Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Nuclear Waste
187th Meeting

Docket Number: (n/a)

Location: Rockville, Maryland

Date: Wednesday, March 19, 2008

Work Order No.: NRC-2072 Pages 1-116

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

ADVISORY COMMITTEE ON NUCLEAR WASTE AND MATERIALS

(ACNW&M)

+ + + + +

187th MEETING

+ + + + +

VOLUME I

+ + + + +

WEDNESDAY,

MARCH 19, 2008

+ + + + +

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., Dr. Michael T. Ryan, Chairman, presiding.

MEMBERS PRESENT:

MICHAEL T. RYAN, Chairman
ALLEN G. CROFF, Vice Chairman
JAMES H. CLARKE, Member
RUTH F. WEINER, Member

NRC STAFF PRESENT:

CHRISTOPHER BROWN
LARRY CAMPBELL
NEIL COLEMAN
ANTONIO DIAS
ED HACKETT
LATIF HAMDAN
NATHAN SIU
DEREK WIDMAYER

ALSO PRESENT:

ANDREW BARTO
*CARLYN GREEN
*JUDITH JOHNSRUD
CECIL PARKS
MERAJ RAHIMI
EVERETT REDMOND

*(PRESENT VIA TELECONFERENCE)

TABLE OF CONTENTS

PAGE

PROCEEDINGS

(8:27 a.m.)

CHAIRMAN RYAN: The meeting will come to order.

This is the second day of the 187th meeting of the Advisory Committee on Nuclear Waste and Materials.

During today's meeting the Committee will consider the following: use of burn-up credit for licensing spent fuel transportation casks and discussion of ACNW&M letter.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act.

Chris Brown is the designated federal official for today's session.

We received no written comments or requests for time to make oral statements from members of the public regarding today's session. If anyone wishes to address the Committee, please make your wishes known to one of the Committee staff.

It is requested that the speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume so that they can be readily heard.

It is also requested that your cell phones or pagers, that you kindly turn them off at this time.

Thank you very much.

Feedback forms are available at the back of the room for anybody who would like to provide us with his or her comments about this meeting.

I'll turn the meeting over to our Congressman member for this session, Dr. Ruth Weiner.

Dr. Weiner.

DR. WEINER: Thank you, Mr. Chairman.

And if we have anyone on the bridge line, could you please identify yourselves right now?

MS. GREEN: Carlyn Green with U.S. Consulting Company.

DR. WEINER: Thank you very much.

CHAIRMAN RYAN: Was there a second party on the line?

DR. WEINER: That second party was us.

We have today with us a distinguished guest from Oak Ridge National Laboratory, Cecil Parks, who will be discussing burn-up credit. The other members who are here are who will be making presentations are Meraj Rahimi and Drew Barto from SFST, and I call on Ed Hackett to introduce our speakers and open the presentation.

MR. HACKETT: Very good. Thank you, Ruth.

And we're glad to be here. I feel I have to comment in advance. I feel like I'm on the bridge of the Starship Enterprise here since I don't think we've had the privilege of briefing the Committee since you've got your new high tech screens here. So it's pretty impressive.

Anyway, as Ruth said, I'm Ed Hackett. I'm Deputy Director for the Spent Fuel Storage and Transport Division in NMSS.

And in short overview, why are we here, we had a Commission SRM following your meeting, the Committee's meeting, with the Commission, and I'll just read you from the SRM. They said at an appropriate point in their review of burn-up credit staff should consult with the Committee and report to the Commission on whether there are other sources of fuel burn-up date other than the French data, and if there are alternative ways of getting at the same fundamental parameters, was our tasking from the Commission.

So to that end, that's formally why we are here. Also to that end, the staff convened an internal burn-up credit workshop in February of this year, including representatives from a lot of the offices that are here with us today, SFST, the Office of Research which has an important role in this regard relative to execution of the research program at Oak Ridge and other locations, representatives from NRR, and of course, the Oak Ridge National Laboratory.

Two ACNW&M members were also available to observe those proceedings.

I think we made significant progress in that workshop relative to the Commission tasking, and that's what the staff will be here primarily to report on today.

I will also mention that we're aware that the industry is working on developing a position paper on this topic and the use of burn-up credit, and we're working closely with them in that regard also.

Following your deliberations here, we are requesting a letter from the Committee regarding your views and your recommendations in this area.

And lastly, I'll say we're also aware obviously that this is likely to be our last formal briefing before the Committee, and speaking for SFST, I wanted to compliment the Committee and thank you for many past productive interactions. We'll be looking forward to a continuation of our interactions under different auspices, I guess. My understanding we'll be under the auspices of the ACRS.

So, again, thank you for many past productive interactions.

With that, as Ruth said, I'll go ahead and introduce the staff. From the staff we have Meraj Rahimi, who will open the meeting and Drew Barto from the SFST staff, and as Ruth noted, Dr. Cecil Parks from Oak Ridge.

And that ends my opening remarks. I'll turn to Meraj.

MR. RAHIMI: Ed. Thank you, Ruth.

Good morning. This morning we're going to talk about the --

CHAIRMAN RYAN: Someone joined.

DR. WEINER: We have someone on the bridge line. Could you introduce yourself, please?

DR. JOHNSRUD: This is Judith Johnsrud.

DR. WEINER: Thank you, Dr. Johnsrud.

Go ahead, Meraj.

MR. RAHIMI: This morning I'm going to talk about the use of burn-up credits for design of criticality safety systems. In PWR spent nuclear fuel casks, I'm using the term "casks" generically to refer to both from the licensing term "transportation packing." That's a licensing term that we use for transportation casks. So when I use the word "casks" or "storage casks" in transportation packaging.

The agenda for today, I'll go ahead and give you a brief background, you know, more on the terminologies to make sure everybody is on the same page. I'll talk about briefly criticality safety analysis sequence for spent fuel pools' racks, which these days these racks are high density racks or burn-up credit racks because early '80s, you know, all the reactors started going from low density to high density racks, which really these are burn-up credit racks.

Now we'll talk about the criticality safety analysis sequence briefly for spent fuel cask and try to make a comparison within the two types of analyses.

Cecil will go into detail about the validations of these analysis, which really that's one of the main points of these presentations, you know, about the validation of computer codes, diffusion codes, criticality analysis codes.

Followed by Drew. Drew will do a brief overview of criticality risk in cask and how we're planning, you know, to use that risk to go back and look at some of our criterion assumptions.

Background. Burn-up is the -- really, let's define burn-up, how we definite burn-up in burn-up credit analysis. Burn-up is the amount of energy released from a fuel assembly in the reactor core, which is in the units what we call the megawatt-days per metric tons of initial uranium. That's the unit that we associated with the burn-up of the fuel, and always the burn-up results in the overall reduction of the fuel assembly reactivity.

On the reactor side, in order to maintain the critical condition, actually burn-up as the reactor operates, burn-up becomes sort of a liability in terms of maintaining critical condition for power. So as the result of the burn-up of the fuel, it is being compensated by the reduction in the boron concentration normally, and eventually when you go all the way through zero ppm, you will have to refuel.

So it is a fuel assembly losing its reactivity as a function of burn-up.

Now, we come to the goals. The goal is for the spent fuel pools to maintain subcriticality condition. We don't want critical condition. So in that case actually burn-up becomes an asset, and since it becomes an asset, that's why we call it burn-up credit, and it is used as part of the criticality safety control system for the racks or for the casks in addition to the poison plates that are use.

Now, to predict a critical condition in the reactor pool, subcritical conditions for the pools or casks, the computer codes, they need to be validated or benchmarked or calibrated. You've got to sort of demonstrate, indeed, that you have a good tool, that your codes can really predict the separate k-effective or critical k-effective in the reactor core came out very well.

And for the reactor cores, which is a very controlled environment, computer codes are validated, you know, over time. Every time you shut down the reactor, you know, and you want to bring it back on line, you predict with your code, okay, what is a critical boron concentration.

You bring it on line. Indeed, you do a comparison and see how your code predicted, and over time it improves your code to do that prediction. So on the reactor side, we have that constant feedback that really you sharpen your tool so that you have that advantage.

This is a very controlled environment as well, and we come to the spent fuel pools, that there are some controls in the pools, you know. It's not like, you know, reactor core. Control rods go on concentration. You do have, you know, heavy boron concentration that is used as really defense-in-depth, and the computer codes are also validated, but you don't have that constant feedback, but instead you have that heavy boron concentration, that you have a really big safety margin in there, you know, that you use a defense-in-depth.

Just briefly I want to say what are the regulations for spent fuel pool burn-up credit racks because that kind of help transition to the cask. The requirements for the spent fuel burn-up credit racks, general design criteria under 10 CFR 50, it says that prevention criticality jurisdiction, hammering, and specifically you go to 50.68 where you see that the requirements are spelled out.

And if the credit is taken, the regulation allows for the rack designers with the licensee, if they want to take credit for some of the boron in the pool, they have to maintain subcriticality below .95.

However, if they want to take credit but they have to demonstrate that without boron, and that requirement really simulates the boron dilutions -- we have in reactors a possible boron dilution scenario -- that the requirement should be you have to be subcritical, below one, without any boron in there.

Normally there are about 2,000 ppm boron in the pool. So it's part of the demonstration that you have to show that you're still below one without any boron, but of course, you always recognize, you know, the fact there is a significant amount of boron in the core.

This is a very sort of simple analysis sequence for the burn-up credit racks of the spent fuel pools. I mean, the spent fuel pools, the racks, in early years they loaded the rack. They used to assume fresh fuel, but you know, in the '80s, because of the need for additional storage in the pool, they were to -- the burn-up credit records, and now the analysis sequence is that you do your depletion calculations using fresh fuel, using the fresh fuel. You put the fresh fuel in the depletion code, and you do your depletion analysis, and then all of your isotopics, they feed into the subcritical code or the T-newt code or the CNP code. You do what we call a criticality analysis. In this case we're trying, you know, to be subcritical. So subcriticality analysis, then you construct a loading curve as a function of burn-up, and you load your racks.

Now, as part of the benchmarks, as you

see, they do two sets of benchmarks, one in the depletion side, and on the depletion side, the implementation of that requirement that I showed in terms of criteria, they say, well, you know, all we can do, you can assume there is a bias associated with your depletion analysis. That bias is about five percent reactivity decrement.

And what that translates is about one and a half percent delta k. This is what the staff of NRR over the years, this is what they have come up with based on the experience they have, that this is adequate, this bias, to account -- this quantity is adequate to account for any biases, uncertainty that there are on the depletion side.

Now, also, on the criticality analysis side of the codes, they assume that they report for the licensee to run a set of benchmarks. These are the fresh pool critical benchmarks in order to have a good idea, indeed, the code works well and if they have adequate bias in there. Again, all of those are spent fuel, but given really the pool is always under about, you know, 2,000 ppm all the time, I mean, this is more like risk informed, that this belief this is appropriate and adequate, what is done on the pool side.

So this is kind of a very simplistic view of how the critical analysis sequence for the burn-up credit racks.

Now we move to the casks. Now, for casks, we've got the storage cask. We've got the transportation cask. Right now for storage cask, we allow the licensee to really rely on the boron in the pool as the primary criticality safety -- one of the primary criticality safety controls because they are in play in most of them. We have the plates in the cask, but boron in the pools is used as the, you know, primary criticality control, and the burn-up as associated with fuel, it's kind of used an unquantified safety margin.

So when it comes to the storage cask during loading in the pool, and of course, once they load it, they put it out on the storage pads, and there is no credible event that would introduce water into the storage cask sitting on the pad.

That's how it's done for the storage cask.

Now, for the transportation cask, which is different than storage cask, different than the burn-up credit racks, these are the casks that are on public highways, public roads, railroads. So it's going to be in an environment that there is no control. So everything is passive. Everything, I mean the whole safety system.

So the idea is less control. The regulation calls that you should assume that there is fresh water in the cask as a design basis, and also another thing with the transportation cask, now since we're talking about a different environment, so we need to be a little bit sharper. We need to sharpen our pencils in terms of we have to have that high degree of confidence in predicting the subcriticality value, the k-effective.

Regulation, or course, you have transportation casks and that says what I just said, that you have to assume as a design basis, you know, that the cask is flooded with fresh water, and that accomplishes really possible events during transport, loading, unloading, all of the events. Because once we certify this cask, it is a generic certification. It is not a site specific for transportation cask.

