compared to what it was 30 years ago.

MEMBER APOSTOLAKIS: It may very well --

MEMBER STETKAR: The total risk might be a lot higher than implied by these numbers, but this

particular fraction that we happen to be, you know, dealing with and focused completely on today might actually be quite small.

MEMBER APOSTOLAKIS: I don't question that. All I am saying is that, if I look back to the history of 30 years, there have been changes due to discoveries, blah, blah, blah, blah. And it stands to reason to say we will see something like this here as well.

Now, the seismic risk is such a huge dependent -- potential dependent failure that probably will overwhelm these numbers. There is no question about it. So that is why it is a challenge, because you can't say one way or another what is going to happen. But history is always -- I mean, there was a time when we were not putting much attention to human error.

I remember that in the early days. I'm sorry, I remember it. "My operators will never do this." You know, I have heard that. Now people don't say things like that.

MEMBER RAY: Wait. You had started talking about details, and that's fine. But I happen to be more focused on tails. Is there some reason,

Don, that you -- it is expressed as $10^{90}$?

MR. DUBE: Because they are very big tails, and I didn't want -- I didn't think it was appropriate to show the 95th to 99th percentiles, because --

MEMBER RAY: It's not because they are not relevant, is it?

MR. DUBE: No, I just -- at some point it --

MEMBER RAY: No, it's okay. I just wondered. It's not part of any policy, it's just --

MR. DUBE: No.

MEMBER RAY: -- a choice you made.

MR. DUBE: Yes.

MEMBER RAY: Okay.

MR. DUBE: So new reactor PRAs are expected to demonstrate how they compare against these Commission goals, and Reg. Guide 1.206 provides the guidance. And the staff is reviewing against SRP Chapter 19.

There is a number of risk-informed related reg guides, and I am just going to list them here. Of course, 1.174 is kind of the umbrella reg guide, and a lot of these are specific to an

application like risk-informed tech specs, in-service inspection, and they refer to 1.174, not consistent with that, those methods.

So for new reactor implementation, these are our issues. The review of these applications has raised some questions about the risk metric guidelines, this issue of large early release frequency versus the Commission goal on large release frequency. As Charlie Ader mentioned, the large release frequency has not been previously finalized in NRC documents. There are some unofficial terms in there, but one will not find a proven or accepted definition.

So pretty much to this point applicants have provided their own definition of "large release frequency." The staff has reviewed these documents, bounced the idea around, looked at alternative definitions, and for the purposes of design certification wrote up a safety evaluation and provided staff's basis.

But one will find that, say, for example, the five active design certifications, the AP-1000, ESBWR, APR, EPR, and advanced boiling water reactor, there is five different definitions out there pretty

much of "large release." Some of them are dose-related, like 25 rem at a kilometer or half-mile boundary.

Some are release-related, so release fraction of cesium-137 and iodine, and others are really more of a containment failure mode related definition, like one applicant at one time had anything greater than design basis leakage of containment is large.

So the fact that there has never been a finalized definition of large release means we have this -- there is an inconsistency issue as well. But the staff has been able to deal with that as of now.

MR. HAMZEHEE: Don, we should also mention that one of the main reasons that we have accepted those definitions is because almost in all cases they were more conservative. So, in other words, no matter what definition you use, those values would be bounding. So that's why at that time we went ahead and approved or agreed with the definitions.

MR. DUBE: Right. Thank you.

And the other dilemma or issue is -- and this is discussed in the white paper -- is use of

current numerical risk metric goals in Reg. Guide 1.174 -- it says "would result," but "may result" perhaps is a better term -- being evaluated against less restrictive criteria than those used for licensing basis of new reactors. So we are reviewing against $10^{-6}$ large release frequency.

How could one theoretically -- and I am not saying it necessarily would happen -- how could one review -- if an applicant came in with a license amendment request with a delta LERF of several times $10^{-6}$, it just seems to be a little bit out of line proportionally speaking. And like I said, the white paper goes into that, so that -- that is one of our dilemmas.

So we kind of divided this into two phases, a licensing issue and an operations issue. The immediate concern is licensing. That is, risk-informed applications that are coming in for risk-informed tech specs or risk-informed in-service inspection, and there is a whole new set of issues on operations and the reactor oversight process, because if one looks at, for example, the mitigating systems performance index, the significance determination process, MD 8.3, which is the staff's response to

incidents, they highly rely on measures of CDF, delta CDF, conditional core damage probabilities, incremental, and all of the combinations.

And as shown in the white paper, there are issues posed there which, you know, in some circumstances if one used a particular baseline CDF one could have major systems out of service for major -- long periods of time and still not even approach the white threshold.

We are not going to try to resolve that issue in the coming months, but that is -- that is something out there of concern. So the focus is on the need for licensing in the short term.

Reg. Guide 1.174, as I mentioned, provides -- is kind of the foundation for risk-informed license amendment requests. The risk acceptance guidelines, which I will show a couple of graphs in a second, is a basis for the baseline risk metrics for core damage frequency and LERF, and a basis for the change in core damage frequency and the change in large early release frequency for the numerical guidelines there.

The bases for these -- and these are spelled out as Professor Apostolakis mentioned -- the

five principles that -- for risk-informed regulation -- you know, maintaining safety margin, defense-in-depth, and so forth. But I will concentrate on the risk-related one, and it says the increase should be limited to small increments.

And so the issue raised is, well, what -- is "small" an absolute term, or is it a relative term? As I mentioned, one could conceive of theoretically an AP-1000 proposing a license amendment request, and its baseline core damage frequency in the lower $10^{-7}$, propose a license amendment request which could be several factors of that.

It would still meet the absolute guidelines in Reg. Guide 1.174, but it could theoretically represent factors of three and four and five times its baseline, which the staff has reviewed and approved so -- in so many words, in a safety evaluation.

MEMBER CORRADINI: I have a question, just for clarification. So not that you would do this, but just as an analogue, if I -- if I am looking at worker dose in an operating plant -- there was this whole thing about -- we went through the

whole thing last month on allowables, and then there is an operational limit, and there is an absolute cap.

Doesn't the analogue work here that if one were to agree to what the CDF and the LRF were to be, you would take a percentage of that as the definition of "small," don't worry about what the absolute value is, worry about what the limit is, and take a percentage of that, and you must fall below that. So if it is $10^{-6}$ for -- or $10^{-5}$ for LERF, you demand no more than one percent variation on that on the cap.

Now you have an operational limit that essentially goes off the cap rather than what I think is a highly uncertain number that is bouncing all over the place.

MR. DUBE: Well, certainly, that is one of the options presented in the white paper. There is an absolute value approach, there is a relative value approach, there is a combination of the two, and all -- everything in between, with advantages and disadvantages. There is a -- they are listed. There are a lot of disadvantages with a relative approach, too. I mean, it poses a lot of issues. I mean,

the --

CHAIRMAN SHACK: But relative to your expectations for new reactors, I mean, you wouldn't make it relative to the computed value for the -- but, you know, base it on the $10^{-5}$ and $10^{-6}$

MEMBER CORRADINI: Right. Sure.

MR. DUBE: I mean, that is your goal.

MEMBER CORRADINI: That is an option.

CHAIRMAN SHACK: Especially for 1.174, where you are talking about voluntary changes. You know, I think it is more difficult when you come to the ROP and you are talking about enforcement actions, and, you know, whether you are preserving safety. In 1.174, they are asking for changes to a licensing basis that everybody has agreed on, and it is a voluntary change.

And so it seems to me that you -- you have a basis to go more restrictive for 1.174, but you are, in my sense of view, more constrained in terms of the ROP and SDP by the safety goal of what is safe enough.

MR. DUBE: Thank you. That is a good point. Appreciate that.

So I won't dwell on this. These are the

acceptance guidelines from Reg. Guide 1.174, one for CDF, and one is for LERF. Do I need to spend time explaining this or --

MEMBER APOSTOLAKIS: No.

MR. DUBE: -- it pretty well accepted?

MEMBER APOSTOLAKIS: You have 11 minutes.

MR. DUBE: So the question is: for new reactors, should the principle of small increase be based on a relative or absolute delta CDF, delta LERF, and/or delta LRF? These are rhetorical questions.

(Laughter.)

PARTICIPANT: Sure.

PARTICIPANT: You need to clarify that for us.

(Laughter.)

MR. DUBE: And/or should RG 1.174 include an alternate or additional delta LRF acceptance guideline for new reactors? Again, a rhetorical question.

MEMBER APOSTOLAKIS: Or should we drop CDF and LERF completely and do something else?

(Laughter.)

Well, there is a time for --

PARTICIPANT: It is so easy the way it is.

MR. DUBE: Okay.

MEMBER APOSTOLAKIS: Very good.

MR. DUBE: These are the reg guides that are impacted. I am not going to spend any time. They are there for your reference -- and acceptance programs. These are some of the possible options. There may be more, but this was in the white paper, and we are entertaining options.

There is the status quo, which is current acceptance guidelines in RG 1.174 and associated reg guides, and the ROP would also be applied to new reactors. It would treat new reactors the same as the current, convert to a relative risk change for both new and current reactors, reduce acceptance guidelines for new reactors by one or more orders of magnitude solely for new reactors.

Option 4 is like use a combination of the two. Option 5 was added relatively recently -- use existing acceptance guidelines for current or new reactor status quo, but establish an LRF -- LRF-based acceptance guideline for new reactors. And this would go with what Mr. Shack said, which we would

probably not change the thresholds for ROP purposes for new reactors, keep them the same for current and operating reactors. And option 6 is kind of a wing-it, which is just assess new reactors case by case.

And my final slide -- and I am doing pretty good time -- this is a status -- the white paper was issued in February. That is the ADAMS number. There was an EDO memorandum to Commissioners, basically the same material. There was a public meeting held February 18 where we discussed these issues. It was a half-day meeting. There was a presentation at the RIC, and we plan to continue and engage stakeholders.

MEMBER BLEY: Don, can you say anything briefly about the public meeting or --

MR. DUBE: I am going to next slide, thank you.

MEMBER BLEY: Thank you very much.

MR. DUBE: Final slide that is in the backup, there was broad representation of the stakeholders. The staff described the pending risk-informed applications and some of these dilemmas on the implementation. There was a lot of discussion on how -- what was the ultimate basis for LRF and CCFP,

where did they come from, described the advantages and disadvantages.

There was additional sub-options suggested by Mr. Chapman, whereby one might perhaps for the first few applications use the current set of risk metrics and then assess the need for a change based on lessons learned. So it is kind of a 1A option or a 6A option, depending where one wants to put it.

Industry followed up with its own white papers providing its views and historical perspectives. And then, going forward we will have additional public meetings.

MEMBER BLEY: Do you have a plan for over time when you expect this to come together and when you expect to have a -- I assume a reg guide comes out on --

MR. DUBE: Nothing is official. But in broad terms, the plan is to continue to engage stakeholders, narrow down the list of options to the really most viable, make a recommendation in a Commission paper, propose it, circulate it, come before the ACRS again.

CHAIRMAN BONACA: Could you go over

page 21? That is --

MR. DUBE: Okay.

CHAIRMAN BONACA: -- option 2.

MR. DUBE: So I don't have a real timetable, but it can't be too -- stretched out over too many years, because then it won't be effective for risk-informed applications.

MR. ADER: Don, we would be looking to do this in a reasonably short time. I mean, this is not the type of issue you are going to deal with in a month or two. But we would really be looking to come to preferred options, and I am sure we would give the Commission options as opposed to -- with a recommendation.

But we would probably go away -- our plan is we are starting to think that, but we really need to now start putting that on paper. We knew industry was sending a white paper. We wanted to take advantage of that. We have that now. So I would expect over the next several months we will start fleshing something out with -- leaning towards a preferred option.

