Official Transcript of Proceedings ACNWT-0198

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Nuclear Waster
177th Meeting

Docket Number: (not applicable)

Location: Rockville, Maryland

Date: Tuesday, March 20, 2007

Work Order No.: NRC-1484

Pages 1-249

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UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON NUCLEAR WASTE

March 20, 2007

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON NUCLEAR WASTE (ACNW)

177th MEETING

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TUESDAY,

MARCH 20, 2007

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The meeting was convened in Room T-2B3 of Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 11:00 a.m., Dr. Michael T. Ryan, Chairman, presiding.

MEMBERS PRESENT:

MICHAEL T. RYAN	Chair
ALLEN G. CROFF	Vice Chair
JAMES H. CLARKE	Member
WILLIAM J. HINZE	Member
RUTH F. WEINER	Member

NRC COMMISSIONER PRESENT:

GREGORY B. JACZKO

NRC STAFF PRESENT:
FRANK P. GILLESPIE
NEIL M. COLEMAN
CHRISTOPHER L. BROWN
LATIF HAMDAN
ANTONIO DIAS
DEREK WIDMAYER
MERAJ RAHIMI
EARL EASTON
LARRY CAMPBELL
ED HACKETT
BERNIE WHITE
GREG HATCHETT

ALSO PRESENT:
BARRY SCHEETZ
WAYNE HODGES
NANCY OSGOOD
EVERETT REDMOND
ALBERT MACHIELS
BRANT CARLSON
GORDON BJORKMAN
PHILIP WHEATLEY

C-O-N-T-E-N-T-S

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

(11:09 a.m.)

CHAIR RYAN: We will go ahead and start the record.

The meeting will come to order please. This is the first day of the 177th meeting of the Advisory Committee on Nuclear Waste.

During today's meeting the committee will consider the following: Savannah River national laboratory workshop on cementitious (phonetic) materials used in waste determination activities; stakeholder views on moderator exclusion; the Idaho National Laboratory U.S. Department of Energy views on moderator exclusion; the roundtable discussion on moderator exclusion; and the ACNW meeting with Commissioner Gregory B. Jaczko who will be speaking to the committee later this afternoon.

Antonio Dias is the designated federal official for today's session. We have received no written comments or requests for time to make oral statements from members of the public regarding today's sessions. Should anyone wish to address the committee, please make your wishes known to one of the committee's staff. It is requested that speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume so they can be readily heard.

It's also requested that if you have cell phones or pagers, that you kindly turn them off. Thank you very much.

And without further ado, I will turn over the rest of the morning's session to Allen Croff, Vice Chair, who is the cognizant member for the session this morning. Allen.

SAVANNAH RIVER NATIONAL LABORATORY WORKSHOP ON CEMENTITIOUS MATERIALS USED IN WASTE DETERMINATION

VICE CHAIR CROFF: Thank you, Mike.

To review sort of how we got to this point, last year we had a working group meeting on waste incidental to the processing where we discussed a little bit about cementitious waste forms, and our staff indicated it was a high priority to them and a risk-significant item.

Based on that we later convened a full working group meeting on cementitious materials, and wrote a letter on it subsequent to that.

Possibly because of that, or for their own reasons, the Department of Energy decided to have a workshop on cementitious materials in December when our letter was in fact done, and these other events had been completed. And we thought it would be a good idea pursuant to our responsibility to track technology related to waste incidental to reprocessing to get - to understand what went on.

Unfortunately it coincided with our December meeting. So we asked Professor Barry Scheetz from Penn State who attended our earlier working group meetings to go to the meeting and report back to us. He tried to do that in February, but Mother Nature didn't agree with our plans. So here we are at a somewhat more pleasant time of year.

So Barry is going to tell us what he heard down in Savannah River at this DOE workshop and what he thinks about it.

Barry.

MR. SCHEETZ: Thank you.

I'm a pacer, so you'll bear with me. The objective that was presented for this workshop was to provide common understanding for the issues involved with the use of cement on DOE supported closure projects, and to establish the needs for better long term performance. It's motherhood and apple pie. We know that; we don't have to go through that.

What the workshop was purported as being centered around - oops, let me work on this; I'm new on this - was the role of cementitious materials for low level waste, and in fact, I don't believe low level waste per se, as such, was ever discussed within the context of the meeting, except for the part of the lecture, the presentations that were given under this heading.