And also there is another requirement under 83, 71.83. Last how we used to do it, it says that if there are uncertainties or other isotopic content of the fuel, spent fuel, you have to assume the most, you know, reactive condition, assuming fresh fuel, and that's how it used to be really in the past because the cask vendors didn't need, you know, the burn-up credit because what was driving the cask design, it was heat, radiation, because they were designing for young fuel, for newer fuel.

But now, we know moving to the older and colder fuel, which heat and radiation is no longer the driving design parameter, it's more criticality. So they need whatever space they need inside the cask to use in order to increase their payload.

So now criticality has become the driving design parameter, and that's why, you know, they want to quantify, okay, these uncertainties. They can take credit for the fact that the spent fuel assemblies, they have less reactivity associated with them as opposed to the fresh fuel.

This is how the fresh fuel analysis used to be for the cask, you know, the vendor. Assume the poor criticality, but the fuel was fresh because that's the most conservative assumption you can make, you know, with respect to criticality.

Assume fresh fuel. They put it directly -- they modeled it in the 3D code, the Monte Carlo code, MCNP t-newt code. These are the Monte Carlo codes, and they ran subcriticality, and what was basically recorded as part of the benchmark was only this part because the assumption was fresh fuel. So the only benchmark they needed to do to benchmark, the cross-section for the fresh fuel because that's how they announced it. No one was asking that because they made conservative assumption.

CHAIRMAN RYAN: How conservative?

MR. RAHIMI: Conservative. If you assume that that is fresh fuel, they calculated fresh fuel. They design for .95 actually, but if you take the burn-up credit, it would be .65.

CHAIRMAN RYAN: Conservatism.

MR. RAHIMI: That's right. It 30 percent. You know, they have margin in there. So we didn't really need to ask for the other stuff.

Now we come to the burn-up credit cask now. As you can see now similarities within the burn-up credit racks and casks, and what I've highlighted here are the additional boxes that sequence for the burn-up credit racks.

Now, why do you report this? Because we go back, that these are the transportation casks. This is our practice, and we have to really know, sharpen our pencil, as opposed to a pool which they have really a lot of margin in their 2,000 ppm, although the analysis they have done was for zero ppm, but it is always, you know, you have that knowledge that in reality the pool has got boron.

So for the burn-up credit analysis sequence now, the task, you know, what racks, you can start with the fresh fuel. You run your depletion analysis, and you put in the isotopic constitution, the criticality analysis. You put loading, the loading curve, and you load the cask.

So the first thing that is different from the racks, burn-up credit racks, as you can see now is the fresh water environment here. We can't assume there is boron, and then on the depletion analysis, the benchmarking, the calibration of this part of the depletion code, we require the isotopic, isotope-by-isotope benchmarking. That's another thing that is different.

And based on that, you derive whatever biases and synergies are that feeds into your decision analysis. Under subcriticality analysis, in addition to the fresh fuel, the staff, SFST, you know, their criteria is, well, you need all of this, again, fresh water environment we are in. You had better also look at the other benchmarks because, after all, you're assuming spent fuel. You are no longer fresh fuel, and we need to know how good your cross-sections are for plutonium, for fission products.

Before you didn't need to do that because you were assuming fresh fuel assumption. It was conservative, plenty of margins.

So these are the additional benchmarks that they need to do in order really to have a good handle on the biases and uncertainties associated with the cross-sections of any isotopes, actinides and fission products.

And also in addition, there's another yellow box here on the SFST. The staff requires the licensee to do some type of verification prior to loading the fuel in the cask to prevent any issue.

Again, because of the environmental difference, we want to have high confidence, indeed. You know, if it's out on the public highway, water, you know, enters into the cask, it remains, indeed, subcritical according to the prediction, and there are no misloads.

So this is the sort of sequence for the burn-up credit cask, and Cecil next is really going to focus on these boxes and why we require these additional benchmarks.

MR. HACKETT: Meraj, if I could, I wanted to make a comment before you guys transition. This is

Ed Hackett, SFST.

The theme here, and I think Meraj got to it, is of course we're aware that there are nested conservatisms, as the Chairman noted, in this process, and the big focus of our burn-up credit workshop was to look at operating on those conservatisms and seeing where we might be able to come up with alternate approaches or potentially in light of having some additional data or other knowledge could we make a dent in those.

So there's a theme there that I wanted to make sure that we had that focus before we transition to Cecil's presentation.

Thank you.

CHAIRMAN RYAN: That's helpful. I hear a difference between .65 and .95 as k-effective. That's a huge difference in criticality risk. It's not a small one. It's a huge one. So I'm interested in how you've explored that in a risk-informed way, as opposed to making conservative assumptions and just accepting the fact they're okay.

MR. HACKETT: Good point. I'd make one further comment in that regard. As Meraj has mentioned, of course we're currently constrained by the regs. which are deterministic and conservative, as we know. That's not to preclude us from going down a risk-informed path which might eventually lead to rulemaking in this area. That's obviously premature at this point, but --

CHAIRMAN RYAN: Or more importantly, insight as to what it means to say, "I've made a conservative assumption." I mean way far away from any risk, are you relatively close to it or where are you on that?

MR. HACKETT: Exactly.

CHAIRMAN RYAN: Because we make bounding type analyses very conservatively, you don't know where you are relative to the risk.

MR. HACKETT: Right. Good point.

CHAIRMAN RYAN: That's what we're looking to get an insight into, or at least I am.

DR. WEINER: Okay. Go ahead.

MR. RAHIMI: I should stress now that the conservative that we talked about, we lost that now with the burn-up credit. When we enter into the burn-up credit area, we no longer got fresh fuel assumption that big .3 k-effective we were talking about. So, you know, the approach is to take away that and use all of that margin. That's really --

CHAIRMAN RYAN: What's going to be helpful to us is to hear the details and the analytic information about how different you are from that case and have you given up all that .3 or half of it or one percent of it or where are you.

MR. RAHIMI: Okay.

DR. WEINER: Go ahead.

MR. PARKS: I'll talk a little bit about the validation data for PWR. I'm going to focus on pressurized water reactors. That's where burn-up credit has been needed and desired over the years, and this is something that has been investigated for a number of years, and so we'll try to give a little bit of background there as I go through it.

What I'm basically going to cover is why and how validation is done, and then sort of shift to what needs to be validated relative to what we're talking about today, transportation packages with spent fuel, and then what those data sources are for the burn-up credit validation, you know, where we've looked for data, what data has been found, and how that is applicable to the areas of interest that we're discussing.

If I go to fast, just slow me down, but I plan to sort of go through this and kind of hit the highlights of the things as I move through.

The first thing I guess I wanted to say is that the software validation that is done under Part 71 is consistent with the well established standards that are both domestic and internationally held for criticality safety outside of reactors. There's three ANSI standards that are consistent in what they put down as requirements for validation: to look at both applicability of the experiments and to cover the range of energy and materials that are in the systems, and there's ISO standards, too, which are consistent with those ANSI standards.

The standards all require comparison of predicted versus experimental data to obtain basically a bias and bias uncertainty. The goal in all of this checking with experimental data is to come up with an acceptance criteria, and I'll show this in a minute, below which you assume if I calculate below this value, then I am, indeed, subcritical for my system.

The ability to demonstrate confidence in the predicted margin of subcriticality is really the focus of what an applicant or the owner of a system, however you define that, is to demonstrate, and the standards indicate it's their responsibility to demonstrate the validation of their codes and data and how they use them for their system that they're responsible for.

And again, we're looking at credible events, not events that are incredible or not reasonable, although I agree there have been, as you mentioned earlier, Dr. Ryan, some bounding cases that are deemed to be unreasonable when they can't define what credible is, but the standards do call for looking at credible events.

Again, if you have a large margin of K-effective predicted, going back to what we talked about earlier, Raj mentioned if you have fresh fuel and you know you have spent fuel in the package, there's about a 30 percent margin there we just talked about, and so the validation can probably be relaxed quite a bit.

You know, real systems are now at .95, but the safety assumption has been up at -- excuse me. The real system may be at .65, but the safety assumption of fresh fuel pushes it to .95, a lot of conservatism. So the need for a lot of validation may be relaxed.

Another comment is down at the bottom of that viewgraph is that crediting contributors to margin without some adequate validation of their contribution is contrary basically to safety practice.

It sort of impacts your confidence in the ability to assure subcriticality. It gets back to what you mentioned earlier also, that you need to understand your margin before you can start understanding how conservative you are.

This gives you a little bit of what's a typical practice currently in the industry. This is actually a very old slide. So it is illustrating an example, but you gain the confidence, as I mentioned. The criticality is in calculating k-effective. K-effective equal to one would be critical. You gain that by comparing your software to critical experiments.

So this slide shows a number of critical experiments. This is a comparison of predicted versus what the actual critical experiment should have been. A one, you see examples were calculated above and below one. The error bars are very large. This is an old slide, just to illustrate there are some statistical errors with the Monte Carlo calculation, and these are very large compared to what we've seen.

And what we do now, we run analyses that the error bars would be smaller than those points. But you get a range of data, and you see basically from a statistical standpoint you can predict. If I predict one more critical experiment that's actually critical, I'd have a nice option in confidence (phonetic) that that first line, the dashed first dashed line, I'd have nice option in confidence that a single figure calculation would be above that line.

Now, if I want to, again, statistically look at a population and did, say, 1,000 more critical experiments, I can, again, statistically come up with a line that says that 999 of the ones I predict will be above that line. So you can get confidence bands on what you want to look at, and this is sometimes up to the reviewer and the applicant both to determine how much confidence they want in their calculations, but again, you compare the critical experiments.

The other thing with the slide I'd like to point out is that the comparison to critical experiments can change with energy, you know, the mixture of importance or the system of importance. How well the codes and data predict that system can change with energy, and that's what's applied basically on the X axis.

And so there is a desire to make sure that the critical experiments you choose are within the same energy band of the actual system of interest. So a simple example would be fast reactors versus thermal reactors. There's a very different energy spectrum of interest.

Similarly, you can do the same as Meraj talked about for the compositions. For instance, additional complexity to the criticality in which you have to predict the radiation of the reactor; you have to predict the composition of the spent fuel. There is a lot of irradiated -- there's a lot of destructive assay data that has been collected over the years for different programs, and this is an illustrative diagram showing about comparison against samples from five different reactors, and you can see based on the spectrum of isotopes -- and these are largely isotopes of interest to burn-up credit, both the actinides and over on the right the fission products.

You know, the number of samples you can see are sort of small with the ones that are outside the major actinides, but also you can do the same type of information. You can get a statistical range of how well you predict against these destructive assays, and some of the cases here, the uncertainties are in the actual assay measurements themselves, but that's factored in.

So what is it that we are interested in? We're interested in a transportation package. What's happening in the U.S. industry is there really is not a fleet of transportation packages available. In other countries, Japan and Europe, there are fleets of transportation packages, and they're designed sort of like the one on your left. This is the Holtec 24 design, which sort of demonstrates the small separation between the assemblies. That water gap allows the neutrons to slow down. So the boron plates are much more effective in controlling reactivity.

However, the penalty for that is you spread your fuel assemblies out and you nominally get 24 assemblies in a rail package. So as we talked earlier, historically this was fine because you would use fresh fuel assumption. You know, the package designs were driven by limits on heat, limits on dose.

As this became not true, as we look at the five-year cooling time requirement for things to ship to the repository, criticality became the limiting criteria because now a high density package over on the right-hand side, you basically lose that -- the boron plates are no longer quite as effective because you've lost that water between them to slow down the neutrons, but now you've got 32 assemblies in a package, and criticality does become the limiting factor.

If you do this with fresh fuel, you will have difficulty meeting the margin, the criteria that has been used.

And the validation should consider both applicability to the materials of interest and the system of concern. So in this case, as Meraj mentioned earlier, you have uranium, plutonium, some minor actinides and fission products all in the fuel, you know, boron in the absorber plates. You have a reflector region on the outside. So these are the kinds of things you should be looking for when you're looking for your validation.

I'll show another slide a little later. This is a slide just demonstrating that the k-effective and the nuclides are important and will change with cooling time. You know, so what's in the reactor and what happens outside the reactor is different. This covers a very large time frame here. The cooling time is logarithmic scale, and so you can see basically the area of interest for transportation is five years, which is shown here out to about 200 years. I mean, that's what has been used in a lot of the work we've done for research in terms of thinking about time frames of interest for interim storage and transportation. It's about 200 years. So you can see there's quite a bit of change down in k-effective.