MR. DUBE: Yes, Mario. You had a question?

CHAIRMAN BONACA: Yes. Just -- would you just go over some of the advantages here on this option 2?

MR. DUBE: Well, option 2 would be -- I will give a hypothetical example. Reactor has a "baseline total CDF of $10^{-7}$," just for purposes of discussion. And one would say to some extent, like Mr. Shack mentioned, that Reg. Guide 1.174 with the acceptance guidelines, rather than be absolute thresholds like $10^{-5}$, $10^{-6}$, it would be 10 percent change.

Therefore, a plant with a baseline of $10^{-7}$, an acceptable change for a license amendment request would be 10 percent. I am just picking numbers for example -- 10 percent of $10^{-7}$, which would be a delta of $10^{-8}$, whereas a plant with a baseline CDF of $10^{-6}$, using the same 10 percent, it would be allowed -- the guideline would be 10 percent of that, which would be $10^{-7}$.

So that -- the advantage is it recognizes that small increases of relative measure, it would preclude the situation where they could have a large relative change -- percent change in core damage frequency and/or LERF for the new reactor.

The disadvantages are numerous. All ROP guidelines would have to be changed. One might not agree what is the baseline. I mean, one would have to concur on that. It would be major changes. The reg guides and processes would impact operating reactors. There would be inconsistencies. Transition would be very difficult -- I mean, I haven't ruled this out, but you can see there is a lot of --

(Laughter.)

MEMBER CORRADINI: Just to clarify -- Mario asked you to look at this one. So are all of the advantages and disadvantages saying that instead of working off of what is the calculated value it is working off of the goal? So that if you demanded the LRF was $10^{-6}$, and you said, "I won't allow for any change more than one percent or X percent of the goal," it -- do you see the same advantages or disadvantages?

MR. DUBE: Option 3 is kind of like that, in the sense that if one were -- since a large release frequency of $10^{-6}$ is one order of magnitude lower than $10^{-5}$, if one were to lower -- use an LRF that was one order of magnitude lower that would kind of -- it is kind of an option 3. It is not exactly

the same. But this is against --

MEMBER RAY: Well, let's keep in mind we are not just evaluating acceptability of amendments, but we are also evaluating the consequences of deficiencies, for example.

MR. DUBE: Reactor oversight process.

MEMBER RAY: Right. And I don't have an answer to this, that is not what I am leading up to, but to me I think about how you weigh -- how you should weigh the consequence of a deficiency much more than what hoops you have to jump through to get an amendment approved.

MR. ADER: If I could add, one of the questions -- or one of the items I would look at that we would consider in decision process is the infrastructure that has been developed in the understanding of the current approach, and to perturb that significantly would be an inefficiency, and you would start that learning process all over.

That is something that I would view as a part of a decision process. I think Dr. Shack hit on it, too. Another question we have is: do you have metrics for amendments? Because we reviewed them against one set. Do we judge changes against one --

the same set? But that may be independent from what we do for operations. So a question could be: we could use the existing metrics for ROP and have a different set for license amendments. Those are the types of questions we have that we are looking at.

MEMBER CORRADINI: So I had a question that is a little bit off -- a bit off base, but I am kind of curious. Is there any other industry such as the airline industry with new planes and new -- do they any analogue that you can see how other regulatory bodies are trying to deal with a new generation of technology relative to changing the regulations for both licensing and operation?

MR. DUBE: I haven't researched that, so I don't know.

MEMBER RAY: There is not enough to --

MEMBER APOSTOLAKIS: Would this be a good opportunity also to address some of the issues that 1.174 leaves open and that are subject to misinterpretation? I mean, I wonder what the scope of this work is. It is just do something similar for new reactors?

In particular, one thing that seems to be kind of not clear in people's minds is the following.

Regulatory Guide 1.174 refers to a single action -- change in the licensing basis. There was the issue of bundling the changes, and so on, and that was -- there is a discussion of that.

As I recall, there is no discussion for placing an upper bound on the cumulative change over the years. And some people -- in fact, the staff came back here in the context I believe -- no, there isn't -- in the context of risk-informing 50.46 and started saying, you know, that we will keep track of them and put a bound.

I explicitly remember Gary Holahan sitting there and saying, "You are free to submit a request every Monday." Yes. We don't forget these things. And during the discussion of 50.46, much to my surprise, several members were very happy to see an upper bound or the cumulative. So is that something that you may want to think about now, or is it, again, on a case-by-case basis, and we leave it up in the air, and we wave our arms?

MR. DUBE: There's others in the audience that can answer that better than me, perhaps Gareth Parry, but --

MEMBER APOSTOLAKIS: I am not looking for

an answer to that particular issue.

MR. DUBE: Not to put you on the spot.

MEMBER APOSTOLAKIS: I am looking for an answer to the question, if there are issues with the current guide that are sort of unresolved, is this a good opportunity to resolve it? Or do you have strict marching orders to do something with CDF and LRF and -- but that was an issue that came up.

CHAIRMAN BONACA: We discussed it. I mean, for me, Reg. Guide 1.174 should not be a motor to drive core damage frequency up and up and up to the upper limit.

MEMBER APOSTOLAKIS: But then, we should say that, and we don't.

CHAIRMAN BONACA: We need to say that.

CHAIRMAN SHACK: I like Dr. Dube's words. "The cumulative effect of such changes should be tracked and considered in the decision process."

MEMBER APOSTOLAKIS: That is very different from saying it should be $10^{-x}$.

CHAIRMAN SHACK: Well --

CHAIRMAN BONACA: We haven't talked about how you limit it.

MEMBER APOSTOLAKIS: Because, of course,

you want to deal with trivial issues in a risk-informed way, and then turn around and change the power by 20 percent. I mean, that inconsistency drives me crazy. You know, you are very stringent here. No, no, no, it is $10^{-6}$. But then, if you are in a non-risk-informed space, wow, double the power.

Anything else? Because we are already three minutes late. I am sure we will have other opportunities to discuss this in a more relaxed environment, right?

MR. DUBE: Yes, right. This has been good.

MEMBER APOSTOLAKIS: I noticed in your future plans the ACRS did not figure, but --

(Laughter.)

MR. DUBE: That's under stakeholders.

MEMBER APOSTOLAKIS: Oh, okay. Thank you very much.

MR. DUBE: Thank you.

MEMBER APOSTOLAKIS: This was a very insightful white paper I thought, very insightful.

MR. DUBE: Thank you.

MEMBER APOSTOLAKIS: Thank you.

Okay. Nuclear Energy Institute. Do you

have any slides or --

MR. BRADLEY: Yes. They should be -- I gave them to the staff, so --

CHAIRMAN BONACA: They should be on the computer.

MR. BRADLEY: Thank you. I am Biff Bradley of NEI, and with me is Doug True of ERIN Engineering. Both of us were involved back in the '90s, late '90s, when a lot of this similar discussion took place. So it is interesting to be back. Let me --

MEMBER RAY: But were you at Newport Beach in '78? That is the question.

MR. BRADLEY: No, I was not.

(Laughter.)

I'm going to just skip that. That is just an overview of what we want to talk about.

I wanted to start here -- and I am going to transition this over to Doug, who has done some work looking at the definitions of LRF and LERF, and I think that might be very informative based on the discussion we had earlier today.

We all know the paper was sent to the Commission. As you know, we also provided a paper to

the ACRS. We also sent our white paper to the Commission. We cc'd the Commission.

We have had -- the staff identified this issue to us a couple of months ago. I think we have had a positive constructive interaction with the staff on this issue. I do think there is a little concern with the timing -- the need for what appears to be very rapid resolution of this, and we know these are thorny issues. So we are a little bit concerned about the drive to do this very rapidly, but the interaction has been very good.

And I wanted to speak to the bullet, the first bullet -- perceived. We reason we put the word "perceived" there is that -- I think that is really a function of, as Doug indicated earlier, the definition of large release and how it equates to large early.

Don had one slide in his presentation that he actually corrected the word from "would" to "may," and that was an important correction, because -- that was on his slide 10 -- use of current numerical risk metric goals would result. I think that still remains to be seen, and it is a function of the definition. So that was an important

correction he made there. I just wanted to note that, and we will talk more about that.

As you might expect, industry does have some concerns in this area. The 1.174 process hasn't just been applied to CLB changes, it has also become the backbone of the reactor oversight process, which is near and dear to all plants' hearts. And it is the foundation for enforcement, inspection findings, and things of that nature that really have a major impact on a plant's operation.

There seems to be some question now about prior policy decisions. I know there were some Commission quotes put out or we have some of our own Commission quotes we can show as well. And I know the staff didn't propose a specific option, but we do believe that option 1 is credible, and we believe it is appropriate, and we will talk to that.

So as was mentioned, the Part 52 risk metrics come out of a 1990 SRM. And then, starting after that, starting in '93 when the quantitative definition of large release was directed by the Commission to be abandoned, we moved on into the era of the 1.174 development and LERF. So this has been discussed already.

We believe these goals have been effective for the design and the licensing, initial licensing of the plants, and that some of these -- some of the issues we get into with definitions of LERF or LRF are not so difficult in design space, but they do become more problematic if you try to apply them in operations space.

So at this point, I am going to turn it over to Doug, who has done a lot of digging on the history of LRF and LERF. Go ahead.

MR. TRUE: One of the things that we decided we wanted to do was kind of go back and provide this historical perspective, because a lot of the players haven't been involved all the way along. I wasn't anywhere near Newport Beach in 1978 either, George, but --

(Laughter.)

-- I have been involved with LERF and LER -- and LRF for 20-some years.

So we tried to put the whole story together, and we basically had two tracks. We had the Part 52 track, which was going up until the early 1990s, and then we jumped over to another track in the late 1990s with 1.174. And so we tried to kind

of wind all of that out, and then attempted to kind of go back over the history of LERF and help reconcile how we ended up with LERF, at least from the industry's perspective.

So as we talked about, the safety goal policy statement introduced the expectation for a large release frequency less than $10^{-6}$ for all reactors. The staff initially defined LRF as a release that had the potential for causing an offsite early fatality, and that definition was carried forward for a while.

The Commission came back later and said, "Well, we would really rather have a more quantitative definition and something that doesn't require a Level 3 PRA," something that we can put in terms of fraction of core inventory release or curies or something like that.

Charlie mentioned there was a lot of research done by the staff, and at the end, in 1993, the Commission directed the staff to abandon their efforts to quantitatively define LERF beyond this sort of qualitative definition that had been in existence. And, in fact, the SRM -- or the SECY and the SRM don't abandon large release. They sort of

leave the qualitative definition as is, without a further quantitative definition.

That left the new reactor vendors who didn't have Level 3 PRAs in a little bit of a spot, in that they had to come up with their own definitions for large release. And as Don I think it was said, many of the designs have adopted different definitions. And I think in all cases they have adopted something that is significantly conservative relative to what you might be seeing in this qualitative definition.

So we have existing DCDs that have been -- gone through the process with a different set of criteria, but all certainly below the LRF definition that the staff initially provided.

We turn to the LERF track -- in 1995, the industry issued -- EPRI issued the PSA Applications Guide, and I was a member of the writing team on that, along with Carl Fleming and Gareth and Blake Putney. And one of the things -- the significant things that we were proud of is coming up with a way to deal with releases.

And we were actually the first people that proposed LERF as a metric, and we picked it

because we -- for regulatory decisionmaking because -- we picked it because it could be used without having to do Level 3 calculations. It was a mechanistic definition that was easily -- easy to implement, pragmatic for the industry to use in decisionmaking, and through work that had been done on Level 3 PRAs, we saw that it aligned well with the early fatality QHO.