The other heading was the chemistry and minerological properties, and contaminate transport in cementitious materials; water and gas transport through cementitious materials; the degradation mechanisms; and test methods; durability criteria; and long term degradation evaluation.

And again, this is primarily motherhood and apple pie issues.

Long term performance prediction, risk assessment, integration, cementitious materials, and performance assessment model - those are the five categories that they had for the meeting, and then they took various presentations and put them under those terms.

The difficulty and the challenge that is before DOE and before us is the short term assimilation of civil engineering data is used as a starting point to go forward. This is what we are basing our information on; this is what we are basing our judgments on.

And if you look at that engineering application, our design for 25 to perhaps 100 year -we are trying to build 100-year roads now. I know when Pennsylvania was looking to construct its own internal low level repository, we were looking at 500 years.

But the bottom line on it is, the vast majority of our experience is limited to the time frame of 25 to 100 years. And the reality of the matter is, is that all of the mechanical properties, all of the evaluation properties that we develop for this cement is developed in that time frame, and they may or may not be applicable to longer time frames.

There is another issue that follows hand in glove with this, and that is, that DOE looks to the civil engineering application of cementitious materials for the warm and fuzzies. They look to these materials or to this group to get insight as to what materials can be added to cement, what adulterants can be added to cement.

We call them supplemental cementitious

materials. They perform in a similar manner to the hydration of Portland cement, but they perform at different rates; they tend to be cheaper; and they have other characteristics.

But the bottom line is that these materials then get used in DOE applications. And I am here to tell you mostly they probably get abused. What they will do is, they will get used well beyond the scope of the area that provided the comfort zone for applications in civil engineering. And of course this now creates uncertainty in the long haul.

The approach that I am going to take here, and the approach that I give in the report was, I didn't like those five topics, and when you looked at those five topics, there are actually issues that cross cut them. And I'd rather do issues rather than topics, and that's what I'm going to try to present here today.

So the issues. The conceptual model: what is the conceptual model? How do we develop it? What should be included in it? How detailed? We'll discuss that.

The perceived needs: everybody at this meeting, this is what we need. And the need, the list of needs is surprisingly large when you look at it in context of what's out there for civil engineering applications for cementitious materials. And the - we'll discuss the reasons.

Part of the proceedings have to do with modeling; part of it have to do with database. I'm going to talk about issues not discussed, and this is my overlay on the whole meeting.

And then I'm going to give you again some observations I have that there were overlays on the meeting.

So let's talk about the conceptual model. The concern about the conceptual model is it's appropriateness. Do we have a conceptual model? We have to be able to develop one that's going to - to look at the performance of cementitious materials. It's going to have to establish the performance of cementitious materials. And then it's going to have to be able to describe it for the time interval involved.

In the October letter one of the questions was, how long is this? How long is it going to last?

That issue was never brought up at the meeting. Nobody discussed anything in terms of, oh, this is going to last 5,000 years, or we are going to project it to last 2,000 years.

The terms, were all discussed in terms of 10,000 years. So the underlying conceptual basis for what took place at this meeting was basically the 10,000-year time frame.

We don't even know the mechanisms for that period of time. So there's a great deal that has to - and a great deal of initial thought that has to go into the development of the conceptual model.

We have to make it detailed enough to be effective, but we can't make it too detailed, because between you and I the amount of material and the amount of information that is going to be necessary to support this is going to be staggering. And under those circumstances you can go too detailed, and I will try to get into that a little bit more.

So this conceptual model has to strike an even chord.

The other thing that the conceptual model has to take into consideration is that in the decades to come, while we are cleaning up DOE, the various sites on DOE, there are going to be regulation changes. And how do we integrate those changes into this conceptual model?

The model has to be robust enough that it's got to allow those changes to be integrated.

And it has to be robust enough to take an iterative approach. There was one very, very good paper by NIST down there, a guy by the name of Snyder, and he was talking about long term modeling, and how to do long term models, and it's this iterative approach. And you sort of meander from side to side down some mean, which you don't know where that mean is until you focus in on your end your result and your final product.

It was an excellent, excellent presentation, and I think it may have just, phht, over the heads of everybody that was there.

But we have to take that into consideration. We have to take into consideration that this is going to change; our standards are going to change. How does this conceptual model change with it, with response to, oops. What we have to also look at is this 10,000-year time frame. Is that the appropriate time frame? Is that the appropriate time frame for the sequestration that we are looking for?