So you can see on the blue curve, the top curve, it's actinide only. That's taking credits for the actinides that are in the spent fuel.

The next curve down is actinides in fission products, and you see about roughly for conversation here about a six or seven percent delta k between actinide only and fission products, and that's predicted. There's not validation on that. It's just that we predict with our codes.

And then the red curve at the very bottom is sort of a best estimate assuming all of the isotopes we believe to be or that are in spent fuel, and we calculate with the codes assuming all of the isotopes.

This is in a spent fuel package, in a cask load with fuel having four weight percent initial enrichment and 40 GWd.

Move to the next viewgraph. It's a little bit different look at this. This goes back, I think, to what you were saying a second ago, Dr. Ryan, about understanding how much credit is available and how much has been removed from the fresh fuel assumption.

You can see at the top fresh fuel assumption. This is, again, in a package. You can see the Y axis indicates it's in this generic burn-up credit cask, high density package, and the X axis is burn-up.

And so you see at the top the dashed line indicates if we use fresh fuel in this package, we'd have a k-effective to predict it around 1.14, a little less than 1.15 k-effective, and as you note with burn-up, the red curve shows major actinides. The k-effective goes down significantly, and we see, you know, at 40 GWd about a decrease of about 25 -- about 20 delta k.

And this is significant credit that has already been provided through the ISG 8 recommendations. There's a lot of work done, research support at SFST to develop a technical basis for ISG 8, Rev. 2, and this is basically the credit that's given or the credit that's recommended to be given in the regulatory guidance that has been issued.

So what's remaining on the lower curve is the delta k between the actinide only and fission products, and one can look at this in one way, sort of taking one position and say, well, that's not very much. You've already given a lot with the actinides. Why do you want this fission product credit? It's, you know, six percent that we discussed earlier.

Well, this is why there's such interest in -- oh, excuse me. Move to that first off. These are the numbers associated with that previous viewgraph, and these numbers are just with the four weigh percent, 40 GWD curve, and so it shows you, again, fresh fuel or about 1.14. You take the major actinides. You lose about 20 percent in delta k. You see the second row over. You get all of the actinides, I guess, about another one percent, you know.

CHAIRMAN RYAN: So you may get to this, but let me ask it anyway. You've talked about major fission products, and I obviously understand that the contribution that fission products would make are dependent on the half-lives of the fission products.

MR. PARKS: Right.

CHAIRMAN RYAN: Are you going to cover how that varies over time or what a major fission product is and discuss that a little bit?

MR. PARKS: I guess let me try to answer that now. That's a good question. In terms of what we're looking for is the stable fission products, the ones that won't change in time. Most of the fission products will have very short half-lives and go away within the five to 20-year half-life, but what we're looking for is those fission products that will build in and will be there throughout the time interest.

There is one that is considered. The Samarium 151 has about a 90-year half-life, and that is the only one that has, although others are stable.

CHAIRMAN RYAN: So I guess the reason I'm asking this is that's an interesting point. Those are the kind of ones that will be there in a long-term storage situation.

MR. PARKS: Right, right, right.

CHAIRMAN RYAN: But for the short term, there's also a margin in the shorter lived fission products that can contribute to burn-up credit during the period of, say, zero to ten years or during the period of transport you could actually calculate it for a given shipment.

MR. PARKS: There is some -- can you reverse this?

In this viewgraph right here, you'll see actually that. You'll see, for example, that middle box on the left. That curve there, that steep curve there at around five years -- I call it "steep." It's the largest on the plot -- that decrease in reactivity is due to the decay of Plutonium 241, and in the build-up of the gadolinium from the europium, which has a half-life of about 4.7 years.

CHAIRMAN RYAN: Okay.

MR. PARKS: So those kind of things have been considered. You start looking at less than five years. As you see, this red curve down here is short-lived fission products go away very quickly. They give you a lot of credit when you're pulled out of the reactor, but as xenon and kryptons go away, the reactivity shoots up.

And, again, as you move to a longer time frames, and of course, transportation, it depends on how long it's going to be on the storage pad, and the 200 years was chosen by the PERT panel the Research put together several years ago as being a reasonable five times 40, the life of a -- I guess it's more than that -- the life of a storage cask on the pad would be an expense.

So that's why it's looked at from five to 200 years. I haven't quite answered your question, but the goal was that you use stable fission products, which would be around during the time frame.

CHAIRMAN RYAN: So you're not trying to take credit for something that is going to vary fairly dynamically over shorter periods of time. I appreciate that. That's that great insight. I appreciate it.

MR. PARKS: I've covered this. These are the six key fission products on the left, and you can see in the red line you get about five percent in this particular case, delta k, and from a percent delta k standpoint, you see very quickly you get 72 percent from the major actinides. The 90 percent comes from the major actinides in the six key fission products, 72 plus 18. So you get about 90 percent there.

Now, the breakdown of the worth of the six key fission products, why they're important, you see they quickly die off. Four of them have importance of around 15 to 30 percent, and then the last two, cesium and gadolinium, are about half that.

Now, you know, all of the other fission products that at least with transportation really have not been considered in terms of moving forward for what we've been doing for research. There's about six percent there.

So this just gives you the numbers if you take the four and the line on that previous viewgraph.

So why is that six percent so important? Why are these fission products very important? Well, they're very important because this is a loading curve, which I think the Committee has seen before.

So I'll give a brief reminder of what it is.

This provides the criteria, again, for a package to be loaded, and you see on the Y axis it's basically the fuel burn-up, and on the X axis is the enrichment, and the goal is to draw a line where if I have -- I can't see -- if you have three percent fuel on the X axis, it's going to take a 40 GWd burn-up to be loaded, to be acceptable, at least 40 GWd to be acceptable based on that first curve.

So everything to the left of the curve is acceptable. Everything to the right of the curve is unacceptable for loading.

And these loading curves represent a constant value of -- in this particular case what we've done here, this is illustrative, but in this particular case, this is .94. We use .94 for administrative margin for our bias and uncertainty. So this is what this is, a constant k-effective value.

So if you take the ISG8r2, the current recommendation from the staff, if you use the process that's in that sort of the way we assume it, you know, we were a little bounding in how we did that. You will come out with a curve, this left curve, and it basically indicates you can ship about ten percent of the fuel in one of those high density packages.

Of course, this is not desirable in terms of being able to take advantage of these high density packages.

CHAIRMAN RYAN: What's "a little bounding"?

MR. PARKS: I'm sorry?

CHAIRMAN RYAN: You said you were out a little bounding in that estimate. What does that mean?

MR. PARKS: Well, I will discuss that. Basically there is -- basically you can take individual for the assay data. You can take each individual nuclide, like said U-235, how we predict the fat or the plutonium, and you take each one and create what you call isotopic correction factors, and that's actually what this ICF stands for in this label right here.

If you take each set and do that independently, you sort of end up getting conservative answers. If you take the whole set and do a best estimate, looking at the whole set of the nuclides, you get a better improvement, and that's really what the second curve is here.

If we use best estimate approaches for predicting bias and uncertainty, the curve shifts from that first curve to the second curve.

CHAIRMAN RYAN: The green one.

MR. PARKS: The green one, yeah.

CHAIRMAN RYAN: And what would the result be in terms of --

MR. PARKS: If you look down below, you get about 16 or 17 percent acceptable. Is that what you were asking?

CHAIRMAN RYAN: Yeah.

MR. PARKS: So the third curve is the red curve, and that's the curve that says, okay, I've used best estimate for the actinides. I've used best estimate, but now I want to get some fission product credit. So the way we've done the red curve is we've said I'm going to pretend that I've got my critical experiments that I want for fission products, and I've got a bias that is probably, you know, I mean, we hope will be reasonable, consistent with what we see for actinides. Again, it gets that .94, and so we get a red curve here that shifts it over to about 670 percent.

Now, one thing that has been done, if you look down at the bottom on the third curve, we used the best estimate for the actinides because, like I'll show you in a minute, we have a lot of data for the actinide assays. We don't have very much data for the minor actinides and the fission products. So we've used the independent isotopic correction factors in order to -- because we don't have very much statistical data. We don't have very many samples.

So, again, so from the red curve on, moving to the right is basically what we can get is we get more assay data, is I get more assay data and more confidence in the assay data, and that curve will shift to the right.

The curve on the very right in a sense, and depending on whose code you use and what kind of best estimate assumptions you want to use, it can be anywhere from 90 to 98 percent, and so it was basically saying, hey, I take my code. I predict it. I'm going to do as best I can. So that's sort of a theoretical limit.

You know, the way we did it, using what we thought was reasonable engineering judgment, we come in with about 92 percent.

DR. WEINER: So, Cecil, if I could ask, basically the placement of that third red curve is heavily dependent on the validation that you can do. Can I draw that message from you?

MR. PARKS: I mean, I would place it a

little bit differently. If we had data that was what we need and what we think we want, that red curve would shift a little bit, but not a lot. It would not shift a lot.

There are some assumptions if you go into this that could change it a little bit, but from a validation standpoint it would not shift a lot.

DR. WEINER: Thank you.

MR. PARKS: So anyway, you can see in this curve, again, this is overlaid over the inventory, 2002 inventory. So you can see to ship a large part of the inventory why industry wants that fission product credit to make these high density packages viable.

Okay. Moving forward, the validations. Hopefully I have laid the groundwork for why validation -- is the validation consistent with the standards requires additional experimental data for the fission products. EPRI has concurred that the experimental data, you know -- this is basically a report they issued after ISG8r2 was released. It basically supported that standpoint. They felt like NRC had given pretty much what should be given consistent with the data that was available.

This is my personal opinion. That was

after EPRI looked at what was being done internationally also. It's not like the U.S. was dragging their feet relative to this process. It's consistent with what's been done internationally. To my knowledge, no other country is providing credit for burn-up, burn-up credit for transportation, and particularly not for fission products.

And, again, it's because of the lack of validation data. There's an application in front of the German regulatory authorities now, and there has been a paper submitted that discusses the fact they are doing validation in a way that is consistent with the requirements that have been discussed already.

So anyway, the sources of data that need to be sought and how they're being sought include domestic experimental facilities and programs, commercial reactor critical configuration, and non-domestic and international programs. I want to discuss each of those briefly and try to give you some insights into what we've seen and what's been done over the years and most recently where we are.

I am not going to focus a lot on the assay data because that has not been sort of the focus of the questions that have been asked. I think it's an important component. So this slide summarizes where we are now with assay data.

Again, as Ed said, we've done a lot of work with research, and there's been two goals of the work we've done with research. One was focused on trying to get data for burn-up credit. Another was to look at, you know, high-up uncertainties with sources from high burn-up fuel.

And so you can sort of see that in the plot to the right. If you look at the red points on that curve, what this is showing, again, is burn-up versus enrichment, and these two lines are sort of loading curves of the ISG8r2 into theoretical. So somewhere in between is where, you know, hopefully we'd like to be in the future relative to giving credit for burn-up. But ISG8r2 is the upper line, and the theoretical is the bottom line.

This illustrates where we have data, assay data. So the red points are actinide only sets, and these were done typically. Historically these assay data, destructive assay measurements were made back as far ago as the '80s, and the interest then, these weren't all done for burn-up credit. They were done for a lot of different reasons, but their focus was on actinides. There was no interest in fission products really, and so you see we have a lot -- not a lot --

relatively speaking we have a lot of data that's actinides.

Now, you move to -- the complete sets are the ones more cent. They're high enrichment and high burn-up. You can see the green up in the upper right-hand corner illustrate where the most recent sets have been obtained, and these are both actinide and fission product data of interest.

And then you shift to the bottom right, and there are a couple of sets, the Japanese set and I can't remember what the one on the far right is, are partial sets. That indicates we have maybe a few fission product data in them and may not have all of the actinides we want, but there are partial sets we've pulled from to get to there.

We're continuing this work with research to try to identify courses of the assay data, and I'll mention that later.

So shifting now to the critical experiments, what's been done? It's been on the table for -- been on the table? -- it's been an area for discussion for at least 15 years doing the critical experiments at Sandia, and Sandia has actually through a DOE nuclear energy program several years ago actually configured the assembly you see in the picture and did one critical series with Rhodium 103.