And the basis for the $10^{-5}$ that we came up with was not a CCFP or anything like that, but we had actually -- it was actually backed out from the acute -- early fatality QHO to be $10^{-5}$, much like the staff ended up doing as part of the 1.174 adoption of the same metric.

And then, since that time, since the mid-1990s, we have been working on standards that help define LERF and define how to calculate LERF properly. And that is the basis on which we have been moving forward.

MEMBER APOSTOLAKIS: This statement "consistency with LERF goal," again, maybe I didn't get it, but if the goal for LERF is $10^{-6}$, how is this consistent with that?

MR. TRUE: What a great --

(Laughter.)

Let's go to the next slide.

The alignment of LERF and LRF -- so I went back to this, and I had to dig back through the files to find all of these things, but I went back to NUREG-1150. NUREG-1150 was done at that time when everything was still kind of in play. We were still working on LRF, and we -- the QHOs were relatively new.

And so in 1150 the staff actually applied that same qualitative definition that I provided to LRF, and actually reported for the various risk calculations that were done what the large release frequency was for each of those designs.

So I went back to that, and I looked, then, at, well, what NUREG-1150 said about LERF. And I went to the accident progression bins that 1150 calculated for each of the reactors for internal events and compared the frequency of LERF that you would get from the mechanistic definition of LERF against the large release frequency calculations that they had done on the Level 3 side of things.

And what we actually found was that LERF was actually 10 times greater than large release

frequency.

MEMBER CORRADINI: So there is something about the definition that I would still --

MR. TRUE: I told you that I was going to get people to scratch their head. So the problem is we probably shouldn't have called it large early release. We probably should have called it high early release or significant early release, something like that, because everyone things of a pie that is made up of -- it's large, and there is a slice that is large early, and then there is a slice that is large late.

And it -- that's why I stood up and said it depends what you use as a definition. The qualitative definition for "large release," which is the only active viable definition today is actually tied to the potential for one or more early fatalities.

MEMBER BLEY: So rather than a pie, it is a layer cake with different releases at each layer, which is what you --

MR. TRUE: In fact, a lot of the work -- I should give Carl credit, Carl Fleming, because when we were doing the PS application -- and a lot of the

work that goes on at Seabrook bore this out, this factor of 10 kind of a difference between a large early release and a LERF being about a factor of 10 different.

MEMBER APOSTOLAKIS: Let's see if we can come up with a concise statement. What is the difference between the words here, large release versus large early release? What is the difference that makes the frequencies different?

MEMBER BLEY: One is measuring fatalities.

MEMBER APOSTOLAKIS: LRF.

MEMBER BLEY: LRF is measuring fatalities.

MR. TRUE: One or more.

MEMBER APOSTOLAKIS: Is referring to the fatalities. Yes, okay.

MR. TRUE: Referring to one or more release that results in one or more fatalities.

MEMBER APOSTOLAKIS: That's right.

MR. TRUE: Large early is a release that has -- that is early before offsite protective actions have been placed, and large in terms of an unscrubbed release of -- large quantity of unscrubbed

fission products.

MEMBER BLEY: Which will have a higher consequence.

MR. TRUE: Which could have a higher consequence under some circumstances, under other circumstances not. And what you find is, when you go the Level 3 site, and you have accounted for weather, and you have accounted for the fact that not all LERFs happen at exactly the same time, and some evacuation may have occurred, and all of the factors that get factored into the translation to actually having an early fatality, that there is -- there is a relatively large gap between those large early releases that have the potential in one way or another to generate significant offsite consequences and actually having fatality.

MEMBER CORRADINI: So can I try to differentiate -- I want to make sure, because Dennis' analogy I think is right on track. So if I go back -- forget everything in the '80s, let's go back to WASH-1400. You had nine release categories, or eight or something. And like --

MEMBER APOSTOLAKIS: Wait, wait, wait. You didn't seem to --

MEMBER ARMIJO: LERF -- if you were designing a plant, wouldn't you design a plant so that LERF -- with a factor of 10 lower than LRF? Because LERF is a more dangerous event. It should be less probable.

MEMBER CORRADINI: Can I try? I mean, just -- because I think this is what is bothering all of us. I think Dennis' analogy is exactly right on the money, which is that from the standpoint of what is released after a degraded accident can have a large -- larger -- different magnitudes and different timing.

And so when you -- the way you described it, I listened but the way he said it is if I have a very early release with a large amount of activity, or a lot of radioactivity, I would have essentially a much lower chance of that occurring. And what you did, if I understand that last line, is I looked at all of the binning and found out that more things were included in the LERF, more categories of releases.

MEMBER APOSTOLAKIS: How can that be?

MEMBER BLEY: Let me try something, because I think this is right. Let me try something.

LERF is related to consequences. And we went to Level 3 to see where the large numbers of consequences were coming from.

LRF is any large release at any time, but the definition of it wasn't linked to fatalities or results of risk assessments. It was set at $10^{-6}$ to ensure that the things that could have large consequences were low in frequency. But, in fact, it included -- because it wasn't design -- because we hadn't done the PRA, it didn't know everything that was in there, so it just said any large release at any time.

So the $10^{-6}$ was done to capture things, but you are right, if you were designing for the barrel of things that go into LRF, that could be a higher frequency than the things that go into LERF, because they have a higher consequence. It is just that when the safety goals were set we hadn't really understood the depth of what contributes to all of those -- to the consequences, so we just picked the large release frequency as --

MEMBER APOSTOLAKIS: Yes. But that would argue against the numerical goal they set. I mean, I can see that --

MEMBER BLEY: Yes, it worked. It worked, because they hadn't defined it that clearly at that time. And the first one is --

MEMBER APOSTOLAKIS: LERF, it seems to me, should be a subset of LRF.

MEMBER BLEY: It is, except --

MR. TRUE: Not by the way it has been defined.

MEMBER BLEY: But the $10^{-6}$ should not have applied to LRF. That is the thing.

VICE CHAIRMAN ABDEL-KHALIK: If one were to drop the L from LERF, then nobody would have any problems with this statement, right?

MR. TRUE: We created a problem defining --

VICE CHAIRMAN ABDEL-KHALIK: Let me just finish.

MR. TRUE: I'm sorry.

VICE CHAIRMAN ABDEL-KHALIK: So if one were to drop the L from LERF, so that we can say early release frequency is usually greater than 10 times LRF, right? And what that implies is that an early release may not necessarily cause an offsite early fatality, an internally consistent definition.

MEMBER BLEY: We are not quite there. The picture you had up where you said LERF is 10 times LRF, it isn't precisely right. I would say LERF is 10 times greater than the $10^{-6}$ that was picked in the standard, picked in the goal.

MEMBER APOSTOLAKIS: Of the --

MEMBER RAY: I think I agree with Said, but I was really trying to say something in response to Sam, which is these are two different circumstances. There is no reason why LERF should be a subset of LRF. They are completely different.

MR. TRUE: They are defined in totally different ways.

MEMBER RAY: Yes, right. And, you know, I mean, you can think of airplane crashes or whatever you want to think of, they are just different scenarios that you are addressing the consequences.

MEMBER APOSTOLAKIS: But how can the LRF not --

VICE CHAIRMAN ABDEL-KHALIK: Because the L in both of these acronyms are different.

MEMBER RAY: Let me answer you this way, George. Supposing you have a plant like I am familiar with -- let the experts debate here.

MEMBER APOSTOLAKIS: Guys?

MEMBER RAY: In which you have a large concentration of people near the plant. So early is a significantly different scenario as far as dose consequences are concerned than an event that is longer in time, right? You arbitrarily constrain the release to be early when there is no ability to protect this large group of people that are near the plant.

CHAIRMAN BONACA: Well, wouldn't the LRF --

MEMBER BLEY: Well, why don't we let --

MEMBER RAY: I don't think so necessarily, because I am insisting that this be an early release. It may, in fact, not be a credible case, but it is something I have insisted upon.

MEMBER BLEY: LERF was calculated as an -- it was what was calculated as an early large release, and it had high consequences, and that is how it got picked up from the Level 3.

MEMBER APOSTOLAKIS: I makes --

MEMBER RAY: Aren't you saying the same thing I am? It has large consequences because it is early?

MEMBER BLEY: Yes, but it wasn't arbitrary. That is -- the scenario that led to it happening early is what was countered. It wasn't arbitrarily assumed that it happened then.

MEMBER APOSTOLAKIS: Let's look at this table and then come back to the discussion. Let's let Doug --

MR. TRUE: Okay. So what I did, and the paper -- the appendix to the paper, attachment to the paper, goes through this, gives you all of the data summarized in this single table. We went through the accident progression bins of NUREG-1150, and those are described as, for example, early containment failure without sprays, early containment failure with sprays, early containment failure with -- in the drywell, early containment failure in the wetwell where it would be scrubbed.

And I picked out the accident progression bins that would meet the LERF definition, the mechanistic LERF definition.

MEMBER APOSTOLAKIS: LERF.

MR. TRUE: LERF.

MEMBER APOSTOLAKIS: Yes.

MR. TRUE: Of being early and having a

significant release of unscrubbed fission products -- the mechanistic definition.

MEMBER APOSTOLAKIS: Right.

MR. TRUE: Which is the way we apply LERF and the way it is defined in 1.174. Okay?

So I just went through the accident progression bins, picked those ones that were LERF out, added them up. That is a LERF frequency from NUREG-1150. Totals are in the first column.

The large release frequency is what the staff reported of having gone through and actually calculated the frequency of one or more early fatalities, of a release resulting in one or more early fatalities.

I divided the large release frequency by the LERF frequency, and it is greater than a factor of 10. This has been borne out by other Level 3 PRAs also.

MEMBER ARMIJO: Doug, in the LERF, there is no calculation of actual doses in early fatalities?

MR. TRUE: No. No, it's a mechanistic definition.

MEMBER ARMIJO: But the LRF has that.

MR. TRUE: Right.

MEMBER ARMIJO: And that is why they are different.

MR. TRUE: That's why they are different.

MEMBER RAY: Okay. I was wrong.

MR. TRUE: L is just a totally different thing.

MEMBER RAY: I thought you were talking about dose in both cases.

MR. TRUE: You can define it to be L is always based on some number of curies or something, but the staff tried to do that, and it is really hard because there is a whole bunch of factors that go into that.

MEMBER APOSTOLAKIS: LRF includes additional failures, additional things?

MR. TRUE: No. Transport, health effects. It changes from fission products being released to health effects.

MEMBER APOSTOLAKIS: There is still the release frequency that you are interested in, not what happens after. What happens after is part of your definition. Why would it come down by three orders of magnitude?

MEMBER CORRADINI: I think Doug said it, but I think you should just restate it. I mean, because I think it -- I think we are all saying the same thing a different way. Said's way of saying it -- so you said in the two criteria, two attributes -- one, it was early by some time, and, two, you said unscrubbed. But I would say unmitigated. That is, I didn't have a containment system functioning as it should have to have knocked down whatever was released.

I want to make sure you define the unscrubbed more precisely, so I understand --

MEMBER APOSTOLAKIS: That's all --

MR. TRUE: That is true if a containment -- when a containment spray was considered. The other one is the BWRs where you have wetwell failures, so the fission products have to go through the pool before they make it out. So it is not a --

MEMBER CORRADINI: Versus a liner failure.

MR. TRUE: Versus a liner failure, a drywell failure.

MEMBER CORRADINI: Okay. Fine. But then, I think -- if I could just finish, I think

Said's way of saying it is -- is I think more expressive, because it is essentially unscrubbed early release, regardless of how much is released.