It may not necessarily be the appropriate time frame for all of the materials that DOE is going to have to address. And some of those could be relatively short term, in the term of several hundreds, say 500 year, on out.

Got to do it. Got to figure out what this model is. And this is the starting point for which evaluations of cementitious materials needs to be done, and it's the key point, I think.

This was brought up about monitoring and maintenance. And actually I brought it up. And nobody wanted to hear, as far as I could tell, this idea of the potential of going back and doing maintenance. The whole discussion down there focused on, I'm going to do this. I'm going to finish it. I'm going to get rid of it. I'm going to walk away from it.

No, you are not. Some of the projects are going to end up as legacy projects. Some of the projects are going to be so large we are not going to walk away from them.

The concept of monitoring, of nonintrusive monitoring, is in my estimation an extremely interesting area right now. And it's an area that I think there's a potential for an enormous amount of growth.

I have colleagues at Penn State right now who can take a sensor and embed it in a piece of concrete, walk up to it with a microwave and interrogate it. It's passive. It sits there 99.99 percent of the time until you tweak it, and you can interrogate it with a microwave beam, and it will begin to oscillate, and you can pick up the oscillations, and determine the state and conditions of the concrete inside.

And this is only the very beginning, this idea of smart aggregates that would be passive smart aggregates that would be placed into the concrete that would withstand the chemical environment. It will sit there, and when you ask it to, when you interrogate it, when you tweak it with a microwave, you can get it to evaluate its surroundings and report back to you.

This is coming, and it's going to be I think the potential growth area is absolutely enormous.

I notice in the letter that there were concerns about how you are going to monitor, and if you drill into something do you provide an access from the exterior to the interior of the monolith, that way, and potentially jeopardize the performance.

This is an area of growth, and this is an area I think of potential future interest.

Maintenance on these things: we are going to do maintenance. We have to do maintenance. It allows us to do that interim approach to focus down on the end state that we want.

The other thing it's going to allow us to do, it's going to allow us to use insight that develops in the interim. We are not going to be out there necessarily every year with a trowel and mortar patching this thing. But with time, on a set schedule, you are going to go out and look at the monolith to see how it's performing. And in that interim, you may indeed come up with new insights, with new techniques that you can apply, and the maintenance will have the potential to extend this.

One of the things that was very, very heavily stressed in the conversations at this meeting was to try to avoid the trap of being conservative. Here we have done this for years and years and years, and frankly I think they have shot themselves in the foot in many instances where they are taking a very conservative approach, and it's too conservative. And I think it has extended the cleanup in many cases, where they just grossly underestimated the performance of the system.

Where you can take credit for it, you need to. You need to set appropriate degrees of complexity in the conceptual model. In fact, I think this next topic was brought up by David Esh, who was down there, about you know, he put it out as a conversational point, that we don't necessarily need a numeric value for a property, but perhaps a less than value is more correct, so that you can provide an acceptable risk to the biosphere.

The idea of getting a finite number tends to overdrive the system. And it's the classic engineer versus science argument. When is enough? When is it enough that I get six decimal places, or seven decimal places, or eight decimal places? When perhaps all I only need is one.

So when we do the conceptual model design on this that we are going to need to do for performance assessment, all of this has to be factored into it.

The perceived model, the bottom line on this whole thing was that there are too many models. There are far too many models. The models are overlapping. Sometimes they are using each other's data. Sometimes the same data has different values. The data is not vetted properly.

Some models are trying to be a model that's all inclusive so that the structure and the components that go into it are well beyond normal uses. They become very very complex, and as a consequence, it makes the model much harder to use.

And in some cases, I'll be honest with you, there are people out there who have vested interest in pushing a model. And that vested interest is a financial interest.

So what needs to be done is, this needs to be honed in. Like asking the question, who should be leading this?

And NIST is a really good potential for a group to lead the charge on this. NIST has an excellent modeling effort. They have an excellent group in thermodynamics. They have an excellent group on mass transport mobile. They may have - and if they don't have everything that's need, they are not far from it.

The concept of reaction transport, this area looks very good. Neil Plummer has developed PHREEQUE and has maintained PHREEQUE over the years, and it's again a thermodynamic program based on an equilibrium situation. But it really looks like it's enhanced. It looks like the know how is there, not necessarily all of the data that we would want or need or desire is there. But I think the mass transport is pretty much okay.