And we have looked at that, and again, I want to point out here that critical experiments that we've used for benchmarking historically for the past 40 or 50 years are well defined laboratory experiments, and so you sort of see. You look at this experiment and you sort of see the simplicity of it. It's relatively clean, fairly easy to model. It's a diagonal pitch, and so you can understand the uncertainties that you're seeing when you compare your software to the experiments, and there's a lot of experiments similar to this, but not with the fission products in it.

So Sandia has proposed and what's kept this from happening has been typically funding and the time lag. In other words, if Sandia started now to produce these critical experiments, it's going to be several years before the data is available and can be utilized by industry, and the funding is another issue.

The second source of data has potentially been talked about since the late '80s, is commercial reactor criticals. You know, the first thought is, hey, well, you have spent fuel and you have it in a reactor. Why can't we use that for validation?

Well, you can to a degree, but there is, again, in contrast to the previous slides, you can see a reactor has a lot of uncertainties in it. There's a lot of uncertainties that exist. It's a complex spent fuel system. Reactors are not -- and they have become more and more complex over the years as the spent fuel assemblies have gotten more complex in their design, their heterogeneity. They've got a lot of poison rods in them and different issues.

So understanding the sources and magnitude of the uncertainty is difficult. You've got to get all of this data from the utilities, but actually Yucca Mountain has done the best job that has existed on that. They have gone and tried to obtain a lot of this type of data from utilities and vendors to create a set of CRCs that is publicly available, and we have worked at Oak Ridge to try to analyze a lot of those, to look for their applicability to these spent fuel packages.

But the difficulties come down to they are very complex systems, and the uncertainties are not quantified and somewhat largely because the isotopics that are in the predicted state are not -- it's an interval experiment. You've got all of your predicted isotopics and your critical are all there. It's hard to determine where these uncertainties come from.

And the next viewgraph shows why I say it is complex. That was the top view of the core. This is the axial view of the core. I mean, you've got the fuel rods, the control rods, where you do or don't have insertion rods, burnable poison rods, spacer grids. It becomes a very complex system to analyze when you want to try to understand bias and bias uncertainty.

We looked internationally. Internationally this is an example. This is not the only thing that was looked at, but there was a REBUS International Program, which is a lot of partners. Belgonucleaire coordinated this before their recent demise. They have disbanded, but the international program was handled there, and they were going to do some spent fuel criticals they said, and what they've done, what they did was up on the upper left you see the commercial UO_2 case where basically they took some spent fuel rods and they put them down into the core, but you really can't see the difference in k-effective. It had very little effect on k because the core itself is largely UO_2 rods, and they put these spent fuel rods down into the middle.

Now, they can see a little bit of a delta k to do some validation by oscillating those rods or putting the fuel in and trying to look at the small difference of K, but they're basically work experiments. The standard fuel has little worth to the system and there's little value to actually doing this fuel validation.

In other words, the Monte Carlo codes have a hard time determining what the uncertainty is.

So a third thing we did was look at there is an international handbook on criticality experiments. It has been pulled together over the last 20 years and has continued to be added to, and has internationally participants from across the world from Russia. So there's a lot of experiments to be put into this handbook.

And we analyzed, to give you a description again of what this plot is you're looking at. On the Y axis is a parameter called Ck, and without getting into the details, we basically looked at and have done sensitivity analyses of all the criticals and the application, and Ck is a measure of the correlation between the experiment and the application of interest.

And so Ck is one. We have perfect correlation. Basically my system and my experiment are exactly alike in terms of materials and geometry and energy and spectra, this kind of thing from an integral standpoint. This is integrated up.

So it's a good measure of looking for applicability of critical experiments to the system of interest, and so that's the Ck value.

Now look across the bottom. It's simply all of the different experiments we looked at, and we looked at 1,000 or more, and what you see is that the red line indicates that Ck is a .8. The blue line is a Ck of .9, or the dashed line, Ck of .9, and you look and you see, you know, most of the MOX have some applicability, but then what do you see up in the upper right-hand corner? Well, gee, you've got a lot of experiments up there that have Cks bigger than .9.

Well, what are they? Those are what we call HTC experiments, and HTC experiments are what I'm going to talk about in a minute, are the French experiments.

Now, I will point out there are some of the MOX experiments also have -- when I say "MOX," some of the uranium-plutonium mixed oxide experiments that have been done elsewhere. There's a few of those that have high Ck values, but not very many. The majority of these up in the upper right-hand corner are those bridge experiments, and I'll show you why the French experiments are very applicable to spent fuel.

We call these HTC experiments, and I'll have to confess my French is terrible, but this is basically burn-up something in French. It's the acronym for it. So the French experts can chuckle around the room because I don't know my French very well, but this is the acronym the French give these experiments, and they are performed at the Valduc facility in France in the 1988-early '90s time frame. I think it ended up around '92, '93.

And what they did was they manufactured MOX fuel pins that were consistent with the ratio of uranium and plutonium you see in spent fuel that's burned at about 38,000 GWd, 38 GWd.

So what they've done is whereas MOX fuel, most of the MOX experiments were typically depleted uranium mixed with plutonium and the ratio of the materials is much different. These were simulated spent fuel rods, actinide only, just uranium and plutonium.

There's 156 critical configuration in four groups. They have simple arrays with pin pitches that vary, which gives a very good look at understanding our code as the pin pitch changes in fuel designs. Forty-one simple arrays with gadolinium and boron solution, vary with pin pitch so that you can -- this is more for borated pool issues.

However, Group 3, again, shows us what you want in a transportation package and somewhat in pools also where you have borated steel, Boral or, you know, some kind of absorber panel between the assemblies.

And the fourth group is two-by-two assemblies, which really represent a transportation package in that you've got a reflection from thick lead or steel around the experiments. So this is a tremendously nice set of critical experiments which go from simple to complex, and bring in the range of what you're looking for in a transportation package, and they give you a large number of critical experiments that you can have good confidence in the bias and uncertainty that you predict as you compare your codes.

And the other thing is I sort of did not mention earlier, and I apologize, is that in the development of ISG8r2, the technical basis that was looked at, there was a lot of questions that came up about the validation, giving as much credit as it was giving for all of the actinide credit that could be given in the recommendation because there were not a lot of applicable actinide criticals. There were some with MOX as we talked about.

But, again, I think the comfort level the staff had, and it's documented in the technical basis, is that there was this knowledge, this as I mentioned six to eight percent of fission product credit that was there, that although unquantified was there. And so there was some comfort that said, okay, we can give the actinide credit, but we're not comfortable giving the fission product credit until things are shored up, until things are supported better.

So this set of experiments provides tremendous support for the actinides. So now you've got very good support foundation for your actinide. You can move on to maybe not worrying as much about difficulty because the fission experiments are very difficult experiments to do. There's no question about that, to try to get a good look into the bias and uncertainty for fission products.

And again, the French move forward and did that in pretty much the time frames from the mid-'90s to I think they finished up in 2003. And this is sort of an overview of those fission product critical experiments. These and the HTC experiments have been repeatedly published in the literature. The details are not available in the literature, but the description of the experiment is in the technical literature in many places because they do hold them for proprietary AREVA, held them for proprietary IRSN. IRSN is also proprietary.

So the fission products that are covered are listed here on the first bullet, the rhodium, cesium, adenium and samarium and gadolinium, and again, the type of gadolinium and samarium is important. You can't use natural of these fission products because that's not what's being credited in the fission products. That's really not what's there in the spent fuel. It's not the natural abundance. It's these viruses that come up after irradiation.

And these experiments, over on the right there's sort of model that we created that demonstrates that they're basically cans of fission product solution surrounded by UO_2 pins or in some cases HTC pins, and sometimes they also had the HTC pins in an array with the fission product solution intermingled around the array.

But what we did in Oak Ridge, again, was to look at the comparison of these critical experiments with the applications of interest to see if the similarity was effective enough and how we would use these in doing a bias and bias uncertainty.

So I'm wrapping up now in terms of summarizing. The assay data validation, available data sources are domestic assay data and international programs, and that's what we tried to demonstrate that a little bit.

Potential data sources for the future. There's ongoing international programs. The Maldu Program is in transition from Belgonucleaire to SKN. It's still ongoing, and they're trying to get more fuel. New partners are joining that program. They're going to get some more assay data, which would be good.

There's a planned assay data program being conducted domestically by DOE for the Yucca Mountain Project, which is working to start back up, and that will be a couple of years away before that data becomes available, but there's activities going on.

EPRI, we've talked with EPRI. They're working to get assay data, both domestically and through their contacts with the French to get domestic data -- excuse me -- to get to assay data. So those are potential data sources.

Our current approach, techniques for

incorporating bias and bias uncertainty from assay data have been developed, illustrated and documented, and I say that because basically the NRC has Oak Ridge, through work with Research, has issued recommended approaches for doing best estimate bias and uncertainty for assay data.

And when I say "best estimate," again, it's trying to look at the data across the whole set, the actinides and the fission products, so that you get some of the compensating whether you're over predicting or under predicting. You sort of incorporate that into your bias so that you get a better, less conservative estimate on your uncertainty.

And unfortunately there's a number of experiments, a number of nuclides where there's very few measurements, and some of those are fission products, but there is some assay data that exists for all the key nuclides, and this is so that you can move forward and do something.

In contrast, I guess I'll interrupt here and just say in contrast, we don't have critical experiment data for many of the fission products. That's the reason where the critical experiments become an issue, come up over and over.

Third, continued participation in the collaboration with domestic and international programs to acquire and assess experimental data.

Now, moving to the criticality experiments and their validation, the French critical experiments using simulated actinide composition of spent fuel have been evaluated. In other words, we have obtained the details of those reports at Oak Ridge. We've analyzed them. We've assessed them and given a bias and the bias uncertainty, submitted those reports to research and SFST also, and they have reviewed them, given us comments back. We're in the process of finalizing those reports.

We've also shared those reports with the French. Interestingly enough, the French have made some changes so that they are some of the details that we've picked up on they hadn't documented well or issues that they've changed our reports a little bit and they're getting ready to ready to reissue those in April. And the NRC report will go out in April, and we plan to distribute that for public release this spring.

And, again, I say it's public release. Those are proprietary data, and so there's basically an NDA that has to be signed. They can be used for the purpose of licensing under Part 71, 72, and Part 50.

MR. RAHIMI: That's for actinides.

MR. PARKS: That's for the actinides. That's the HTC data. That's right.

The French experiments that include fission products had been received and assessed at Oak Ridge, and we've analyzed them. We have evaluated them and feel like they are what needs to be purchased in order to if you want to do the experiment, if you want to do this now and not wait to do a domestic program that's going to take several years, then you should purchase these now and utilize them.

The other sources of available data, domestic and foreign, have been assessed as I've talked about. The quality and extent of the French data exceeds other available sources. It's very clear to us.

Potential data sources that could still be looked at. There are some recent experiments that were done in Japan which are going to be publicly available, and should be put into the handbook, but it's unclear as to how applicable they are. We hope to get those assessed. They really have not provided us the fission product solutions to date. They're still struggling with getting the chemistry on that to the point where they want to report it. But these are something we're going to look at.

The performance of domestic experiments that Sandia has been studied. You know, it's what needs to be done. If funding becomes available to do those experiments at Sandia, how will they be performed in order to provide the -- how would they be designed in order to provide the applicability we want for these type of systems.

The current approach recently has been focused on developing the technical basis for utilizing the fission product data, the validation of the fission products, the French fission product data. And I note that other data could potentially be utilized, CRC. However, it would be much larger uncertainties and penalties relative to how that's done.

Larry?

DR. WEINER: Larry, go ahead.

MR. CAMPBELL: This is Larry Campbell, Chief of the Criticality Shield and the Dose Assessment Branch.

I just want to make one comment. The French were kind enough to let Oak Ridge evaluate the value of their data. However, there's an agreement that that data has to be turned back over to the French. It cannot be issued or released for use unless it's purchased.

I just wanted to make that point.

MR. PARKS: Yes. One further clarification is what we've agreed to with the French is a right to distribute the data, and if purchased. The other thing is that currently that option to purchase that data currently expires this summer.

Now, that doesn't mean it can't be renegotiated and as a matter of fact, we've already mentioned it to them that we'd like to move that, but you know, time is becoming sort of important on making a decision.

CHAIRMAN RYAN: What's the price? Everybody is thinking that. I thought I'd ask.

(Laughter.)