Back to the layer cake example, the LRF is the top, the LERF is a whole bunch of stuff that gets released based on time, and a definition of what -- of how it is released.

MEMBER APOSTOLAKIS: So it is not necessarily --

MEMBER RAY: But not the --

MEMBER APOSTOLAKIS: Is it true, then, to say that the early release is not necessarily large?

MEMBER CORRADINI: Correct.

VICE CHAIRMAN ABDEL-KHALIK: Or early release may not necessarily result in offsite early fatality.

MEMBER CORRADINI: Large enough.

MR. TRUE: Well, I also did it based on cesium-iodide fractions.

MEMBER APOSTOLAKIS: Do you agree with this, what we just said?

MR. TRUE: I agree with what --

MEMBER APOSTOLAKIS: That the early release is not necessarily a large release in the

sense that it may lead to deaths.

MR. TRUE: LEFT. The definition of LERF that we use --

MEMBER APOSTOLAKIS: What we call LERF now is -- it's including all sorts of releases that do not -- some of them do not necessarily lead to fatalities, and that is why its frequency is greater.

MR. TRUE: Yes. Yes.

MEMBER RAY: See, the reason why I thought that --

MEMBER APOSTOLAKIS: The moment I tried to understand it -- okay.

MEMBER RAY: Well, because it had been said earlier that what was characteristic of the LERF was that you hadn't time to take mitigating actions. So I just made the natural connection that what that meant was there was more of a threat. And that may still be true, I don't know, but in any event it is not part of the calculation.

MEMBER APOSTOLAKIS: But, then, if what you said is correct, which I understand now, which is at least for me progress --

MEMBER RAY: Yes, it is progress.

(Laughter.)

MEMBER APOSTOLAKIS: -- why did they call it LERF?

MEMBER RAY: Because it isn't a small release or an insignificant release.

MEMBER APOSTOLAKIS: But it does include relatively small --

PARTICIPANT: I think you should drop the L from LERF.

MEMBER APOSTOLAKIS: It is too late for that now.

MR. TRUE: You can't do that, because there are other scenarios -- there are -- like the drywell failure or wetwell failure scenarios that are not -- have virtually no potential to cause any --

CHAIRMAN SHACK: But you could call it SERF, significant early release.

(Laughter.)

MEMBER ARMIJO: I am just trying to understand this. Just one simple question. Could you consider the LERF as a reactor-specific term? In other words, and so this is a characteristic of a particular reactor, but LERF is a reactor, the site, doses, and everything else.

MR. TRUE: No, it is the other way

around.

MEMBER STETKAR: Let me try something here. I know what LERF means, because I have done the same exercises that you have. I think the problem is the fact that the second column in your table is called a large release frequency. It is actually a surrogate fatality frequency. It is not a release frequency. It is the frequency of having one or more fatalities from releases.

MR. TRUE: Right.

MEMBER STETKAR: And that does include the offsite consequences, the sheltering, the weather, everything, which may not be very effective for a decent fraction of the large early releases, and may be very effective for a very high fraction of the large late releases, or whatever. But, indeed, that second column, it is -- the confusion is the semantics of calling that a release frequency.

MR. TRUE: I only took from NUREG-1150 --

MEMBER STETKAR: It is not your --

MR. TRUE: This definition -- the definition that has been qualitatively adopted by the Commission is a release as a potential for causing one or more early fatalities. The way that has been

interpreted, and in fact the way it was interpreted in the staff's research on trying to define the large release, was that it was one or more of the -- or frequency was a release with one or more fatalities.

All NUREG-1150 did was go in and say, "What is that frequency?" and they reported that as large release frequency.

MEMBER STETKAR: After having done, though, the consequence, seven percent of the releases do result in a --

MEMBER APOSTOLAKIS: In light of what John just said, I have a sequence. Okay? There is a release here, but then there are other things that must happen to have a fatality.

MR. TRUE: Right.

MEMBER APOSTOLAKIS: I understand what John said that when we say "large release frequency" we mean the frequency of the whole thing that leads to fatalities?

MR. TRUE: Yes.

MEMBER APOSTOLAKIS: Or just the release that will eventually lead to fatalities? In other words, there may be another group of things that must happen here that have some frequency. So these are

part of the large release frequency.

I mean, the early release frequency, these are not included?

MR. TRUE: Right.

MEMBER STETKAR: It is just -- the large early release frequency is where you drew your first line in the air with your hand. It is the definition of a -- not taken out to curie content, but a large amount of curies that are released --

MEMBER APOSTOLAKIS: That is right.

MEMBER STETKAR: unscrubbed early. You don't know what happens to those curies after that point, so --

MEMBER RAY: Yes. But the assumption is that you are concerned about it because --

MEMBER STETKAR: A higher fraction of those releases may result in a fatality compared to a large release.

MEMBER RAY: That is where I got -- made the wrong connection.

MEMBER APOSTOLAKIS: So the misnomer, then, is the LRF.

So, Stan?

MR. LEVINSON: Stanley Levinson from

AREVA. As I listened to the conversation, I thought of a very simple way, semantics aside. LRF is the metric for a Level 2 PRA, or LERF is a metric for a Level 2 PRA, and LRF, whatever it means, is a metric for Level 3 PRA.

MEMBER APOSTOLAKIS: Which is what John had said about --

MR. LEVINSON: Basically, right.

MEMBER ARMIJO: I am going to come one more time, and then I will give up.

MR. TRUE: Okay.

MEMBER ARMIJO: LERF is a plant characteristic. LRF is a plant plus all of the other stuff that happens.

MR. TRUE: Yes.

MEMBER APOSTOLAKIS: Can someone take this down and put it in --

(Laughter.)

Either you guys or the staff, somewhere there make the distinction very clear, so next time we meet we will be again confused.

MEMBER CORRADINI: Less.

MEMBER APOSTOLAKIS: No. I really think --

MR. ADER: In the public meeting we had, Doug made that statement, and I wrestled with it the same way. When I got the white paper and saw that there is -- "large" is defined differently, then --

MEMBER APOSTOLAKIS: So you agree with this interpretation.

MR. ADER: Yes.

CHAIRMAN SHACK: But we still don't know what the Commission had in mind when they said the LRF was less than $10^{-6}$.

VICE CHAIRMAN ABDEL-KHALIK: Well, that is very clear. Now I understand.

CHAIRMAN SHACK: They didn't really have the definition at the time.

PARTICIPANT: Anything more you want to say about this, Doug?

MR. TRUE: Just that this confirmed the --

MEMBER APOSTOLAKIS: Would the staff entertain, then, the possibility of actually changing the nomenclature? I mean, excuse me, this is terrible. This is absolutely terrible, to have all of these experts here talking for 40 minutes trying to understand something.

I would change the terminology at some point -- not LERF, because that is well established, but LRF -- LRF I think, you know, based on the interpretation we heard, maybe we need another name.

Let's go on. I know nobody is going to say, yes, we are going to do it.

CHAIRMAN BONACA: Could you explain -- what is the conditional probability of LRF given LERF?

MR. TRUE: It is less than .1.

MEMBER APOSTOLAKIS: So what he is saying -- you are saying there is that four percent of all these sequences in LERF result in --

MEMBER BLEY: At Peachbottom.

MEMBER APOSTOLAKIS: Yes, yes, yes.

MEMBER STETKAR: Four one-hundredths of one percent of the sequences that are binned into something called LERF would result in one or more fatalities. And at Zion, 8.5 percent of the sequences that are binned into something called LERF, would result in one or more fatalities.

MEMBER APOSTOLAKIS: Okay. So let's keep going.

MR. BRADLEY: George, we are done with

the LERF versus LRF, so we --

(Laughter.)

MEMBER APOSTOLAKIS: It is in the statement somewhere that you favor option 1.

MR. BRADLEY: I want to speak to that.

MEMBER APOSTOLAKIS: Yes, that's important.

MR. BRADLEY: Okay. So we are going to move off the lofty world of LERF and LRF and talk about some -- oh, Charlie is not going to let us go quite --

MR. ADER: Yes, I hate to move on. That was -- LRF has not been defined. I understand Doug's logic as LRF was used in 1150. Each of the applicants, as Don said, has different definitions. One of the challenges we would have if we go to LRF is, then, we would have to come to an agreement of what a definition is. So I understand the logic, but I don't want to leave the impression that LRF has a definition that is consistent across the applications that we are struggling with.

MEMBER APOSTOLAKIS: And what I said is when you come up with a definition which then everybody will follow you may want to consider

changing the words, because it is confusing.

MEMBER ARMIJO: How can you calculate something that hasn't been defined?

MR. TRUE: You do it conservatively. That's what they have done. That's what the applicants have done is they have used a definition which they -- any definition of LRF that could be used, and they submit that and they say, "Look, we are less than $10^{-6}$." That is my simplistic characterization.

MEMBER APOSTOLAKIS: Okay. I think we need to move on. So, Biff, you wanted to say something?

MR. BRADLEY: Yes, I wanted to speak a little more to some of the other reasons we believe option 1 is viable for --

MEMBER APOSTOLAKIS: Which is the status quo, right?

MR. BRADLEY: Right, status quo.

MEMBER APOSTOLAKIS: Okay.

MR. BRADLEY: I think in reading the NRC paper there was a presumption in there, or a concern, that the margin available for risk increases in a 1.174-type application could be consumed, and

that plants could substantially increase their base CDFs over time above what was considered in the licensing process.

And I just wanted to -- and, you know, we have looked at this in terms of the operating plants, and there are a number of things you need to bear in mind, and that is historically -- and if you look at how these applications have been implemented -- that hasn't happened. There are a number of other constraints; it is not risk-based. It is a risk-informed process. It includes defense-in-depth, safety margins.

When the applications themselves are developed, they have all kinds of deterministic backstops and other elements in there that preclude you from just sucking up all of that risk that is theoretically available in the delta CDF, for instance.

Another thing to bear in mind is that the changes that are granted for -- the vast majority have been in a very small region which is an order of magnitude smaller than the allowable region. It is quite rare for NRC to grant something that goes above very small. So the reality of application has been

these are really constrained by an additional order of magnitude.

The other thing I think is that risk applications over time, even though each application may theoretically allow a small delta increase in risk, the actual effect of these applications has been shown to lead to or contribute to what -- a reduction of CDF over time.

Obviously, we are not trying to claim that all of this -- this reduction is all due to applications. Much of this is due to other things, plant improvements that were made as a result of the IPEs, improvements to the modeling methods, more realism in the models. But it is probably safe to conclude that the risk-informed applications have led to a better safety focus at the plant.

And we haven't seen a trend of increased CDF due to large numbers of plants implementing things like risk-informed tech specs, risk-informed ISI, etcetera. And this was a picture we showed to the Commission in a briefing a couple of months ago, just to try to make the point that while these things theoretically allow a risk increase, what we have seen practically has not been that effect.

MEMBER APOSTOLAKIS: But the industry is not recalculating the CDF every year. What is the basis for this curve?

MR. BRADLEY: These are numbers -- as part of MSPI, we actually did go back and rebaseline, look at all of the baseline CDFs. That is the basis. These are -- up to 2005 here, these are --

MR. TRUE: That is MSPI data. What basically we did was we went -- this started in a paper we wrote back in 2001. We went back from the 1992 to then and gathered information from utilities on their calculated CDFs. So it is a progression of how the calculated CDFs have changed, not necessarily how the actual performance has changed year on year.

MEMBER APOSTOLAKIS: So you mean you have access to CDFs for 2001 and 2003 and --

MR. TRUE: Yes.

MEMBER APOSTOLAKIS: -- they recalculate every year?