The idea of taking and coupling reaction transport with mechanical problems - or mechanical properties is not there. Nobody has done that. And this is something that is going to be an area - that is perceived as an area of importance, that is an area of need.

The bottom line on it is that I don't know anybody out there that's doing this. So this is a fresh area.

And I moved these around this morning; that's why they're coming up funny here.

Going back to the duplicate model, one of the things that we need to keep in mind with this duplicate model, many of the models are taking data output and they are just fitting the data. They don't know why the data is doing what it's doing. It has not necessarily have anything to do with the mechanism that's going on. It's just data fitting. And that's fraught with danger.

I think everything, any of these big models that we endorse, or the model that we endorse, must be mechanistically controlled. And it's got to be applied appropriately when it is.

So this is very important, and these were issues that came up.

We have a degradation model right now. We now - I teach in class how cement falls apart. And Walton, who is now at the Southwest Research Institute, when he was out at Idaho, had a really nice little monograph on the durability of cementitious bodies for low level waste disposal. And he's got a nice little model. We know the mechanisms. We know what mechanisms come apart, or make the concrete come apart.

But the question is, in the long haul, is there anything there out there beyond the next 500 years that is going to kick in? Is there something out there that becomes more important at year 500 than it does at year 200?

This remains to be seen. Getting a robust integrated degradation model was needed, and was perceived to be needed. And that wouldn't necessarily be that far off of making it work.

What was very important that was

discussed was the transport in the vados zone. And here you have two-phase flow in soils. And there's been very, very little work done on this according to the people who talked at the meeting. I'm not a vados zone person, but I can look at the vados zone, and look at the transport in there, and imagine it is similar to transport in a porous material, aka cement or concrete, and the two-phase flow in these materials is a challenge. There are a lot of people working on it, but in the mechanisms in soils, this was deemed to be a very important area.

The other thing that we need to do is, we need to look at probabilistic models. This idea of coming up with a number, and coming up with the number, is short sighted. We have to, if we are going to do this, and we are going to try to predict out these long time intervals, then what we really need to do is, we need to see what the probability is of this occurring. We need to apply risk assessment concepts. We need to just - Monte Carlo works very well. I can't emphasize that more.

There were people who were talking at the meeting who are hamstrung that they cannot - and I believe Hanford I believe is one of these - that they cannot use a probabilistic model to lay out the performance of whatever their model. They have to have the number.

And you can't do it. It's just not a feasible concept. At least with the probabilistic approach, we have an idea, and we have an understanding, of what the distribution of the probability of an occurrence is, and the number you can check to see where it falls within that.

But it just seems silly that we are hamstringing our efforts.

Data needs: there's lack of some fundamental thermodynamic data. We have thermodynamic data for many, many phases, but not necessarily all of the phases. We don't have thermodynamic data for radionuclide complexes necessarily that would be necessary to go into like PHREEQUE and these models.

So there is going to be some data that is going to be necessary. That data is going to have to be vetted. It should be collected with an acceptable protocol.

So this idea of standards and standard data acquisition methods becomes increasingly important, because you can use several different ways of getting data. If you are using the Scheetz method, or the Dias method, the Dias method may be an ASTM vetted method, and mine may not be. I'm putting my data in, and that just muddies the water.

If we are going to do this, it should be done with some kind of a standardization, and a standard - acceptable vetting process.

The thermodynamic database, as I said, is not too bad. It's there. There is some more data that is needed.

What is missing is the kinetic data. And the kinetics data becomes - (makes sound effect). You know at least thermodynamic data you can calculate. The kinetics data are going to be dependent upon external factors, the environment in which the concrete or the cementitious body is setting; what the moisture is; the temperature; the carbon dioxide partial pressure. There is a gazillion variables potentially that could go into that.

And what that does is, it makes it exceedingly difficult to get this data.

If you look at the cement literature, Fred Glasser who sat right over there at our meeting earlier in the year, he's done a great deal of work on the hydration of various phases in Portland cement. But he hasn't done the hydration of these phases in the presence of fly ask, which is a supplemental cementitious material that's widely used in both civil engineering applications and in DOE applications.

All of this has to be taken into consideration. And when you look at the variability of components versus the variability of environmental constraints, this is a daunting task.