MR. PARKS: That is unfortunately business sensitive. I guess I'll answer it this way. I think it's fair -- I thought about how to answer it -- it's in the millions, which gives people pause because you say, "I'm paying millions for stacks of reports."

I would say that I do know from the documentation the French have given us that the cost them to produce those experiments is probably about six to eight times that, and I also know that from estimates we have from Sandia that the cost of doing a domestic program would be at least three times that.

CHAIRMAN RYAN: Three times the purchase price.

MR. PARKS: Right. Plus you have the time lag.

CHAIRMAN RYAN: That's very helpful.

MR. PARKS: Yeah. Basically I want to make sure I'm clear about this. I would love to see a domestic program done in America. Our first recommendation when we talked to DOE years ago was to do a domestic program and purchase the data if you want it right away.

But you know, those are sort of the facts.

CHAIRMAN RYAN: That's very helpful.

MR. HACKETT: This is Ed Hackett of the staff.

I don't want to put words in Cecil's mouth and he's in a more sensitive position, as Larry mentioned, but in trying to speak for the staff or maybe at least for myself, in the deliberations that we had at the burn-up credit workshop, I'd go so far as to say even though this number is millions, probably for the reason Cecil cited and the quality of this data and the potential impact on the regulatory environment, I might go so far as to say this could be a bargain to go ahead and purchase that data for the impact that it could have.

DR. WEINER: thank you.

MR. RAHIMI: Thanks, Cecil.

Now we're going to move to the next presentation. Drew is going to give sort of an overview of the area of the risk, criticality risk in burn-up credit casks and how we're going to use that hopefully risk study in looking back at some of our criteria, you know, implementing the regulation, how to reconsider some of those criteria.

MR. BARTO: All right. Thanks, Meraj.

As Meraj said, I'm going to talk a little bit about risk related to criticality safety in transportation. I want to talk about some components of risk, of criticality in transportation and, as Meraj said, talk about some things that had been done and some things that we're going to do moving forward related to risk.

Now, criticality analyses for transportation of spent fuel under Part 71 have not traditionally considered the risk of criticality as we've already discussed. The analyses have been performed assuming very conservative fresh fuel composition and fresh water in leakage assumption, and then back in 2002, we were able to develop a burn-up credit methodology for spent fuel transportation, or ISG 8, which was still a very conservative methodology.

Now what we'd like to do by considering the risk of criticality in transportation now, along with some of the additional data that we now have available and that may soon become available as Cecil discussed, we'd like to move forward and be able to develop a technical basis for changing our recommended burn-up credit methodology to grant more credit for burn-up, but while still maintaining this high degree of conservatism.

Next.

Now, when we talk about transportation, we're really not just talking about the time that it's on the road or it's on the rails. Really transportation under Part 71 covers loading, transportation, and unloading and all of the procedures that accompany that.

So when you're talking about the transportation phase, which is what we typically talk about with risk, in order to have a criticality, you need to have a severe accident, severe enough to allow fresh water in leakage, and you need to have this accident in the presence of fresh water.

And in addition, you need to have a high reactivity misload in that cask. Now, this is talking about burn-up credit casks.

During loading and unloading, criticality would require some event that causes fresh water to be introduced to the package, and in addition to this sort of unnamed event, you also need to have a high reactivity misload.

And when we're talking about misloads here, we're not just talking about an operator picking up the wrong assembly and putting it in the cask or picking up the right assembly and putting it in a wrong location in the cask. Thoroughly any event in the supporting analyses for the movement of that fuel, the physical movement of that fuel or any of the verification activities, any event in those activities that would cause an unintended assembly to be loaded in the cask.

Now, as far as the probability component of risk, there's been some work done on looking at the probability of criticality, the various phases of transportation for burn-up credit casks. There was an EPRI study about two years ago that looked at the probability of criticality during the transportation phase and found it to be very low, as one would expect. Most of that low probability is tied up in simply having a severe accident in the presence of fresh water.

CHAIRMAN RYAN: What's "low," Drew?

MR. BARTO: I believe the overall probability was somewhere on the order of ten to the minus 13 during transportation.

CHAIRMAN RYAN: And, again, from a numerical standpoint, so they're probably a fresh water intrusion during the loading or unloading. I got the impression that you weren't really sure you could tell me what one of those events might look like.

MR. BARTO: Well, that's what I was about to get into. Loading we have a feel for. I mean, everything that we've seen loaded is going to be loaded in a Part 50 spent fuel pool with high boron concentration, but really the unloading, we're not aware of what that looks like at this point.

CHAIRMAN RYAN: Why is it a credible scenario to evaluate?

MR. BARTO: Right. That's something we're going to have to look at, if it's credible or not. At this point it's difficult to say because we don't know where is the facility or this is going to be unloaded. What does that facility look like?

DR. WEINER: You mean unloading from a transportation cask --

MR. BARTO: Right.

DR. WEINER: -- to some other container.

MR. BARTO: Right.

CHAIRMAN RYAN: Moving the fuel out of one to the other.

DR. WEINER: Yes.

CHAIRMAN RYAN: Right?

MR. BARTO: Right, or whatever. I mean, you know, it could --

CHAIRMAN RYAN: I mean, I understand the interest in fresh water because of the reactivity questions, but I really am struggling with how I could even construct a wild hypothetical as to what that would look like. So I guess that's one of the problems you're going to wrestle with.

MR. BARTO: Right, exactly.

CHAIRMAN RYAN: Fair enough.

MR. BARTO: Okay, and then another

complication is, as we've discussed already a number of times, you know, when you're talking about the probability of criticality during transportation, you know, you have a postulated event of getting fresh water in the cask during transportation that has a very low probability. We can argue about what that probability is, but we know it's low, but it is something that's required as part of your design basis under Part 71.

DR. WEINER: When you look at the probability of water getting into a cask during transportation, is the fraction of any route, transportation route, part of that probability assessment?

In other words, how likely is the cask to be near water in the first place?

MR. BARTO: It will have to be part of the -- I can't speak to the exact details of what EPRI has done, but that would have to be part of the consideration.

DR. WEINER: Larry Campbell.

MR. CAMPBELL: Yes, Larry Campbell.

We have recently sent a user need request to Research. It's barely open, for Research to take a look at the risk aspects, but I believe this went over last week, and we're just getting started on it, and any feedback that the Committee could have in this area would be appreciated.

We have a feel of the areas we might be looking into, but we're just kicking this off.

DR. WEINER: Thank you.

CHAIRMAN RYAN: Can you provide us with the text of your request?

MR. CAMPBELL: Yes, yes.

DR. WEINER: Good idea.

MR. BARTO: Absolutely. Now, in getting to misloads, which is one component you need to have for the criticality and burn-up credit cask, the probability of having a misload is also something that has been looked at.

As part of the EPRI report that I already mentioned, you know, part of the overall probability of criticality is looking at what is that probability of misload, and they came up with a number on the order of ten to the minus five, possibly lower depending on certain assumptions, and this was based on the information that's available about fuel movements in spent fuel pools.

CHAIRMAN RYAN: That's the kind of number, if I may, Drew -- you say ten to the minus five and possibly lower based on certain assumptions. So that means ten to the minus five is the highest probability?

MR. BARTO: I think that's probably more like an average. Again, somebody --

CHAIRMAN RYAN: Well, I've struggled with that because you said ten to the minus five and lower. You said nothing about ten to the minus four.

I really think that thinking about this in terms of risk you've really got to get more precise in these numbers and what they really mean from the range of events or processes.

MR. BARTO: Right. That's something that we're going to look at again, and this is something that came from an EPRI report.

CHAIRMAN RYAN: I appreciate you can't speak to that, but I'm always nervous when I hear somebody give a number and then they say, "Or it could be lower or it could be higher." How much?

DR. WEINER: Do you have a comment?

MR. HACKETT: I guess I'd comment on that relative to what Larry brought up, Mike, is that is an element of our user need request with Research.

CHAIRMAN RYAN: Right. Okay.

MR. HACKETT: And of course, it gets into the area of human reliability assessment, which as we all know, can be a bit a bit of a murky area at times.

CHAIRMAN RYAN: But I think the best effort to quantify those things instead of, you know -- of course, the itch is always, well, we'll fall back on a bounding case because it's too high.

MR. HACKETT: Absolutely.

CHAIRMAN RYAN: And that's what I think we need to avoid.

MR. HACKETT: Good point.

MR. BARTO: And then, again, we're just getting started on sort of our own look at this, and as part of this Oak Ridge National Lab is preparing a draft NUREG on burn-up verification overall, but part of that is another look at what is its probability of having a misload.

DR. WEINER: Well, there must be available data on the probability of misloads. I mean, misloads happen.

MR. BARTO: Right, and there is data available about spent fuel pool movements, and there is data available about cask loadings at this point. You know, what there isn't is there's not any data available about burn-up credit cask loadings, or at least not a lot of it to be able to say we've loaded

1,000 casks under this burn-up credit assumption and misloaded so many of them. You know, that data just isn't there.

But you're right. The next best thing is looking at movements within pools.

MR. RAHIMI: That's what Oak Ridge, you know, has looked at, looked at all of the reactor event reports, misload in the rack, burn-up credit rack, and you know, drawing inference from that, and we do have also some misload data into casks.

But as Drew said, you know, we don't have data in misloads in burn-up credit casks.

DR. WEINER: Yes, I understand that.

Sorry. Go ahead.

MR. BARTO: No, that's okay.

Now, our current ISG 8 guidance FOR burn-up credit recommends a burn-up measurement, an out-of-reactor, in pool measurement in order to reduce this probability of a misload, and again, at the point of drafting an ISG 8 guidance, we didn't really have information about the probability of a misload, but we wanted to reduce the probability, whatever it was.

So we are, again, as I've just discussed, we're having Oak Ridge do a draft NUREG on burn-up verifications overall.

CHAIRMAN RYAN: This is out of ignorance I ask this question. So I apologize, but a severely under burned fuel could be two things. One is a few elements that are different than the one you thought it was. It's a newer fuel element.

MR. BARTO: Right.

CHAIRMAN RYAN: Or a fuel element for which the burn-up that you thought was there is not what's there. Can you talk about what's the more likely mistake?

MR. BARTO: Well, I think it's probably more than likely that you -- well, when I say severely under burned assembly, I just mean a fuel assembly that exists in a pool that does not have a lot of burn-up, and you know, for whatever reason fuel assemblies have been removed from cores after --

CHAIRMAN RYAN: So you're taking the wrong one than the one you thought you had or it's just not well understood?

MR. BARTO: What I'm talking about --

CHAIRMAN RYAN: You understand there's several different errors that can occur when you pick the wrong element. If I said I picked Element 62 and I actually took it --

MR. BARTO: Right.

CHAIRMAN RYAN: -- and there was something wrong with the calculations for Element 62, that's one kind of mistake.

MR. BARTO: Exactly.

CHAIRMAN RYAN: And if it's I picked 63 instead of 62, that's a different mistake.

MR. BARTO: Right.

CHAIRMAN RYAN: So are you going to look at both of those kinds of cases?

MR. BARTO: We're going to look at that, and I think our early indications is that the probability of an operator simply picking up the wrong assembly is something that's fairly low.

CHAIRMAN RYAN: Fairly low, being backed out at the ten to the minus 13, tenth, sixth?

MR. BARTO: I couldn't give you an estimate of that, but low, probably lower than that ten to the minus five. I mean, it's hard for me to really --

CHAIRMAN RYAN: So actually what we're talking about is picking the wrong fuel element. It's more likely that the knowledge of a fuel element is insufficient to really verify that the burn-up credit you're giving to that fuel element, you know -- that that could be an error. That's the real issue that we're looking at here; is that right?

MR. RAHIMI: Yes. I mean, the uncertainty about the burn-up of the fuel assembly, that component, I mean, all of the reactor records, they have about four percent uncertainty associated with the burn-up they've assigned. That is sitting and designing the rack.

So that component is always, as you will see, it will go into the burn-up credit calculation. It's three to four percent reactor record uncertainty associated with the burn-up.

CHAIRMAN RYAN: What does the reactor record uncertainty mean?

MR. RAHIMI: That is the burn-up that the utilities over the reactor core calculations has calculated.

CHAIRMAN RYAN: Fair enough. Okay. Now I understand. Thank you.