MR. TRUE: Some plants recalculate; some plants don't. Everybody generally recalculates every two refueling cycles, so every three or four years. But each year this is the average of the ones we had available.

MR. BRADLEY: I mean, the point of all of this -- go ahead.

MR. TRUE: If I can just add one other thing. Another thing we did to kind of validate this was we went back to NUREG-1150 -- two NUREG-1150 studies and actually took the dominant cutsets from those studies, replaced the equipment reliability, initiating event frequencies, and maintenance and availability data, with the current NUREG/CR-6928 data for the same events, and found that we got about a factor of four reduction on just improved industry performance over that period of time, which I think really comes out of the maintenance rule and its focus on the risk-significant equipment, making sure that we are maintaining that equipment in a good manner.

MEMBER APOSTOLAKIS: What do you mean -- oh, A-4, because --

MR. BRADLEY: Configuration of --

MEMBER APOSTOLAKIS: What is 50.44? I forget.

MR. BRADLEY: That is the combustible gas control rulemaking.

This is to show some of the major

applications just on the timeline and where they started, but the problem being here is that we haven't observed in reality for the operating plants an upward creep in CDF due to 1.174 coming into play.

VICE CHAIRMAN ABDEL-KHALIK: But without the incremental changes in CDF produced by these applications, this line would have dropped a lot faster.

MR. BRADLEY: Well, I mean, that's -- you could theoretically think that. I don't think that's true, and I think the things like the maintenance rule and the risk-informed tech specs actually it could be argued contribute to better CDF consideration than what we had in the old deterministic methods.

MR. TRUE: I will give one anecdotal retort to that also, in that one of the things we looked at in comparing the data from the study we did where we took NUREG-1150 and took the new data and put it into a NUREG-1150 model, was that the maintenance unavailability had actually gone up, because we had -- we are doing more online maintenance than we were doing in the 1990s.

But what we found was that the equipment

reliability improvements that have been gained by being able to do better focused maintenance, by having more online maintenance, have actually more than offset that. And, in fact, the equipment reliability improvements have greatly outdistanced that small increase in maintenance unavailability.

So I think -- within the data I think there is even a case that says that at least some of these have resulted in improvements.

MR. BRADLEY: Okay. I know I am running out of time here. I wanted to -- in Don's presentation he had a couple of Commission quotes, so we will do likewise.

We are quoting policy. I think you were quoting expectations. But there are -- this is just a quote from the 2008 introduction to the advanced reactor policy statement that just came out in October of last year. And just -- you can read it.

But we believe the Commission has been consistent in stating that this is a goal, a design goal for the new reactors, but it doesn't result in the need for a new regulatory regime. There was also an effort by the staff some years ago to propose a whole suite of new regulations that would apply to

new reactor designs that was also dismissed by the Commission as somewhat analogous to what is going on today.

So these are just some of the -- this is all in our paper. And if you have read the paper, there is nothing new here. We do believe that these metrics we are using were derived from the safety goal policy statement. So it would seem that if we are going to consider changing the metrics we need to go back and look at the underlying policy statement. I already mentioned the advanced reactor policy statement.

We are concerned -- the new plants do have better designs, but I think, you know, we have anticipated being able to use the risk-informed applications we have developed. The tech specs, for instance, are just a better way to address equipment out of service in surveillance intervals. It is much smarter than the old version of tech specs.

And we are concerned if the -- if there are significant constraints put on the risk metrics, plants really won't be able to implement those or use them in the way they were designed.

And also, as was mentioned several times,

the whole inspection and enforcement process is predicated on 1.174-type risk numbers. And it would appear that a reduction in those would subject the new plants to inspection and enforcement at levels that really have minimal correspondence to public safety.

MEMBER RAY: Well, Biff, are you saying, then, that absolute -- in this problem of absolute versus relative change for significance determinations, for example --

MR. BRADLEY: Right, yes.

MEMBER RAY: -- you would go with "absolute," is that what you are saying?

MR. BRADLEY: Well, I would go with what we have today, which is "absolute."

MEMBER RAY: But even for a plant that has -- where an absolute change for this new plant design would be a much more significant change than it would be for an existing plan.

MR. BRADLEY: Well, yes, and I think that is tempered by some of the other things we are going to talk about, which is the fact that these are not -- this came up earlier, that these aren't -- the risk profiles for these new plants aren't complete

yet.

So we are seeing some very low internal events numbers for some of the designs, but 50.71(h) requires all these plants to have -- meet PRA standards for internal events, external events, including seismic and fire, and probably by the time we get to the actual licensing LPSD as well.

So I think we need to bear that in mind as well, is that the numbers are going to change as these plants move toward operation.

CHAIRMAN BONACA: Don't you have concern on the ROP?

MEMBER APOSTOLAKIS: In fact, Mr. Dube had a list of disadvantages. It would be useful if you addressed those.

MR. BRADLEY: Yes. We have looked at -- and, you know, we had -- at the public meeting we discussed those and suggested some others that are in our paper, but we --

CHAIRMAN BONACA: Could you go over them now? I mean, we could look at it.

MEMBER APOSTOLAKIS: Or we can do it at the subcommittee level. If he wants to --

MR. TRUE: The fact of the matter is this

whole thing came on us fast, so we tried to get the first paper out. We just sort of set the stage. I think it may be better to come back and go through the --

MR. BRADLEY: Let me -- I could finish this, and if we still have time I would be happy to --

MEMBER APOSTOLAKIS: Sure, sure, sure.

MR. BRADLEY: -- go back and look at his slide.

One of the problems we are concerned about is really not a technical problem, it is more just a perception issue of having co-located sites where you are having enforcement actions and things that show up, you know, in the press or whatever at totally different levels. We believe that is a very difficult thing to explain and for the public to understand.

MEMBER CORRADINI: Let me make sure I understand what you are saying. So your point is if I've got Plant X that was built 40 years ago, and Plant Y that is coming up in five years, and they have different absolute standards, that causes a confusion by the public?

MR. BRADLEY: Yes. You could add --

MEMBER CORRADINI: What is the confusion if I have a plant -- just so we're clear, what is the confusion of the plant that I -- I have a new technology, and I only demand it to be as safe as a 60-year old technology.

MR. BRADLEY: Well, that is not -- I don't think that is what we are saying.

MEMBER CORRADINI: Well, but, I mean, that is kind of what I heard the argument is in reverse.

MR. BRADLEY: No. This is really just, you know, enforcement space. It just -- there is supposed to be a correlation in enforcement to public safety. Regardless of the plant design, I mean, if these things are at an arbitrary level, it is way below any kind of, you know, goals that we have used up to now, there would seem to be a different standard being applied.

MEMBER APOSTOLAKIS: It seems to me in different words, really, but the same thing. It depends on how you look at the Commission's goals. The Commission's goals are not for LWRs. The Commission's goals are a statement of the American

public as to what risk is acceptable for reactors. And that is independent of the type of reactor you are using.

If you look at it that way, then your comment doesn't apply, because the Commission says as long as you are below $10^{-4}$, say, core damage frequency, that is good enough.

MEMBER CORRADINI: So let me just counter that from a policy standpoint. If I go from 104 reactors to 110 --

MEMBER APOSTOLAKIS: That is different.

MEMBER CORRADINI: -- at sites that are co-located as populations are growing, that addresses the policy. What I am asking is from the standpoint of just a design standpoint, because I do agree with you how you enforce it might be different than how you design it.

I thought that -- at least I thought Mr. Dube's discussion was there could be a break -- a difference as to what I have for essentially allowing for a new design versus how I enforce it. And I think you used the word ROP or --

MEMBER APOSTOLAKIS: Yes.

MR. BRADLEY: And I think we even

suggested -- I think one of the reasons we've got a roomful of people here is that this enforcement is very, very large.

MEMBER CORRADINI: I understand.

MR. BRADLEY: CLB changes is one thing, but to say we are going to start enforcement at a different level, that gets a lot of attention.

MEMBER CORRADINI: I appreciate that. I appreciate that.

MR. BRADLEY: And we have even suggested that if there is a way to divorce that and have a -- because there is a rush to do this rapidly. I think getting the enforcement part out of the immediate concern would make things a lot better.

MEMBER CORRADINI: Okay. Thank you.

MR. BRADLEY: Okay. Another issue that we struggle with even today, we are, you know, working on things like SDPs, where you are down in the $10^{-7}$s, fire PRA, change evaluations. These things are already down -- $10^{-7}$, $10^{-8}$s -- where we are starting to get swamped by the uncertainty bands in PRA, and it is really difficult to make, you know, well-informed decisions when the thresholds are deep within the uncertainty bands. And we are worried

that lowering them further is just going to exacerbate that even more.

So that is just another concern we have with the state of the technology, and, really, its ability to go to those low numbers.

We are concerned that if there is a suggestion or a lowering of the values that the -- you know, new plants will not be able to use risk applications that we have spent years developing, and that in many cases are just a better way to run the plant.

And, finally, as I mentioned, the CDFs that are -- the DCD CDFs are internal events, fire, and selected LPSD. Seismic is done separately through SMA. There is no quantification of CDF for seismic, so that is set aside for the LRF and the CCFP work that the new reactors do.

Now, 50.71(h) is going to require full quantification of seismic, fire, internal, and possibly shutdown one year prior to fuel load. So I think we need to bear that in mind, that we make decisions predicated on like the DCD numbers that Don showed earlier. They may not hold up once we get to that point.

There is also -- Part 52, I mentioned all of the backstops. Don made a statement that we could have large periods of unavailability. Well, that is not -- that is really constrained -- I am assuming he is referring to Tech Spec 4B. There is a deterministic backstop. You can never have anything unavailable longer than 30 days regardless of the risk impact.

So there are -- these things aren't really allowing you to suck up all of that, you know, or have huge amounts of unavailability. That is really a misnomer. There are all kinds of constraints that are built into these applications.

As a matter of fact, there is a cumulative -- we have talked about cumulative impacts. Some of these -- 4B, 5B -- actually have requirements to go cumulatively look at the impact of what you are doing and adjust it as necessary if your CDF is going up.

So a lot of that is really built into the applications. A lot of the things that the NRC paper seems worried about are really taken care of pretty well in the applications themselves.

Just a final note. This really isn't

pertinent to -- directly pertinent to this, but the design features that are put into the new plants that make them so much safer, both in-vessel, ex-vessel, all the design features, those things are codified into the DCD and the COL process.

They can't be -- there is Tier 1, Tier 2 requirements. There is a change control process with explicit consideration of severe accidents. We have gone way beyond what we do for operating plants there that -- these things are locked in place, and there is strong change control. So if the concern is we are going to remove features from the plants, that, you know, there is other deterministic constraints in the regulation that would preclude that. So just to note that.

So, in summary, we believe, you know, Part 52 has been very effective for design and licensing, but that once we transition to the operating phase, in part due to a lot of these definitional issues we have discussed, we should -- we believe 1.174 is adequate and supportable.

Obviously, the definition of LRF and LERF and all of this discussion we had today plays into that determination, but we believe that we can make

that case. And we think it is good to have a consistent Commission policy across the fleet, and so -- that's all we have.

MEMBER APOSTOLAKIS: Thank you, Biff.

I would really like to have a subcommittee meeting with more time to discuss these things. And I hope you guys would be willing to come.

MR. BRADLEY: Yes.

MEMBER APOSTOLAKIS: So maybe we can schedule this offline at some point in the near future. And I will say -- I will repeat what I said a long time ago, that you don't have to have definitive answers to questions before they come to us. We will do it the way we did 1.174.

I mean, if you have what you would consider a half-baked idea, let's talk about it. You know, and there is no --

(Laughter.)

Didn't we do that -- quarter data.