It's an impossible feat to get a database of kinetic data for everything. This is where a well developed conceptual model should be able to focus this in, and at least put constraints.

There was an expressed interest - there is a lack of redox couple information in this highly alkaline environment of the Portland cement. Portland cement, in order to be stable as Portland cements need to be at pH greater than about 10.6. Typically the pore fluids of a Portland cement are in the neighborhood of 13.3, 13.4, because of potassium hydroxide that is being manufactured into the cement.

So the oxidation reduction for immobilization of species of interest is very important. We will typically use ground granulated blast furnace slides because they contain elements of sulphur which acts as a redox couple and pulls them down.

But you know the reality of the matter is, good hard data, evidently, is not there to the dismay of many who are out there modeling.

Same way is the lack of speciation data. And this is what I was trying to get at earlier for the nuclides in this high pH environment. Most of the work has been focused on environmental issues, and you very rarely get the high pHs for environmental issues.

Same way, needs lack of experience with transport in the vagos zone. It's interesting that if we went out and Googled cement, we could probably fill this room with publications. But you know there is no single database with engineering properties.

Now we have standardization where we have an A type of cement. And we know what that type on cement is like, because there is a prescriptive standard for it, and you can go to Washington and get Type 1, you can go to Washington State and get Type 1, and they will still fall within that prescriptive standard.

And you know, you can't go anywhere and find the data. You can't find engineering data for this. And this is what was asked for. What's out there that we can look at that we could use? There is no single source for this. The sole source are the della Roys and the Fred Glassers of the world that are out there. They are wonderful databanks, but they are just not there. You can't plug a card reader in and dial and expect to get all the information out of it.

But we need this. This is something that would be a great input to both the DOE program, and it would certainly be a great input into civil engineering in general.

Data needs: as a framework for the survivability of blended cement. You know we talk about these blended cements, and we talk about using supplemental cementitious materials in Portland cement. I would challenge you to find a concrete anywhere in the United States that's placed that doesn't have a supplemental cementitious material added to it.

Why? Because they make cement better. And if you - I mean I can get on my high horse here and start talking about cement manufacture, and what

I think about it. But the reality of the matter is that we adulterate the cements with materials that are generally waste products - and I hate that term, waste products - they are cast offs, they are important materials, they are useful materials, that one industry doesn't need, doesn't want, but one other industry can use. So they are cast off materials.

But they will in all cases augment and improve the properties of the cementitious body. Otherwise who would use them? I mean that's the bottomline. They all offer some benefit.

The problem is that they are cast off materials from manufacturing processes today, and they vary. And as manufacturing processes change over the next couple of decades that we are going to be applying this, they are going to change.

We don't know what the properties are, we don't know the survivability, we don't know the durability of those materials. We have an idea that they are going to be good, because the cementitious reactions that take place with the use of supplemental cementitious materials is the same as what's taking place in Portland cement. But they take place either at different rates, or through slightly different routes - I am not going to say mechanisms, because mechanisms of hydration are pretty much the same, but they will take different routes.

But how do you get the necessary thermodynamic data, or the necessary kinetics data, on a target that is going to be moving?

They are important. We can't live without them in the cement industry. But the reality of the matter is, we don't know very much about them.

As I used the example of Fred Glasser a little bit earlier, he started to do this, and he can hydrate cement for you as a function of time, and as a function of a small increase in temperature.

But if we throw fly ash in, or we throw silica fume in, or if we throw ground granulated blast furnace slag from Alabama in, all of a sudden the wheels come off the cart.

So this framework has to be set up, the data has to be there, and we have to understand it, and we have to understand it in the context of it changing.

Cracking, in the letter, cracking was

posed as a significant problem. It is a problem, but I'm not sure that it's a catastrophic problem. There are cracks, and then there are cracks. When you use the word cracking, it's sort of derogatory. It sounds like it would fail.

The reality of the matter is that if a crack is less than point zero zero eight inches, whatever that number is, it won't carry water. And nobody cares in a civil engineering application because it will not carry water.

So you can have a material, a cementitious body, that is cracked to high heaven, and if nothing is going to flow through those cracks, so what? It's engineered to withstand the cracks. Most cracks don't penetrate very far, when they do crack. And it depends upon the structure of the body.