MR. BARTO: Okay. Getting back to this draft NUREG that we're having Oak Ridge develop, it's sort of an overall look at burn-up measurements. So what this NUREG is going to include is they're going to look at available out-of-reactor, in-pool measurement techniques that have been used at some sites. They're going to have a comparison of in-core versus out-of-core burn-up determinations, including another estimate of the relative uncertainties of each of these methods, and again, an independent estimate of the probability of a misload in a cask and the consequences in terms of delta k-effective of each of these misloads.

And we're hoping to be able to use the information in this NUREG to be able to develop some potential additional options for burn-up verification in our ISG 8 guidance..

DR. WEINER: Are non-U.S. data also going to be included in the review of available techniques and available measurements?

MR. BARTO: I'm not sure if we -- did you?

MR. PARKS: In a qualitative way, Ruth. As you know from Drew's comment earlier, there is a lot more loading and unloading of transportation packages that have been done in other countries than the U.S. So from a quantitative sense, no, but there is a qualitative discussion of what is done in other countries, but not too much their misloads more than the measurement issues.

DR. WEINER: Thank you.

CHAIRMAN RYAN: Just a follow-up, Cecil, on that point. Are there any data on misloads in other countries?

MR. PARKS: I do not know.

CHAIRMAN RYAN: Okay.

MR. BARTO: Having looked at it a little bit, it's probably not -- having looked at the U.S. side, it's probably not as comprehensive as what's available for the U.S. side just based on the sheer numbered of movements that have happened here versus other countries.

CHAIRMAN RYAN: But we don't know that because we haven't seen the data.

MR. BARTO: Right. As far as the consequence component of criticality risk, there has been some work done on the consequences, number one, of having a misload. EPRI released another report a couple of years ago that showed the consequences in terms of k-effective, of various misload scenarios, and we recently had a NUREG CR developed by Oak Ridge published on that same topic.

Now, previously, the industry has made a good case that fresh fuel is extremely unlikely to be loaded into a spent fuel cask, given the obvious differences if you were to just look at a fuel assembly, fresh fuel assembly, shiny; burn fuel assembly, not.

That being said, there is fuel out there in pools, as we've already discussed, that for whatever reason has been pulled out of a core early, long before its intended full burn-up level, which would be very difficult to distinguish between those two just by sight. Indications we have if it has been burned for any amount of time it's going to be difficult to tell between it and fully burned assembly or if it has been sitting in a pool for a number of years.

DR. WEINER: What would be the reasons -- this is just my ignorance -- what would be the reasons for pulling an assembly out early other than some damage, some, again, damage.

MR. BARTO: I think that's probably one of the main instances if you have a leaking fuel assembly early in a cycle. In other instances, you know, maybe it wouldn't be a severely under burned assembly, but for whatever reason some utilities have decided to change manufacturers of fuel. So they may have fuel, you know, thrown up a core perhaps that's been pulled out of a reactor and not ever reinserted into the reactor.

DR. WEINER: Thank you.

MR. BARTO: That would have, you know,

only a third of its intended burn-up level.

So included in the Oak Ridge evaluation of this misload consequence is a look at various members of under burned assemblies loaded into casks and what are the consequences in terms of k-effective, and the results are that slightly burned fuel is still very reactive, and a misloaded assembly or two can still have a large effect on k-effective of the cask.

As far as the overall consequences of a postulated criticality event, we do have a draft report being developed by Oak Ridge, and that report is currently under evaluation. It's under evaluation. We can't really talk too much about it, given that it's sort of pre-decisional and that there are some safeguards and security issues involved in any evaluation of that type.

MR. RAHIMI: Yeah, that second report, that would be the second component of consequence looking out there. What is the consequence of increasing k-effective going critical/super critical physically on the cask. So that would be the second part of the consequence.

CHAIRMAN RYAN: I'm a little stuck on the analytical part of this. I mean, the components of misloading to me are what I said earlier. One is I pick up the wrong fuel element because I pick up the wrong ID number fuel element. They all have unique IDs. So, you know, hopefully there's a process that I know I'm picking up number six and not number seven.

So I would guess; I'm guessing the probability of that kind of error is relatively low, and I'm trying ot understand that, you know, we've calculated some worth of the spent fuel rod as it sits for whatever burn-up history it has, and there's now some percentage uncertainty, like five percent uncertainty in that.

So I guess, you know, based on the earlier numbers of having very large margins between .95 and what a cask might be loaded, I'm trying to figure out how you get there. How many misloads would you have to have to challenge that .95 in a single cask?

That kind of detail, you know, analytical analysis I think is very, very important for two reasons. One is to take away some of the reliance on bounding analysis and really understand the risks and, two, to communicate better to the public what the risks are.

So you know, I think that's real important work to do.

MR. RAHIMI: That analysis has been done, and actually Cecil and I can pull John. We looked at single assembly, fresh, or two assembly, one assembly under a burn in every location in a burn-up credit cask. What is the delta k?

CHAIRMAN RYAN: So that's kind of a theoretical study. so that's the consequence part.

MR. RAHIMI: Yes.

CHAIRMAN RYAN: Now I really think it's important for you to understand what is the probability. How many fuel assemblies have been misplaced.

MR. RAHIMI: That's right.

CHAIRMAN RYAN: That's the right information.

MR. BARTO: That's the next step.

CHAIRMAN RYAN: It's very important to understand.

MR. PARKS: And some of that was done in the report Drew mentioned, too. Again, all it had to rely on was the existing LER database that's in the U.S., which is fairly limited, but --

CHAIRMAN RYAN: With the research effort you've got underway.

MR. PARKS: Yes. So there was some effort done towards that.

CHAIRMAN RYAN: And I appreciate that, but some effort doesn't help me.

MR. PARKS: No, I understand.

MR. HACKETT: This is Ed Hackett, SFST.

Dr. Nathan Siu from the Office of Research is with us and Nathan has taken the principal look for the office at the EPRI report, and I believe he has some comments.

DR. SIU: Yeah, and again, Nathan Siu, Research.

I just wanted to manage expectations just a little bit here. It's one thing to demonstrate that the risk is very low, and of course, you have to look at the process. You have to postulate scenarios. You have to discard the scenarios that just are not believable. At some point if the risk is, indeed, very low, you're going to come with a set of scenarios that don't look very plausible, but they have some likelihood.

If you want to come up with the most accurate estimate of the very low risk, it can be very expensive because you start looking at these scenarios and say, "Well, I'm going to work on that more and convince myself that's not really plausible after I remove some conservatisms."

So I think you may not want to point towards the most accurate estimate, which might possibly end up with astronomically low numbers that you'll have to defend, and you might not need to for the purpose of the process, for the purpose of coming up with a better way of addressing the burn-up credit issue.

So, again, that just is a caution.

CHAIRMAN RYAN: I'd be happy just to get away from the bounding analyses we've got now and get somewhere into the probability area. So I agree that you can take it to an extreme, but I'm trying to get somewhere closer to a more risk informed approach rather than bounding analysis.

Okay.

MR. BARTO: Now, going forward with respect to criticality risk, as Larry already mentioned, we've just developed the user need request for research to assist us in developing an independent estimate of criticality risk and to evaluate any future industry positions related to this topic.

Also, internally we've started having several working groups within SFST sit down and look at our ISG 8 to see if we can modify some of these burn-up credit criteria based on what we have learned or will learn in the future about overall risk of criticality and transportation.

And then further down the road, we will involve industry representatives in developing these criteria.

I'd also like to note that NEI and EPRI are developing a position paper on burn-up credit and early indications are some of this paper is going to look at risk and sort of use risk to base some of these positions on, and that we are intending on working with them to evaluate this position, and we look forward to receiving that report and working with them to resolve some of these issues.f

DR. WEINER: So if I could summarize the areas where there is uncertainty in granting burn-up credit, one area is what we were just talking about, which is the possibility that you simply have the wrong assembly in the wrong place.

MR. BARTO: Right.

DR. WEINER: And the other is the uncertainty about the burn-up itself. What is the concentration of actinides? What is the concentration of fission products? And that's where you need -- that's where the major data need appears to be.

Have I got it right?

MR. BARTO: Do you mean just with respect to risk?

DR. WEINER: Just with respect to risk, yes.

MR. BARTO: I think as far as the uncertainty on the assigned burn-up level for individual fuel assemblies, I think that's pretty -- you know, my opinion is that's pretty well quantified as Meraj said. It's kind of in the three to four percent range. Really the concern with misloading is really these under burned assemblies. So there's the picking up the wrong assembly, putting it in the wrong place, but there's also whatever calculations that led you to want to pick up a single assembly. If there's any error in that or if there's any error in the way burn-up values are assigned to assemblies, not on a reactor core calculation side, but on sort of the data management side or anything like that.

So there's a number of areas that have to be explored with respect to the risk of a misload.

DR. WEINER: You stated it better than I did. Go ahead. I didn't mean to interrupt you.

MR. BARTO: No, that's okay. That's all I have actually. I turn it over to Meraj now for a summary.

MR. RAHIMI: Thanks, Drew.

I want to go back to the sort of box, the flow chart that I had at the end of my presentation. These were the boxes that we looked at, Cecil looked at that will give you information about the chemical assay, about the critical benchmark, French critical benchmark that go into this box.

You talk about risk, which really is addressing these burn-up verification measurements where the risk comes into play.

So having heard all of that information, right now our path forward is that the SFST by now is examining actually the use of a generic bounding bias uncertainty for the isotopic validation because that's sort of a similar approach that the NRR has toward the isotopic depletion that's five percent reactivity decrement, one and a half percent which the judgment is that is adequate for that environment.

You know, we're going to look at that because in the meantime we've got application in front of us. We've got 1040. We've got VSC-24. These are all asking for burn-up credit, and while continuing to view burn-up credit applications for casks based on a case-by-case isotopic validation methodology, what we've seen that each applicant is coming in with a really different variation of isotopic validation using their best estimate that Cecil described, combination of best estimate and the correction factors.

So we're looking at each of them, but our goal is, you know, maybe we can develop a basis for having a bounding, having a fixed bias uncertainty for isotopic.

DR. WEINER: What would be the basis for the database experiment or whatever, the basis for a fixed number? How could you justify, say, five percent, whatever?

MR. RAHIMI: That's right. That's what we're going to try to though. Right now we have quite a few chemical assays. We've looked at, you know, how far we're off. You know, are these codes -- you know, the 2E codes or the SAS2 point efficient code (phonetic), how far they're off in predicting these isotopic inventory.

As we're sort of expanding that data, we'll get to a point saying, okay, I think we've bounded that so that the applicant -- they don't have to go back and repeat all of the 70 benchmarks for each sample, you know, a fixed number. But, yes, we have to have that basis, develop that basis on the measurement.

I mean, right now on the fission product side, you know, we're a little bit light. There are not enough data. Some isotopes, you know, Rhodium 103, you were talking about five or six, you know, data points, and we'll do trending analysis if we have more data.

Once we have that basis, then, yes, we can say that there will be four percent, five percent, whatever it is, all transportation cask out of it.

In the area -- yes?

DR. WEINER: Go ahead.

MR. RAHIMI: In the area of criticality, the yellow boxes, SFST is recommending to obtain the data from French critical experiments because as was discussed, those appear to be very applicable experiments. It has presumed product in there. Even the HTC data, the actinides, you know, they're a very clean system, very similar to the cask.

But in the meantime, the staff will review applications using commercial reactor critical staff that we have. That's the only thing we have. It is not the cleanest type of benchmark. It is an integral benchmark. It is complicated. As Cecil mentioned, you know, there is a lot of things it could result in a little bit larger bias, you know, but not much because with all of the improved calculation, ISO 100 burn-up credit cask; so we kind of have some experience on looking at how to use reactor criticals. That's what the staff is going to do in the meantime.

With respect to the risk, again, I'm repeating what Drew mentioned. Examine why are we looking at the risk. It is for us maybe to go back, you know, reconsider staff's position or criteria that we've set in the area of burn-up verification measure. That's number one, looking at that.

And how can we look at that. Instead of burn-up actual physical measurement, can a bounding analysis be done, given the risk numbers?

Options like that, and also looking at, you know, the depletion and criticality in terms of, okay, how much data do we need to develop that basis and also for the critical benchmark as well.

So those are kind of the three type bullets I wanted to come out with, and it was the upshot of all of this information, what we're doing, you know, in the meantime.

Any questions?

DR. WEINER: Allen.

MR. CROFF: Yes, I have questions.

MR. RAHIMI: I thought you might.