CHAIRMAN BONACA: I would like to understand what are the next steps that they are planning. Could I --

MEMBER APOSTOLAKIS: Charlie, do you want

to brief us as to --

CHAIRMAN BONACA: Tell us what the next steps are going to be and the timing of it.

MR. ADER: We are trying to take the information we got from the public meeting. We've got the industry white paper now. We have internally been discussing, but we need to start putting on paper, again expanding the white paper that Don had written to better define what we would see advantages and disadvantages, to a set of options.

They may not be the options that were in the white paper. They may be a subset, or they may be the same.

I am anticipating over the next several months we need to start narrowing some of that down. We don't have a definitive date that we have to deliver a product, but we need to -- from our end we need to try to move it through at a timely -- I won't say rapid, but a timely pace, because it is I think a significant issue that needs a fair amount of discussion. We want to try to allow that.

CHAIRMAN BONACA: But there are some pieces -- for example, we just heard that, you know, there is a belief that Reg. Guide 1.174 should be as

effective as it is today. Now, we need to verify that.

MEMBER APOSTOLAKIS: And discuss it.

CHAIRMAN BONACA: And discuss it. And so do you have plans for doing that, a kind of analysis and understanding and -- because that is -- will be, on our part, for example, opportunity for participation.

MEMBER APOSTOLAKIS: Yes. I mean, at which timeframe do you think we can have a subcommittee meeting? The fall?

MR. ADER: We would hope that we would be before that. I know your schedule is going to be difficult, but -- and from our perspective, we do -- from New Reactors, we do have an application in that is trying to take advantage of risk-informed tech specs. We are trying to accommodate that application.

So this is -- originally, when we looked at this issue, we were saying this is -- this is four years down the road. We don't have to worry about it until we have operating -- you know, have granted the COLs. We are starting to see the applications, so we are trying to support that.

By doing that, that would -- we would tend to want to narrow the focus of what we are trying to do and not solve all of the issues that are out there. Some of this is a policy decision of where you want to go, where the Commission wants to go, with the current risk metrics versus new risk metrics with their expectations of enhanced safety.

We would like to try to get that decision, and that would start framing -- if the Commission says "status quo," then our work to implement this is very minimal. If the Commission says, "No, we would like to -- we have given you direction to use a more restrictive LRF definition, and we would like you to implement that, then we have a fair amount of work." If they take a different tack, then it could open it up, so --

MEMBER APOSTOLAKIS: I was --

MR. ADER: I guess what I am saying, I would not see -- I mean, we will take this question back on 1.174 issues, but I would not see trying to tackle those until we have tried to deal with the -- you know, the fundamental policy issues that we --

MEMBER APOSTOLAKIS: But you have already sent this -- the SECY to the Commission.

MR. ADER: We have sent the white paper to the Commission to inform them of these were the issues that we were -- seeing implementation issues that we would start engaging stakeholders.

MEMBER APOSTOLAKIS: I would really like to have a subcommittee meeting before you guys send the recommendation to the Commission.

MR. ADER: We would anticipate that.

MEMBER APOSTOLAKIS: Good.

MR. HAMZEHEE: That means it has to happen soon, if you want to have that subcommittee meeting.

MEMBER APOSTOLAKIS: You don't want it not to happen, because if we disagree we are going to end up, again, you know, they sent this letter and now they disagree with the staff, let's do it before you send any recommendations.

MR. ADER: That would be --

MEMBER APOSTOLAKIS: What we want --

MR. ADER: No, that would be our plan, clearly.

MEMBER APOSTOLAKIS: So we will schedule a meeting, then, offline. The calendar is already full for the next few months.

Any other comments or questions from members?

MEMBER RAY: Yes. George, I wanted to -- Biff said something that I absolutely agree with. It applies to other things we are discussing here now -- I just wanted to reinforce it -- which was at some point you can just establish an arbitrary limit, a deterministic limit that eliminates this concern that people develop over, well, on a probabilistic basis we can do -- take something out of service forever.

Take my battery charger, for example. It always used to drive me nuts the short time you could have the battery charger out of service.

Well, on a risk-informed basis, it would be out a long, long time, but it doesn't need to be and it shouldn't be. So my point is simply to underscore that sometimes in order to get the advantages of PRA you need to have some reasonable deterministic, arbitrary limit, and just say that's it. And --

MEMBER APOSTOLAKIS: These are the backstops he mentioned?

MEMBER RAY: Yes. That's what he said. And he mentioned that -- and it was in a hurry, and I

just wanted to underscore it, because I think it's important.

MEMBER APOSTOLAKIS: Anything else from the members? Yes, sir.

MEMBER BLEY: Just two points. One, I want to thank Doug for the great presentation. And I guess my memory of how LERF had come about -- I had been doing Level 3 PRAs -- was a little corrupt. I thought we did it from the Level 3 back, but we did it from the Level 2 bins that could lead to Level 3 consequences.

The only point I want to make is LERF does have the potential -- any LERF, any large unscrubbed release has the potential for one or more fatalities. But the LRFs that were calculated, the ones the staff had done, are the ones that were actually calculated in Level 3 to lead to one or more fatalities.

And that is a distinction that still causes us a little of the problem you raised in the beginning, George. That's all.

MR. TRUE: It is also true, though, that SERFs --

(Laughter.)

-- small early releases --

(Laughter.)

MEMBER APOSTOLAKIS: Any other comments?

MR. TRUE: -- has the potential.

MEMBER APOSTOLAKIS: The staff, do you have any comments, parting remarks?

(No response.)

The public? Anyone who wants to say a few words?

(No response.)

Well, thank you very much, gentlemen. And, Don, this was very informative.

Back to you, Mr. Chairman.

CHAIRMAN BONACA: Yes, very helpful indeed.

With that, we will take a break until 10:50, and close the record at this point.

(Whereupon, at 10:34 a.m., the proceedings in the foregoing matter went off the record.)

# Risk Metrics for Operating New Reactors

ACRS Committee Meeting

April 3, 2009

Biff Bradley - NEI

Doug True - ERIN

NUCLEAR ENERGY INSTITUTE

# Overview

- Issue
- Evolution of risk metrics
- PRA & risk metrics in design and licensing
- Risk metrics in the operational phase
- LRF vs. LERF
- Quantitative thresholds
- Problems with different metrics

# Issue to be Addressed

- NRC paper on risk metrics recently provided to ACRS and Commission
  - Perceived differences in risk metrics and thresholds between Part 52 licensing and currently operating plants
  - Concern with existing NRC risk informed processes (CLB changes, reactor oversight process, MSPI)
  - Prior NRC policy decisions called into question
  - Proposes six options for consideration
- Industry supports Option 1 (same metrics as for existing plants)

# Evolution of Risk Metrics

- Part 52 risk metrics preceded Regulatory Guide 1.174 development
- Design Certifications and COLs rely upon:
  - Core Damage Frequency (CDF)
  - Conditional Containment Failure Probability (CCFP)
  - Large Release Frequency (LRF)
- Operating plants rely upon:
  - CDF
  - Large Early Release Frequency (LERF)

# PRA & Risk Metrics in Design and Licensing

- Part 52 requirements and risk goals for new plants have put appropriate focus on:
  - A low and balanced computed CDF,
  - A low computed CCFP (<0.1) for the corresponding computed CDF, and
  - A low LRF for the corresponding computed CDF.
- These metrics have been effective for design and initial licensing purposes

NEI

# LRF History

- Safety Goal Policy Statement introduced large release expectation
- Staff initially defined LRF qualitatively:

  *"A large release is a release that has a potential for causing an offsite early fatality."*
- Commission directed staff to provide more quantitative definition
- In 1993, the Commission directed NRC staff to abandon efforts to quantitatively define LRF
- New reactor vendors have provided their own definitions
  - –Unique to Design Certification application
  - –Generally very conservative and simplified definitions

NEI

# LERF History

- In 1995, EPRI PSA Applications Guide introduced LERF as a risk metric
- Mechanistic definition, aligned to early fatality (EF) QHO
- LERF quantitative threshold of $1x10^{-5}$/ry suggested based on
  - Level 3 PRAs
  - Consistency with LRF goal
- Staff adopted LERF for RG 1.174 as surrogate for EF QHO
- PRA standards developed to address LERF

# Alignment of LERF & LRF

- NUREG-1150 applied staff qualitative definition of LRF
- Recent comparison performed of internal event LERF accident progression bins to computed LRF
- Results show for all NUREG 1150 plants:

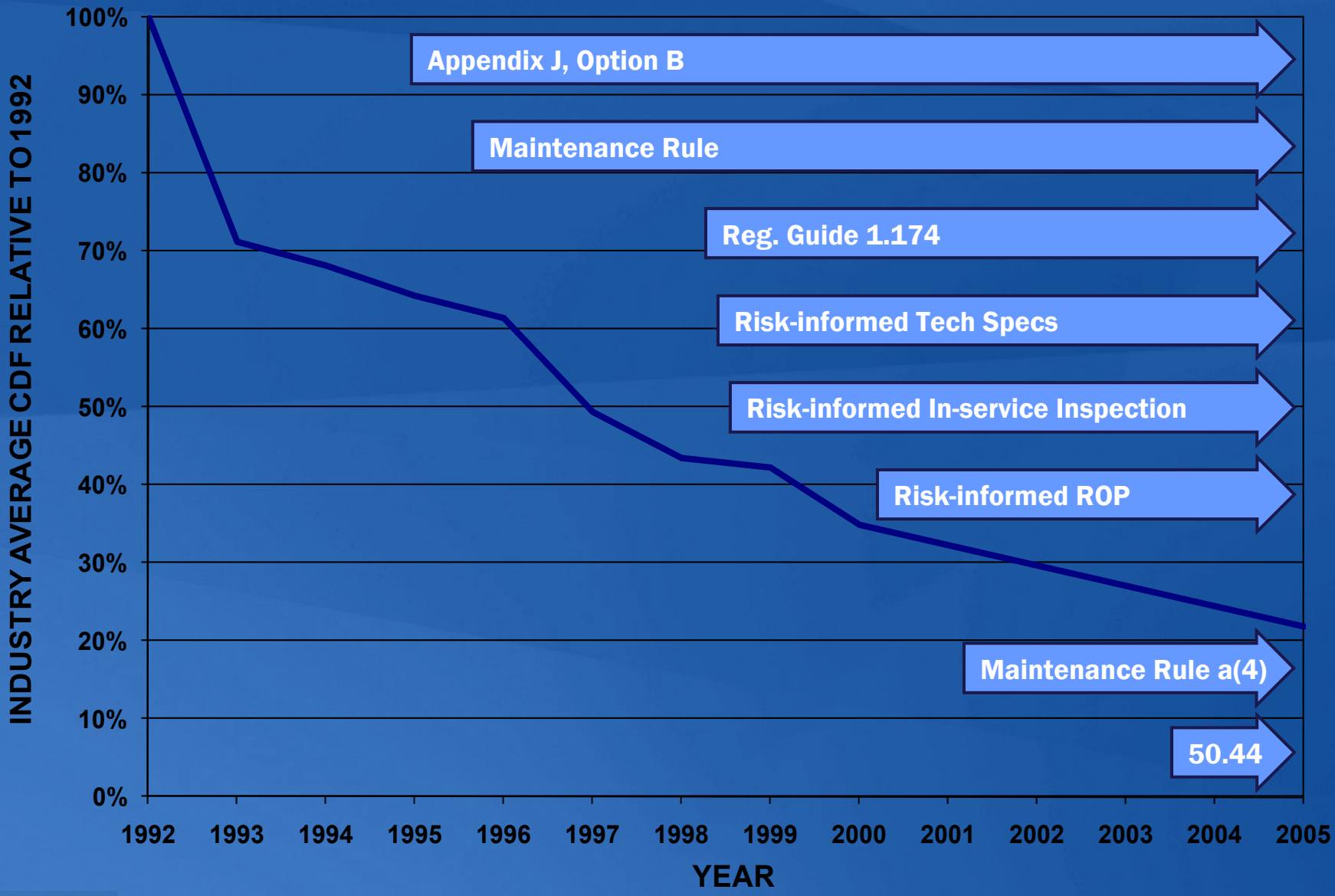
  LERF > 10 * LRF

# NUREG-1150 LERF vs. LRF

| Plant | Estimated LERF (/yr) | Large Release Frequency (/yr) | Conditional Probability of LRF Given LERF |
|---|---|---|---|
| Peach Bottom | 2.27E-06 | 1.0E-09 | 0.04% |
| Surry | 5.29E-06 | 2.0E-07 | 3.8% |
| Grand Gulf | 6.46E-07 | 3.0E-10 | 0.05% |
| Sequoyah | 6.75E-06 | 6.0E-07 | 8.9% |
| Zion | 7.10E-06 | 6.0E-07 | 8.5% |