You know cracking could be good, it could be bad. I'm not sure it could be good, but it doesn't necessarily have to be bad.

Are there models for cracking? No, not that I'm aware of. We know why things crack. We have a fairly significant idea of why things crack. Are there models that will start with fundamental composition of a Portland cement and predict cracking? No. Most cracking is going to be irrespective of what the cement is. We do need to have a better understanding of cracking. But cracking isn't a four-letter word.

There was a significant concern about the monitoring of the microstructural development of the hydrating cementitious bodies. And nothing there. The background that I am using on my slide is a hydrating cementitious body. I mean how do you quantify that? How do you model it? How do you put it into some kind of a transport, reaction transport scenario, and context?

There are some challenges here. But we really do need to know what is going on. The microstructure is everything. These are pores, this dark shadow here are pores. The fuzzy nature is the glue. That's the glue in Portland cement that's making it Portland cement.

I can control that. There are products on the market that are nanometer seeds that are being sold in the United States, and are used to product concrete in the tens of thousands of tons over the past 25 - almost 30 years now that are the same composition as those, as the glue, and it goes into concrete at 400 parts per million, very very small mass amount, but in vary, very large numbers, and it can control the microstructure. It's a seed. It templates the growth. You can make waterproof cement in that case.

But how do you model it? So these are things, and these are going to be challenges to the scientific community.

This again is the data necessary to support the degradation model. We know what's important. What was discussed down there was basically sulfate attack and carbonate attack as the two principal sources of the degradation of Portland cement.

I'm not sure that that's totally always the case. I'm not sure in some scenarios how much of a problem carbon dioxide really is.

We know that cement is thermodynamically unstable. We state that up front. The end state of this is silica, it's quartz, it's carbon dioxide, it's water, and it's calcium carbonate. Those are the components that cement started from. And that's what they'll ultimately end up going to.

But that's if they are exposed to a high relative humidity and a high moisture environment - or a high carbon dioxide environment. The

Colosseum, the Colosseum had cementitious material in it. If you go - and actually della Roy did this, she walked over and you can picture this genteel little lady going over and pulling this pick axe out of her bag and going whack, and walking away. Nobody challenges.

And so you have a piece of cement from the Colosseum, and if you look at it, it's quartz and calcite; it's exactly what it started as. But what's the Colosseum been? It's been exposed to the atmosphere.

Chris Langton as part of her program of study with us at Penn State when she was a student there, she went over with the National Geographic Society, and she went to Crete, and she got water basins, that were still carrying water, that had this material in it, right? So concrete or cementitious material, and the degradation and alteration of these is a function of its environment.

So here you have something that's lasted for several thousand years - now it was a pretty crappy cement to begin with, but nonetheless it was a cementitious material - it's still carrying water, thousands of years later, because it's always carried water. It's been kept wet. It's been kept out of the air, and drying and humidity. So it depends on where your concrete goes.

If you look at the applications that we're talking about, about going back in and filling a submerged - or an underground tank, or filling a canyon to close one of the canyons at Hanford or Savannah River, what's that concrete going to be exposed to? It's certainly not going to be the Colosseum. So the alteration products, so the kinetics of those alteration products, aren't going to be the same.

In that canyon where it's restricted from carbon dioxide, it's in a 100 percent relative humidity environment all the time, it could last thousands of years or - well, I'm not going to say tens of thousands - it could last thousands of years, or multiple thousands of years, before those alteration processes start.

So this - I'm hoping to try to pull all these threads together and make a net out of this. We need to understand that.

Sulfate, everybody is concerned about, is from sulfate in the groundwater. So if you have a tank and you are going to put this in - out at

Hanford in a shallow landfill, and the gypsum that is in the environment out there, and the environment changes, we get more rain and you are percolating sulfate laden groundwater through it, you have the problem - the potential of causing problems.

Look at what's taken place in California. All of these multimillion dollar houses are built out there. This is the latest fiasco in the cement industry, the concrete industry. They built all these big houses. They poured concrete basements, the walls for the concrete basements, and they were just fine. Then they landscaped the house, and they put gypsum, ah it's nice, these nice white stones, they put gypsum landscaping all around the house. Gypsum has got a finite solubility, and it soaked in next to the foundation. And guess what? They got degradation.

This is a billion dollar lawsuit, billions of dollars in lawsuits. And they could have solved it very simply; used quartz instead of gypsum for your landscaping.