MR. CROFF: First, a number of times you used the word "bias." Exactly what do you mean by "bias" and how are you using it or how are you planning on using it?

MR. RAHIMI: Well, bias, the way I see it, is the systematic prediction by your code, systematic under prediction or over prediction of a system. For example, you have 20 experiments. You'd done critical benchmarking. You model that with your code, and as you can see, your code systematically under predicts, you know, under predicts or over predicts, and when you see a correlation and you see a systematic under prediction by your code, that is called bias.

MR. CROFF: And I'm assuming you see this in your code.

MR. RAHIMI: Yes, in depletion codes, in comparing the data in critical benchmark, you know, you represent.

MR. CROFF: Okay, and let's say you have some bias number. What do you do with it? Use it basically as part of a correction factor kind of a thing?

MR. RAHIMI: That's correct, yes. We use, you know, that bias when we calculate the system. For example, we say, well, our system -- our code says the k-effective of this cask, you know, is .92. That's the k-effective.

And we say, okay, we've had two percent bias from our depletion code. We add, you know, that two percent. You know, we add, let's say, .02. Then we add one percent from our critical criticality code. We add that one percent, .01. Point, nine, five, we just made it.

So after calculating, you know, we add all of these biases to see if we -- we have to be there.

MR. CROFF: And the underlying assumption here is that the measurements are more right than the codes?

MR. RAHIMI: The measurements? Yeah.

MR. CROFF: And I'm thinking mostly about the depletion area here where those are tough measurements. Basically you assume that the measurement -- you know that the measurement is better than the codes.

MR. PARKS: Well, you basically are doing a comparison with measurements. You don't always know where your uncertainty is coming from, Allen, and so as Meraj said, the bias is the systematic trend between your measured data or experimental data and your predicted, but then you have the range of uncertainty. So if I'm positive or minus, my bias may be zero, but you look at that range of where your data is, where you C over E values are, and that's the uncertainty, and that uncertainty may come from the measurements and experiments or it may come from the actual prediction of the software itself.

MR. CROFF: Okay. The next area, in your box diagram you've got the depletion and you've got the criticality. All things considered, where is the greatest aggregate uncertainty, I guess I'll call it, in depletion versus criticality calculations? Does one of those dominate the uncertainty in the bottom line, if you will?

MR. RAHIMI: Overall I can tell you if we go isotope by isotope, let's say, in the area of chemical assay, the first box, with the U-235 I've seen it be off from the measurement by two percent, the isotope. As I go down the chain, you know, I have seen being off by ten percent. Again, this is based on like a 1D code, but then recently and in the past few years, you know, we've switched over a 2D code to do a better job. So those, I think, prove.

But overall, we're talking about I think it's in the same range, let's say, that the NRR has about, you know, on two percent you could say, change to a three percent with the chemical assay.

In the critical benchmark of looking at the MOX, basically, again, we don't have a fission product critical, but looking at the reactor critical experiment, which is an interval experiment, those we're seeing, you know, the total of maybe one, one and a half percent, one and a half percent biases that I've seen.

I'm giving you ballpark numbers, you know. It all depends really on the code you use, the cross-section liabilities. There are so many factors that go into it, but looking across the board, we're talking about a few percent and the critical few percent on the chemical assay side.

MR. CROFF: Okay.

MR. PARKS: The only thing I'd add to that, using the codes that we've utilized, if you take the assay data that we have that I show in that viewgraph and you take the best estimate sort of approaches, the bias, the uncertainty, in round numbers will give you right now about two, two and a half percent delta k, and we would do better on that, we would hope. We would have done better on that with the actinides. Like Meraj said, we haven't done anything with the fission products.

MR. CROFF: Okay.

MR. PARKS: But assay does tend to dominate a little bit more.

MR. CROFF: Okay. I want to get to your -- you showed that loading curve with the microscopic numbers and that kind of thing.

MR. PARKS: I have trouble reading it myself.

MR. CROFF: Has anybody tried to quantify the benefits of these, you know, of the increased loading, and by the benefits I mean if you put more in a cask, you have fewer shipments presumably and fewer accidents and lower cost. Has anybody tried to quantify the risk reduction to the public and the cost savings, you know, as you move down those curves?

MR. RAHIMI: Yes. Oak Ridge has done in terms of the number of shipments is saves in terms of each of those things. I don't have the number, but I believe John did have, you know, some numbers on how many shipments we're talking about. Maybe it was fresh fuel versus burn-up credits, not so much about as a function of loading.

MR. PARKS: No, no. We did it both ways. There has been some benefit. I'm sitting there struggling about it, and it has been documented in technical papers, conference papers where we looked at the number of shipments that would be reduced as you go to a 32 element cask versus 24 element cask, and the estimate of the cost savings associated with that was in the millions, a hundred million or more just from actinide only. Assuming the actinide only burn-up credit inventory you could have versus the fission product, we looked at it both ways. If it was fresh fuel and what the gain was to get to actinide only, and then the gain to get the fission product.

But to answer your question relative to risk, no, I think there's a general understanding that as you cut the number of shipments down, obviously the overall risk is lower, but we do not do any quantitative assessment on that.

MR. CROFF: Okay. I'd be interested in a couple of those papers.

MR. PARKS: And IU can send the papers to you, and there's different assumptions you make as you probably understand, but I think that the ones that I'll give you will give you sort of a ball park.

MR. CROFF: As a corollary to that, I think you mentioned at the outset the focus on the PWRs. What about BWR fuel in terms of burn-up credit?

MR. PARKS: BWR fuel, each assembly has less reactivity worth than a PWR, and therefore, the poison panels that you can put in between each assembly, you get more control out of them.

Therefore, the amount of burn-up credit that you need for BWRs is much less and has not been quite the driver yet in terms of interest. However, we're getting ready to look at that with the research in terms of looking at, you know, what is the sort of best approach, recommended approach to getting that little bit of credit that you may need to extend the BWRs to a high density.

As you know, in the pools, you don't have boron in those pools, and they do it differently in BWRs. So we're just now beginning to look at that a little bit more, but the reason there hasn't been the drivers is because the reactivity of each assembly is smaller and you don't need as much burn-up credit.

MR. CROFF: A point of clarification. The loading curve you have up there, is that just PWR fuel or is that --

MR. PARKS: This is PWR. This is actually -- in the top left-hand corner it's actually 17 by 17 Westinghouse. If you take different assemblies, the CE or the Westinghouse 14 by 14, you'll get different loading curves.

MR. CROFF: Okay.

MR. PARKS: Which may give you different inventory loading. So this is just the Westinghouse 17 by 17. We can do an aggregate or based on --

MR. CROFF: Okay. On the misloading business and the 90 percent under burned assemblies, one obvious approach might be as you're loading this, as you pick them up out of the pool to do some kind of a measurement of radioactivity, obviously they're going to be much less radioactive than a fully burned fuel. What are the thoughts about doing measurements as a mechanism for reducing the probability of misloading?

MR. BARTO: Well, as our guidance stands now, that's the case. We would require measurement to be performed prior to loading the confirmed, confirm the burn-up value. However, as you can imagine, the equipment that exists today to perform these kind of measurements, it has not been something the utilities are inclined to want to do. It's very expensive. Any time you put something of this magnitude in the pool, it can be a problem. So it's something that's very expensive, and I think through the report that we're having Oak Ridge do that's taking an overall look at burn-up measurement, that's one of the things that we had them look at. Is there anything other than what's been done? Is there a more simple measurement that can be done that's not as robust, but something that would tell you, yes, this assembly has been burned, highly burned versus one that has not been so burned, but it's something we're looking at, but I think there's a great deal of difficulty associated with any kind of out of core measurements.

MR. RAHIMI: Well, I would say that right now that's the staff recommendation position in ISG, you know recommends they perform measurement, a physical measurement, and these measurement devices, one of them was originally developed for IAEA for safeguard purposes, but you know, in the '90s it was developed. It could be used for some kind of verification, and that's what the staff recommendation is now.

But industry's position is at this point there is no need to do the measurement because we believe, industry believes they do a very good job in controlling to prevent misloading, and they know the burn-up of the fuel assembly would be three, four percent reactor record. That's the industry position. That's why they have for the over and over again kind of imposed measurement, but at this point staff position is to do measurement, and that's why we are looking at, okay, the risk.

Okay. What can we do, you know? Can they do a bounding analysis?

But as of now, you know, that is exactly the staff's recommendation, to do the measurement, and that's how the HI-STAR 100 certificate was issued, but in the certificate, there is a measurement requirement.

MR. PARKS: And one of the things we're doing in this report on measurements has been done through Research, and Research has basically asked us to look at the measurement techniques that are out there that Drew and Meraj have noted, but also try to look at the reactor records and try to get a better grasp on that in terms of how it can be used in transportation, and so the overall goal of the report at least in my mind is to try to provide some information on those two areas and to sort of help the reader determine, you know, what value is there. Is there value added to doing the measurements, and if the measures are going to be done, how should they be done to provide that added value?

So the report also does look at records, I guess is the key thing I wanted to note, to try to look at the industry's look at the records.

MR. CROFF: Okay. Regarding consequences, as in the physical consequences of a criticality, I understand what you say about your ongoing report. I guess I just wanted to be explicit, and for all the years we've been transporting fuel and, you know, the potential of a criticality, nobody has ever done and published a study of the physical consequences. It sort of surprises me that nobody else has.

MR. PARKS: Because there's criticality in a package?

MR. CROFF: Yeah. It seems like sort of an obvious thing to do, to have done at some point.

MR. PARKS: From a technical fidelity standpoint, going through the details of what happens in a criticality excursion, it's quite complicated in a package. Now, you move to what the consequences are in terms of what that excursion results in and it can be a little simpler. So I don't think it really has been, Allen. You know, the work that we've done with NRC has been about the only thing I think you can find very much in the literature that I'm aware of.

MR. HACKETT: This is Ed Hackett, SFST.

And I think, Allen, that's a very good

question, and I think part of it relates back to the Commission and the Commission's strategic goals of zero possibility of risk of inadvertent criticality. So we haven't -- at least, we're from the NRC side. Of course we haven't done that. The rest of the world I can't speak to.

I think what you can say broadly, of course, is that as a minimum it's a disaster of enormous proportions for the industry if something like that were to happen, regardless of getting off into the actual quantification of the consequences in terms of potential fatalities and other effects on the public.

Certainly it would completely undermine, you know, confidence in the regulatory framework if such a thing were to occur and hence the Commission's strategic goal set it where it is. So I think that's part of the reason there probably hasn't been a driver from our side to actually get off to looking at details of consequence assessment.

MR. CROFF: Okay. Thanks.

I think with that I'll pass.

DR. WEINER: Mike?

CHAIRMAN RYAN: I had my questions answered.

DR. WEINER: Jim?

DR. CLARKE: I guess picking up on that, on the consequences and more so the -- not the actual consequences, but the perceived consequences, if you will, just the impact of something like that on the industry, I wanted to ask about the benefits as well and changing, you know, changing what you're doing now and granting burn-up credit.

Cecil had a slide number six. Can we pull that up?

Is that a real situation or just a general cartoon? So you're picking up four assemblies?

MR. RAHIMI: That's a quarter marker.

MR. PARKS: This is a fourth of it, one quarter.

DR. CLARKE: Okay.

MR. PARKS: So you actually have 32 and the one on the right you can see three, six, seven, eight times four is going to be 32, and you have 24 on the left in the entire package.

DR. CLARKE: Okay. I guess that was really my question. That is a real situation.

MR. PARKS: Right. This is basically the system that we're trying to validate, is the one on the right.

DR. CLARKE: You mentioned that we don't have a transportation fleet, I guess a fleet of transportation casks. Given the range of spent fuel with different burn-up credits, how would this play out? Would you have ranges of burn-up credit that would correspond to a different number of fuel assemblies that you could put in a different cask?

I mean, how would -- maybe just asking what other countries do is a way to get at it.

MR. PARKS: Well, okay. There's two issues. What other countries do historically, they have done a lot of transportation. The other major nuclear industry countries, France, U.K., Japan, they have been recycling, and so for years they've had casks designed and developed to carry spent fuel. Again, their assumptions are always fresh fuel also.

So then they had these casks designed, and they were usually low density packages. How much they could put in each package is relatively low, but they had this large fleet. They have a lot of packages, and what they want to do oftentimes or what they want to do historically was raise the enrichment. So now I don't have three percent enrichment anymore. I've got four percent and say, "Oh, I need credit in my package design that's already certified and built."