# Risk Applications at Operating Plants

- RG 1.174 applications have not led to increased CDFs or reduction of margin
  - Changes constrained by other elements of risk informed process (DID, margins, etc)
  - Changes mostly granted in “very small” delta risk region of RG 1.174
  - Risk informed applications have led to improved safety, not reduction of safety


INDUSTRY AVERAGE CDF RELATIVE TO 1992
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
YEAR
Appendix J, Option B
Maintenance Rule
Reg. Guide 1.174
Risk-informed Tech Specs
Risk-informed In-service Inspection
Risk-informed ROP
Maintenance Rule a(4)
50.44

# Risk Metrics in The Operational Phase

- **Commission consistent in maintaining that new reactors would not be measured against a more stringent risk requirement**
- **Reiterating in 2008:**

  ***"... the policy statement* does not state that advanced reactor designs must be safer than the current generation of reactors, but rather that they must provide the same degree of protection of the environment and public health and safety and the common defense and security that is required for current-generation light-water reactors."***

***Policy statement on Advanced Reactor Regulation, October 14, 2008**

# Problems with different or new metrics for Part 52 plants

- **Inconsistent with commission policy**
  - Safety goal policy statement
  - Advanced reactor policy statement
- **New risk metrics would penalize new plants**
  - Limit operational flexibility (maintenance rule, Tech Specs)
  - Subject plants to inspection and enforcement at levels not corresponding to public health and safety
- **New risk metrics would create public perception problems**
  - For example, co-located sites with different thresholds for enforcement actions

NEI

# Problems with different or new metrics for Part 52 plants

- The proposed risk metrics values could be well within PRA uncertainty bands
- Proposed new risk metrics could truncate ability of new plants to use risk applications
- Risk profiles for new reactors are not yet complete
  - Internal events, fire, external events (seismic) and possibly shutdown PRA will be required prior to fuel load

NEI

# Preservation of Safety

- Risk applications contain deterministic backstops and DID considerations
- Part 52 contains comprehensive change control process that addresses severe accident features

# Summary

- Part 52 licensing process and commission policy effective in enhancing new reactor severe accident prevention and mitigation capability
- New reactors should transition to RG 1.174 risk metrics when operating
- Maintains consistent commission policy and rational regulatory framework


# Implementation of Risk Metrics for New Light-Water Reactor Risk-Informed Applications

## Advisory Committee on Reactor Safeguards

Donald A. Dube, NRC, Office of New Reactors (301) 415-1483

**April 3, 2009**

U.S.NRC
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*Protecting People and the Environment*

# Meeting Purpose

**Brief the ACRS regarding the implementation of risk metrics for new light-water reactor risk-informed applications, and identify potential paths forward.**

# Agenda

- Near term and longer term needs
- Background
- Implementation issues
- Options
- Status

# Risk-Informed Initiatives for New Reactors

- In the near term, risk-informed applications have been proposed:
  - Risk-Managed Technical Specifications
    - Risk-informed completion times
    - Surveillance frequency control program
- Longer term initiatives (post-COL) may include:
  - EPRI research program on risk-informed inservice inspection of piping
  - Special treatment requirements (10CFR50.69)

# Background: Risk Metrics for Operating Reactors

- **Core Damage Frequency (CDF) < $10^{-4}$ /yr**
  - **Surrogate for latent cancer fatalities in the Commission's quantitative health objective (QHO)**
- **Large Early Release Frequency (LERF) < $10^{-5}$ /yr**
  - **Surrogate for prompt fatalities in QHO**

# Risk Goals for New Reactors

- Core Damage Frequency (CDF) < $10^{-4}$ /yr
- Large Release Frequency (LRF) < $10^{-6}$ /yr
- A deterministic goal that containment integrity be maintained for approximately 24 hours following the onset of core damage for the more likely severe accident challenges
- Conditional containment failure probability (CCFP) less than approximately 0.1

***SRM on SECY-90-016, 6/26/90***

# Commission's Expectations

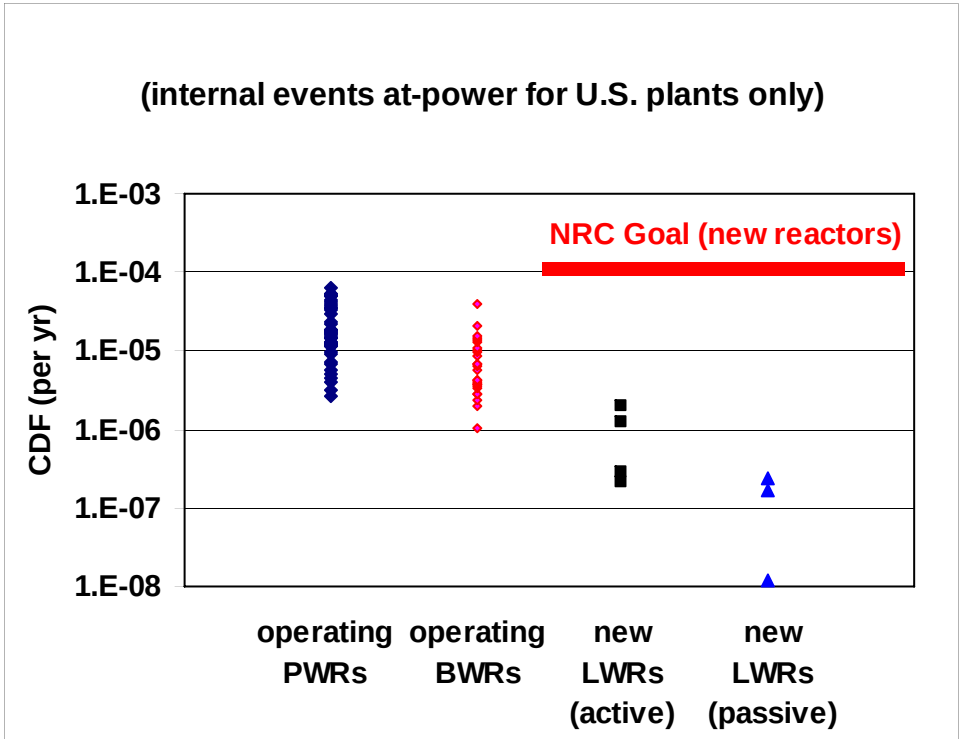
**The Commission "fully expects that vendors engaged in designing new standard (or custom) plants will achieve a higher standard of severe accident safety performance than their prior designs."**

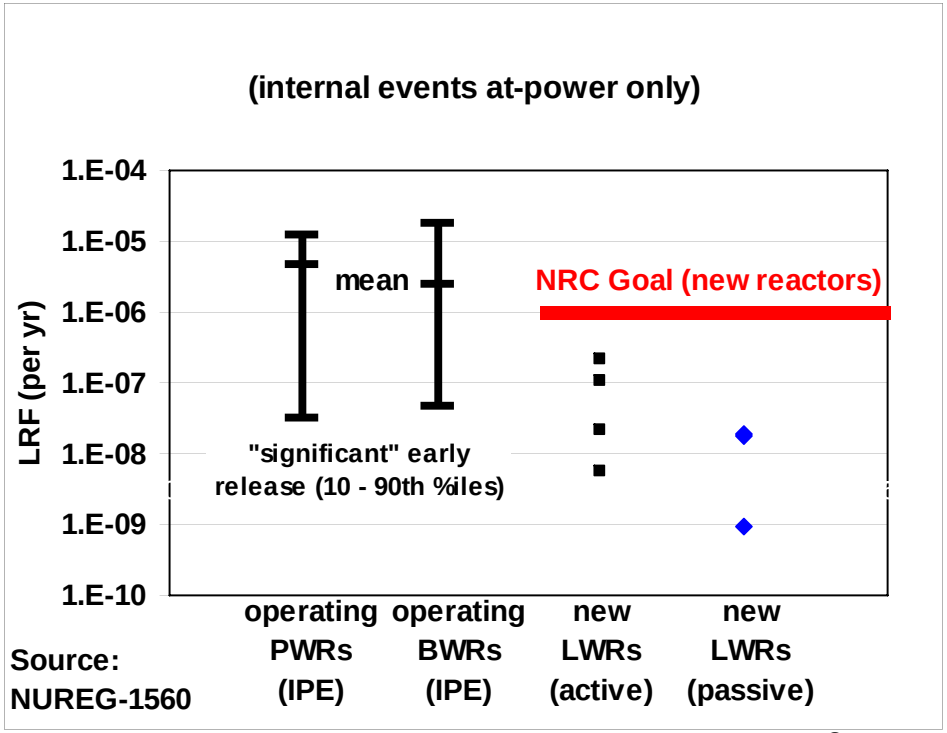
**- August 1985**

**"The Commission expects that advanced reactors will provide enhanced margins of safety and/or utilize simplified, inherent, passive, or other innovative means to accomplish their safety functions."**

**- July 1994**

# CDF and LRF by Plant Type



# Background (cont.)

- New reactor applicants' PRAs are expected to demonstrate how the design compares against the Commission Goals
  - RG 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)"
  - Standard Review Plan (SRP) Chapter 19.0, "Probabilistic Risk Assessment and Severe Accident Evaluation for New Reactors"
- Regulatory guidance associated with risk-informed initiatives are based on LERF (e.g., RG 1.174, 1.175, 1.177, 1.178, 1.201)

# New Reactor Implementation Issues

- Review of these applications has raised questions about risk metric acceptance guidelines for implementation of risk-informed initiatives for new reactors:
  - LERF versus Commission's goal on LRF
  - LRF was not previously finalized in NRC documents.
- Use of current numerical risk metric goals (e.g., LERF) would result in risk-informed applications/amendments being evaluated against less restrictive criteria than those used for the licensing basis of new reactors.