But these are the kinds of issues. And the people who have talked about this figured that the sulfate and the carbonate were the big issues. Well, we know how to handle those.

There were a couple of issues not discussed. One of the issues that was not discussed was the role of organics. Organics are used, modern concrete is a soup, it's an organic soup. I've actually seen one situation where they were calling for the addition of a retarder, an addition of an accelerator, plus an air entraining agent, plus a superplasticizer. And you know, it's like taking Valium and then taking an upper to overcome the Valium, and taking Exlax to plasticize everything.

(Laughter)

This whole issue of organics is very important. We rely very very heavily, construction, engineering today relies very heavily on the use of organics to ameliorate the radiologic properties of concrete.

Folks in the DOE have used it. We have other wastes that can integrate into it that are organic. These are probably the biggest long term threat. We don't know how they are going to behave. They are certainly going to respond to a radiation field from entrained emitting particles.

This is an issue that needs to be addressed, and needs to be talked about, but wasn't.

The other one that surprised the

bejeebers out of me was this: and this is baffling. You had - and I'm going to kick my academician colleagues in the shins. I hate that word, oh, it's only an academic exercise. Bull.

But you know you mix things up in the laboratory with a Waring blender. It's a food blender, a food mixer, that you use for - in the kitchen, right? It's the same thing. The Hobarth - not the Waring blender, I'm sorry, the Hobarth blender, the Hobarth blender was developed and standardized by ASTM to mix concrete, or mix mortars for cement.

So we mix it in the lab with small scale. And you just can't do it. You can't do a big scale, so you mix small scale, and you get these to vet the mechanical properties.

Well, when it comes to doing it big scale, it doesn't work. The properties are different. In our laboratory, what we are doing is, we will do the lab scale just to point us in the right direction. Then we will go to a three-quarter yard from a quart to three quarters of a cubic yard to do it, and then when we really want to vet it, when we really want to get the correct properties for Penn DOT who we were working for, we got the local cement company to mix it up and bring it in, back the truck up to our building, and dump it into our molds, and then we test it.

Some of the most recent research that one of my graduate students is finishing up right now is for a Penn DOT project. We've seen the proof testing for concrete bridge deck applications, and the company - the engineering company mixed it up in a four cubic yard truck, and they roll it.

Now you can picture a truck, right, and it's half full, and it's rolling and mixing. They did it half full, and then when they start delivering this to the site, the truck is full. Now, you know, you are rolling it, and the energy that you are putting in, and the mixing, that makes it different that you are carrying that cement up and you are dropping it down the diameter of that barrel, and you are getting good agitation and good mixing.

If it's half full versus full when you are mixing, that's different. And we can see it. And it just surprised the bejeebers out of me that this wasn't recognized by my colleagues both from the DOE side, from the national laboratory side, and from the academic side.

Fred Glasser is over there. He knows it. I know it. But I think Fred and I were just two people out on the fringe.

This is a very, very important issue, and it needs to - the devil, you know the devil? It's in the details.

Finally, I have one last observation. I've been doing this for 32 years, and up until this meeting, every meeting I've been at in the past people are bemoaning the fact, ah, I need characterization equipment. I can't see this; I can't see that.

You know there wasn't one person down there who said anything about characterization. We must have it. I mean we must be able to do what we want to do with all the instrumentation that's out there. There wasn't one peep about having limitations.

And I was sort of pleased at that. We've come - that's a major milestone as far as I can see that we understand - that we have available to us whatever is needed in order to characterize these bodies.

I'd like to just take - this is a slide you don't have - I'd just like to take two minutes and I had some comments on the letter, your October letter.

There were some wording in there that was used that I thought could have been chosen better. The description of blended cements, dirty cements, leaves a negative connotation when I read it. They are blended cements, and they are blended for a reason, because the materials that are added really do carry something to the mixture.

Yeah, I understand, I understand the term dirty, and I understand how it was used in the context of - within which it was used. But you know I don't like it.

The other thing that we need to talk about I think is the movement of water through concrete. The description in the letter suggests that you have a porous cementitious material; you pour water in the top and it runs down through it, flows out.

I mean that was the connotation that comes with it. The reality of the matter is that the permeability of a reasonable cementitious body is about 10 to the minus six centimeters per second to 10 to the minus eight centimeters per second. And once you get down below 10 to the minus eight and 10 to the minus nine you are pushing on to diffusion, to thermally driven movement of water through an object.