And so they've sought burn-up credit in their systems, not just transportation, but in their storage and reprocessing systems to increase -- to use burn-up credit to go with enrichment.

In this country, one reason we've looked at -- this is my personal opinion. I've dealt with burn-up credit since the '80s -- is that we have not settled on our full fuel cycle, and therefore transportation has always been somewhat a stepchild in terms of not having it completed, in not knowing exactly how we're going to do things.

And so there's not a large fleet of packages designed and built. There's a lot that's been certified for transportation, and so industry and DOE has always wanted if we're going to build all of these packages, we'd like to get them as optimized as possible.

And so when you get to these optimization issues, you get to what we're talking about today, trying to make sure that you understand your margins, you understand where you're at, you understand the risks so that you can design an optimal system which is the best for the cycle relative to cost and to risk, and you understand the margins.

And so that's why when I say they're

working to develop a fleet, that's one reason they sought this full burn-up credit. It has been sought by DOE and sought by industry to get, quote, full burn-up credit for actinides and fission products so that you get the maximum flexibility and the best optimization.

And so a cash shown on this viewgraph here on the right is a 32 assembly PWR, which would be for rail shipment. Some reactors do not have rail. You have to use a truck. You can either put -- you know, there's been a package designed for four, but more likely it would be two assemblies in a truck cask.

So there would be a range of casks, and then you have BWR designs where you either change out the basket and you'd have higher density.

DR. CLARKE: So you have different casks for different burn-up credit, would you not?

MR. PARKS: Not necessarily. This package on the right could be -- you could do actinide burn-up credit in this package on the right. However, the inventory that would be allowed to go in there would be less, but you could do it the way you do it, but again, that's not the desire.

DR. CLARKE: Okay. Yeah, because where I was going, I was going to the TAD and how this relates to it relative to the TAD.

MR. PARKS: Relative to the TAD, again speaking for myself and what I know is that if it does go to a smaller loading of spent fuel, you do not need as much burn-up credit. So you would not -- perhaps you may not need fission product credit depending on the design and how much loading they put in.

DR. CLARKE: Okay.

DR. WEINER: Yes, that's been stated that you don't, actually wouldn't need it.

Antonio, and then if I could just say, we are well over our time and I'd like to then cut it off, but go ahead, Antonio.

MR. DIAS: I think as far as supporting the reprocessing facility in France, I don't think they transport as many number of assemblies in a cask. I think it's a much smaller number.

DR. WEINER: Well, thank you very much. This was really a wonderful presentation, very comprehensive, and you've given us a lot of information and a lot to think about, and thanks again.

MR. RAHIMI: Thank you.

DR. WEINER: And, by the way, Cecil, you were asked to send some papers or links. If you send them to staff, to Chris Brown, he can circulate them to the Committee.

Thank you again.

Mr. Chairman.

CHAIRMAN RYAN: Thank you very much, Dr. Weiner.

With that we are scheduled for a 15-minute break. So we'll reconvene at 11 o'clock.

Folks on the bridge line, we'll close it for the moment and reopen it at 11 o'clock.

Thank you.

(Whereupon, the foregoing matter went off the record at 10:42 a.m. and went back on the record at 10:59 a.m.)

CHAIRMAN RYAN: While we're waiting, we had a request for some observations and comments on the previous session we just had before the break. So we'll ask him to make those comments in about ten minutes and any other comments we might want to have, we'll be happy to have those as well so that the staffs and the consultants and support folks all have the benefits of the comments and we're all here together.

So with that, I'll turn the session back to Ruth.

Ruth.

DR. WEINER: Everett, go ahead. You had some comments.

MR. REDMOND: I did.

CHAIRMAN RYAN: Would you pick up the screen?

DR. WEINER: For the record, this is Everett Redmond.

CHAIRMAN RYAN: From NEI.

DR. WEINER: From NEI.

MR. REDMOND: Well, I thank the Committee for letting me have this opportunity to just give a few brief comments.

First, I want to say I very much appreciated the interaction that occurred today and the extensive amount of effort that both the staff and ACNW put into this. I was very pleased with what I heard and very much appreciate all of the effort here because this is a real issue that we're dealing with.

I just want to first touch and say that the two pictures that were shown, one of the 24 casks and one of the 32 casks, those 32 assembly casks are being loaded today. They are deployed at many sites out there, and they will continue to be loaded. So this is a real situation, and we do have what I would call burn-up credit casks now that are loaded at sites.

And one of the comments I want to make is in regards to unloading or misloading events. There was a statement that we don't have any data on misloading events in regards to burn-up credit casks. Well, as I said, there are burn-up credit casks, the 32 assembly casks that are out there. So data in terms of misloading that covers all of the dry storage systems out there does cover burn-up credit casks, the casks that we are looking to transport using burn-up credit.

Another comment I'd like to make is in regard to burn-up measurements for a second. At the end it was stated that there's a burn-up measurement program that is in Holtec's license certificate. That's true. However, that burn-up measurement program does not, in my view, really protect against misloading. It's focused more on reactor records, and in fact, that burn-up measurement program as outlined permits them the utility, general licensee, to use measurements that were taken at another facility for that facility.

So it's not focused on preventing a misloading event. It's focused on reactor records.

Now, as Meraj said, reactor records have an uncertainty of three to four percent. Typically the industry uses five percent for the uncertainty when comparing the reactor records to the loading curves for wet storage, and we propose to do the same thing in terms of spent fuel casks for transportation.

I'd also say in terms of the measurements for a second that the measurements that are done, interestingly enough, have to be benchmarked or compared to reactor records because you cannot do, as I understand it, you cannot do a measurement that tells you exactly what the burn-up is without a reference. The reference is an assembly whose data comes from the reactor records. So it's kind of almost circular.

We have extreme confidence in the reactor records because the same records used to load these casks are the same records used to operate the reactors in choosing the assemblies that go in.

One other comment, another comment I'd like is in regards to Cecil's presentation, which I enjoyed, on slide nine they list a fission product worth of the top six fission products and outlined that, and as I understand it that's done with a best estimate calculation, not the isotopic correction factors that were talked about a little later that currently have to be applied in doing these analyses.

So if you were to include the isotopic correction factors in that comparison, I would venture to say that those worths would probably be considerably less. Cecil or Oak Ridge could speak to that better, but my guess is they would be considerably different in any case.

There was discussion of the unloading condition and concern that loading and unloading could be in fresh water. As we've talked about loading is in borated pools for PWRs.

Unloading, Yucca Mountain has committed to using soluble boron. So if we're talking about that facility, they will have soluble boron in their spent fuel pools.

We also, you know, recognize the facility for unloading would be an NRC licensed facility or at least anyplace commercial would go to, and one question I have is just couldn't the NRC impose soluble boron in the spent fuel pools for unloading. I just toss that out there as an idea.

One other comment I'd like to make, too, is in regards to conservatism, there was one section that wasn't discussed here, and that's some other areas of conservatism that are in transportation analyses, criticality analyses that's unique to transportation, and this is not done on the spent fuel storage site and wet storage, and that is that in the criticality analysis, we have to assume a work configuration of the basket.

So model a basket in its absolute worst configuration, be it whatever gives you the highest k-effective. On the wet storage side, what we do there is model at normal conditions and calculate reactivity, delta ks associated with the different tolerances and combine those statistically and add that in.

So it is accounted for, but in a much more conservative fashion here.

Also, we do 75 to 90 percent credit for the B-10 and the neutron absorber on the spent fuel transportation site, not on the wet storage site. And also we're required to model all of the fuel assemblies in the most eccentric position that gives the worst configuration. So that would be, for example, hypothetically all fuel assemblies move to the center, all four quadrants move to the center. It's not a credible configuration, yet we have to do it.

So there's additional margin, if you will, built into the way we do the analysis completely separate from the burn-up, separate from the isotopic information we were talking about.

And on just one last point I'd leave in regards to the storage presentation or discussion of storage, and it mentioned that there's an unquantified safety margin in regards to the burn-up of the assemblies. That's true. I would point out though that the certificate permits you to load anything down to fresh fuel. So you're permitted in storage to load anything from fresh fuel up. There's no burn-up. So it is unquantified, but it can very drastically all the way down to zero.

And I said that was the last thing, but I will say one thing else in regards to burn-up measurements for a second or not burn-up measurements, but loading, and that is that when we do loadings, we're required to have two independent verifications. You do double verification in loading, and misloading events have historically not been considered in the criticality analyses for either transportation or storage, which you know has indicated to me that NRC doesn't really consider a misloading event to be credible. We've got the two separate sets of requirements during loading.

And with that I appreciate the opportunity to toss out a few words here, and I certainly appreciate ACNW's and the staff's efforts in this regard. Truly, it's very appreciated.

CHAIRMAN RYAN: Thank you very much.

DR. WEINER: Does anyone have -- Allen, you had a question or a comment?

MR. CROFF: Yes, it's a question. I understand that industry is preparing some kind of a white paper on burn-up credit. When might we see that?

MR. REDMOND: Yes, and I should have mentioned that. I apologize for that.

Industry is working on a white paper to talk about burn-up credit and potentially high burn-up fuel. I'll tell you there are two things that are going on actually. We're working on a white paper, and EPRI is working on a topical report, which the topical report is slated for completion by the end of the calendar year, and that would be an expansion upon the white paper and provide some more technical details, focus on risk and some other things.

We will be meeting; industry will be meeting to discuss the white paper in late April, and then we will progress from there. I would hope to have something in some time in the early summer in terms of the white paper.

Ed Hackett mentioned that we are interacting with SFST, and we are and we appreciate that, and after we meet, we will be meeting with them to discuss a little bit more about the white paper so that, you know, we have interaction and feedback from them.

The purpose is for us to kind of propose, you know, what we as industry, the vendors, the utilities all agree upon as what we would like. You know, if we had our way, what we would like to see, and you know, you've heard some of us say that, well, why don't we just do it exactly like we do it in Part 50. Well, that does kind of make some sense. I mean, it's the same.

But we're not going to be as simple as that and say that we want it that way. We're going to recognize, you know, the situation here, that it is different. It is transportation, but we're going to throw out what we would like to see in terms of that, and then also we have a high burn-up fuel issue to deal with, which does work its way back into criticality as well.

MR. CROFF: Thank you.

DR. WEINER: Thank you.

That's it.

CHAIRMAN RYAN: Okay. Thank you very much. We appreciate everybody hearing that.

MR. RAHIMI: I would like to provide some rebuttal to some of the comments that Everett made, just a response. This is Meraj Rahimi, and I'm with Spent Fuel Storage Transportation Division.

Everett mentioned with respect to the burn-up credit cask being loaded at the present time. None of those casks -- even HI-STAR 100 are being loaded under storage license. They are not being loaded under transport certificate. So that's a big difference.

If they are proceeding with not doing burn-up verification measurement at this point, that's this apposition; that's the risk, you know, they're taking. But it's important to make sure all of those casks being licensed are under a storage license fee.

CHAIRMAN RYAN: Okay. Thank you.

MR. RAHIMI: And also, the best estimate versus correction factors, correction factors is not the only way we have entertained, and we have application in front of us. It's a combination. We have allowed, you know, best estimate. According to the Oak Ridge method, vendors have used that.

So I think the notion that a correction factor is the only method is really not true because we have also entertained with best estimate methods.

And one drawback of best estimate, you need to have data. They have had data, enough data for actinides. That's what they've used for a best estimate, but for the fission product, not enough data. They go correction route, correction factor method.

Okay. Well, if you need to sum up, I had a number of actually responses, but I think at this point maybe I'll just end it.

CHAIRMAN RYAN: We've heard from all of you. Then we'll end there.

MR. RAHIMI: Yeah.

CHAIRMAN RYAN: Thank you very much.

All right. With that we'll end the session on burn-up credit. Again, I want to second everybody's views that we really appreciate the thorough presentations and the detailed briefing you've provided us. It's getting a lot of important insights into where you are in the work, and some of the things that may be ahead. We'll react to all of that in our letter.

So thank you very much.

Okay. I will take just a two-minute break for those who don't want to sit through the letter writing session on a completely different topic. So if you want to depart now, that's fine. If you want to stay, you're welcome.

We'll take a couple of minutes just to let that happen, and the folks on the bridge line, please stay with us.

(Whereupon, at 11:11 a.m., the Advisory Committee meeting was adjourned.)