# New Reactor Risk Metrics

- **Licensing:**
  - **How should acceptance guidelines for new reactor license applications or amendments proposing to implement risk-informed initiatives consider Commission's expectations:**
    - **CDF?**
    - **LRF?**
- **Operations:**
  - **Reactor Oversight Process thresholds rely on CDF, ΔCDF, conditional core damage probability (CCDP), incremental CCDP, LERF, ΔLERF, etc.**
  - **How should risk metrics for new reactor operations consider Commission's expectations?**
- **Focus on needs for licensing first**

# Regulatory Guidance

- **Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis"**

- **Risk-Acceptance Guidelines:**
  - **Baseline risk metrics of CDF and LERF**
    **AND**
  - **ΔCDF and ΔLERF due to change**

- **Basis:**
  - **Increases should be limited to small increments**
  - **CDF threshold related to backfit regulatory analysis guidelines**
  - **ΔCDF limit based on *absolute* change and set close to limit of resolution of PRA models**

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# From RG 1.174

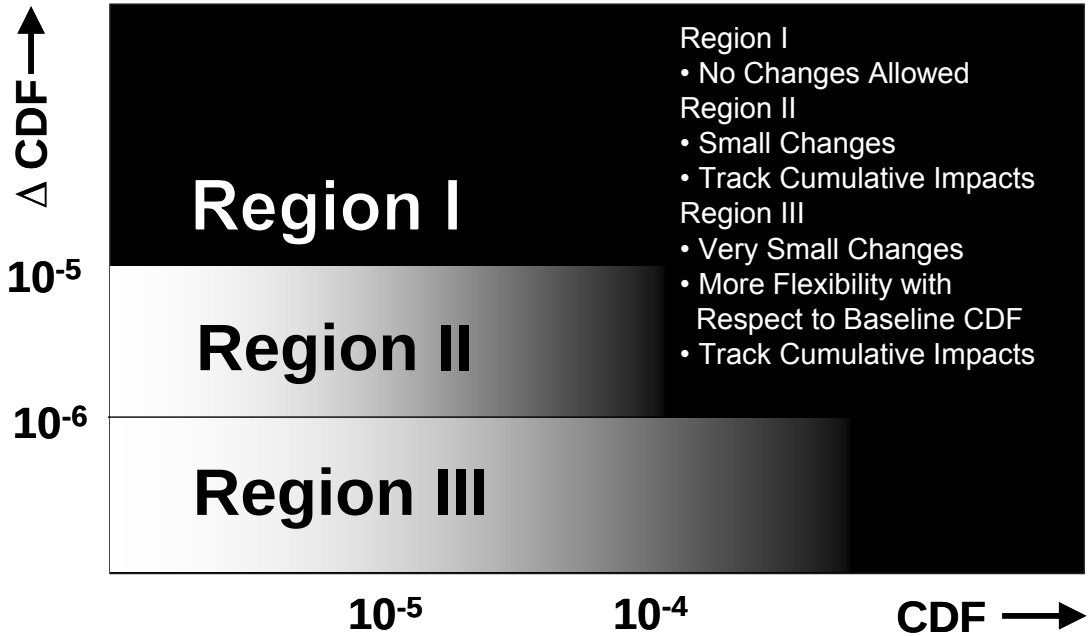


**Figure 3. Acceptance Guidelines for Core Damage Frequency (CDF)**

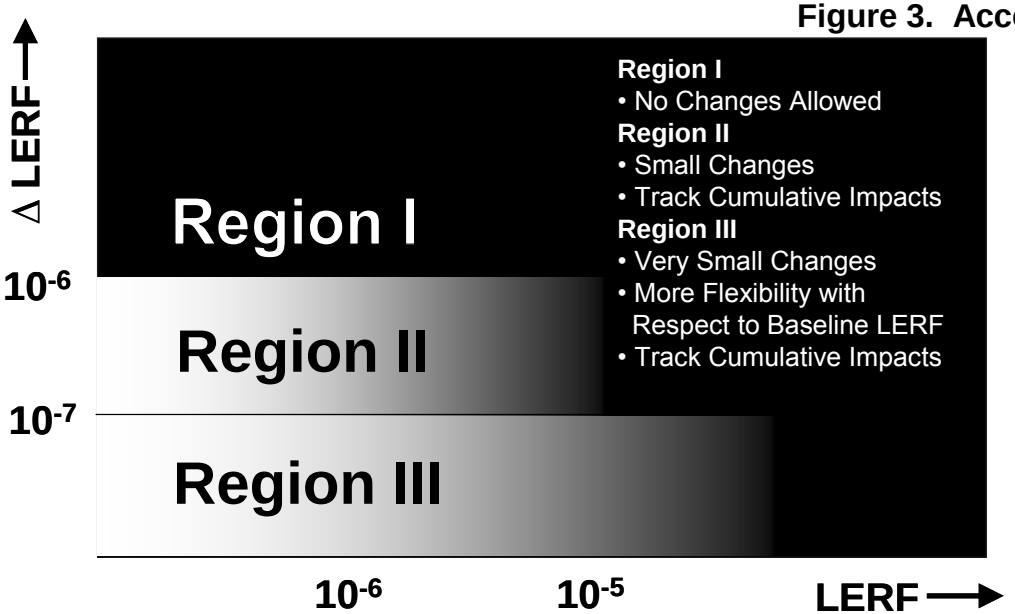


**Figure 4. Acceptance Guidelines for Large Early Release Frequency (LERF)**

# Regulatory Guidance (cont.)

- **For new reactors, should the principle of "small increase" be based on *relative* or *absolute* ΔCDF and ΔLERF or ΔLRF?**

- **Should RG 1.174 include an alternate or additional ΔLRF acceptance guideline for new reactors?**

# Regulatory Guidance (Cont.)

- Other programs, processes, and regulations:
  - Regulatory Guide 1.163, "Performance-Based Containment Leak-Test Program" (specifically, ILRT test interval extension)
  - Regulatory Guide 1.175, "An Approach for Plant-Specific, Risk-Informed Decisionmaking: Inservice Testing"
  - Regulatory Guide 1.177, "An Approach for Plant-Specific, Risk-Informed Decisionmaking: Technical Specifications"
  - Regulatory Guide 1.178, "An Approach for Plant-Specific Risk-Informed Decisionmaking for Inservice Inspection of Piping"
  - Regulatory Guide 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities"
  - Regulatory Guide 1.201, "Guidelines for Categorizing Structures, Systems, and Components in Nuclear Power Plants According to Their Safety Significance," 10CFR50.69
  - 10CFR50.65, "Maintenance Rule"

# Some Possible Options

- **Option 1 Status Quo:** Current acceptance guidelines in RG 1.174 (and associated regulatory guides) would also be applied to new reactors
- **Option 2 Convert to *Relative* Risk Changes:** New and current reactors
- **Option 3 Reduce Acceptance Guidelines for New Reactors:** Acceptance guidelines in RG 1.174 would be lowered by 1 or more orders of magnitude solely for new reactors
- **Option 4 Use a Combination of Existing and New Acceptance Guidelines**
- **Option 5 Use Existing Acceptance Guidelines for Current and New Reactors (*Status Quo*), but Establish an LRF-Based Acceptance Guideline for New Reactors**
- **Option 6 Assess New Reactors on a Case-by-Case Basis**

# Status

- White paper issued (Adams # ML090430220)
- EDO Memorandum to Commissioners, February 12, 2009 (ML090160008)
- Public meeting held February 18, 2009
- Presentation at RIC 2009
- Continued engagement of stakeholders

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# Results of February 18, 2009 Public Meeting

- **Broad representation of stakeholders in attendance**
- **Staff described pending risk-informed applications and implementation issues**
- **Significant discussion on derivation of LRF and CCFP**
- **Advantages and disadvantages of each option discussed**
- **Additional sub-option suggested whereby one might proceed with the current set of risk metrics per RG 1.174 on the first few risk-informed applications, then to assess the need for change based on lessons learned**
- **Industry to follow-up with white papers regarding its views on the historical perspective of *large release* as well as preferred option(s)**

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# Back-up Slides

# Options in Detail

**Option 1 Status Quo**: Current acceptance guidelines in RG 1.174 (and associated regulatory guides) would also be applied to new reactors

**Advantages**

- Provides a consistent set of acceptance guidelines for both existing and new reactors
- The bases for RG 1.174 acceptance guidelines are derived from Commission's 1986 Safety Goals
- Acknowledges and gives credit to new reactors for lower risk estimates

**Disadvantages**

- May not be consistent with Commission 1985 policy statement on expectations that new reactor designs "will achieve a higher standard of severe accident safety performance…."
- Less restrictive change process than the Commission established for the review of new reactors
- Options could allow large ***relative*** increases in CDF and LERF compared to the baseline CDF and LERF estimates for new reactor designs

# Options (cont.)

## Option 2 Convert to *Relative* Risk Changes: New and current reactors

**Advantages**

- Option recognizes that "small increase" is a relative measure and precludes large % change in CDF and/or LERF for new reactors

**Disadvantages**

- Inconsistent with the underlying technical basis for the current *absolute* thresholds in RG 1.174
- Potential disagreement between industry and staff regarding what constitutes the "baseline" for CDF and LERF changes
- Major changes to current regulatory guides and other processes would be required
- Impacts currently operating reactors
- Results in inconsistency between existing and new reactors, and may be viewed as penalizing new reactors for having lower risk estimates
- Transition from existing *absolute* acceptance guidelines to *relative* (% changes) could be difficult
- Depending on the chosen limits for acceptance guidelines, past conditions that were deemed acceptable might not be found acceptable under the new formulation

# Options (cont.)

**Option 3 Reduce Acceptance Guidelines for New Reactors:** Acceptance guidelines in RG 1.174 (and associated regulatory guides) would be lowered by 1 or more orders of magnitude solely for new reactors

**Advantages**

- Acknowledges that new reactor CDF/LERF estimates are significantly lower than existing reactors and adjusts acceptance guidelines accordingly
- Consistent with Commission policy statements on expectations that new reactor designs "will achieve a higher standard of severe accident safety performance…."

**Disadvantages**

- Inconsistent with the underlying technical basis for the current ***absolute*** thresholds in RG 1.174
- Penalizes new reactors for having lower risk estimates
- Results in different treatment for new and current reactors of a proposed licensing basis change resulting in a ΔLERF of $4 \times 10^{-8}$/yr, for example
- May be inconsistent with the Commission's Safety Goal Policy Statement on acceptable level of risk

# Options (cont.)

## Option 4 Use a Combination of Existing and New Acceptance Guidelines

### Advantages

- Option addresses some of the concerns regarding large ***relative*** changes to risk with new reactors
- Consistent with Commission policy statements on expectations that new reactor designs "will achieve a higher standard of severe accident safety performance…."

### Disadvantages

- Inconsistent with the underlying technical basis for the current ***absolute*** thresholds in RG 1.174
- Penalizes new reactors for having lower risk estimates
- Results in different treatment at new and current reactors of a proposed licensing basis change resulting in a ΔLERF of $4x10^{-8}$/yr
- May be inconsistent with the Commission's Safety Goal Policy Statement on acceptable level of risk

# Options (cont.)

## Option 5 Use Existing Acceptance Guidelines for Current and New Reactors (*Status Quo*), but Establish an LRF-Based Acceptance Guideline for New Reactors

**Advantages**

- Option consistent with the goals that the Commission established for the review of new reactors
- Provides a consistent set of acceptance guidelines for both existing and new reactors with regard to ΔCDF
- Consistent with the underlying technical basis for the current absolute thresholds for ΔCDF and ΔLERF in RG 1.174, as modified to reflect Commission policy regarding ΔLRF for new reactors
- Consistent with Commission policy statements on expectations that new reactor designs "will achieve a higher standard of severe accident safety performance…."
- Allows anticipated risk-informed initiatives to move forward

**Disadvantages**

- Options could allow large *relative* increases in CDF and LERF compared to baseline CDF and LERF estimates for new reactors
- Requires significant changes to regulatory guides

# Options (cont.)

## Option 6 Assess New Reactors on a Case-by-Case Basis

### Advantages

- No changes needed to regulatory guides and related documents for current reactors
- Staff could await the accumulation of sufficient new reactor operating experience before making a decision on the treatment of new reactors

### Disadvantages

- Current and new reactors would be treated inconsistently
- New reactor applicants/licensees would not know the acceptance guidelines for risk-informed initiatives
- Defers any decision on the treatment of new reactors