So we have something, a good quality concrete, a good quality cementitious body, has got a very low flow. So if it's a thin member, it might not take very long to go through. But if it's a large cementitious object, like a filled canyon or a tank, and you look at water flowing through this, and you look at the head necessary to drive it through something of that permeability, you know, you're never going to get that head.

So these things don't - water doesn't run through this concrete. Even in 10,000 years water doesn't run through this concrete. Get Walton's paper and look at that. He's done some really fundamentally crude calculations on the flow of water through cementitious bodies, and you know, the numbers for any number of feet are coming up in the hundreds of thousands of years.

So even if it's cracked - remember, not all cracks carry water. This is turning into a lecture, and it shouldn't, but here comes - not all those cracks are going to carry water.

And particularly if this thing is kept

in a moist environment, it's going to maintain this microstructure for a long time. You are not going to get a lot of surface penetration of carbon dioxide, of oxygen. It's only going to occur in thin members if they are exposed.

The other - the other issue in the letter that I wanted to bring up, where it has to do with the one recommendation on the chemicals that cause degradation, I know that was talked about in our meeting here earlier.

You know I'm not sure that that's really that big an issue. It's important, but it's not like there are a gazillion out there. It's not like the periodic tables influencing this.

The degradation of concrete is going to occur from just a finite number of compounds. Somebody can go out and do this. But there are other issues, there are other needs that I think are bigger. And I'm not sure that I necessarily agree with that.

The other issue in there was monitoring, and I think I touched on monitoring. I think monitoring is necessary. I think monitoring and maintenance, hand in hand, are necessary, and going to happen. And I think that, if you want to put your money somewhere, put it there.

I'll take questions.

VICE CHAIR CROFF: Okay, thanks Barry.

We got started a bit late, but not got a lot of time left. So a couple of questions each, maybe?

MR. SCHEETZ: And NIST I think is a reasonable choice. I really do. I think NIST has the modeling capabilities. NIST has the thermodynamic capabilities. NIST has the programmatic mind set to do it.

What they don't have they can get. And the other thing they probably don't have is the crinkly green lubricant.

MR. HODGES: To put this in context, before your presentation, which was a real wower, I asked the question, who is putting all this together, and who is capable?

And I suggested that NIST is - what will it take - is DOE putting all of this together?

MR. SCHEETZ: You know that - I think they would like to.

MR. HODGES: You are talking about probabilistic performance assessment. And it could just be a series of interactive models that are involved. Who is putting all of this together, looking at the uncertainties, and looking at the interconnections?

You haven't talked at all about coupled processes. And it would seem to me that that's an issue.

MR. SCHEETZ: I did talk about coupled processes, with the mechanical properties in reaction transport, reaction transport. So there are some of those coupled properties.

But those are data needs rather than -

MR. HODGES: I feel the pressure from my colleague on the left.

Let me ask you a very simple question. Let me try to put this without putting words into your mouth.

But what I heard initially from you is that the long term performance assessment of these cementitious barriers is a very difficult process, and is next to impossible at our current state.

My question to you is, what is preventing us from extrapolating from the present, or from a few tens of years, or maybe a hundred years, into a thousand years, 10,000 years?

What is the issue here that is

preventing us from this type of extrapolation?

MR. SCHEETZ: Nothing. I mean we can extrapolate.

MR. HODGES: With limitations on the uncertainties.

MR. SCHEETZ: If you - the limitations on the extrapolation is going to be - what's the environment that you want to extrapolate this into?

MR. HODGES: It really is, when you talked about the processes over the next 10,000 years being unknown, what you really are talking about are not cement properties necessarily or processes, but more the environmental processes. What is the climate change going to be? What is the change in the water table? What is the change in the geochemistry?

MR. SCHEETZ: That's the constraints. I mean -

MR. HODGES: It's less the cementitious characteristics and more the environmental characteristics?

MR. SCHEETZ: Right. And what I have to stress, again, and I know I can't begin to stress this enough, you think of the ore basin and the Colosseum, right. The Colosseum has been exposed to varying relative humidities and carbon dioxide at 10 to the minus three - or three point five.

MR. HODGES: Let me interrupt you, because you are taking up too much fo my time.

(Laughter)

Barry, a very quick question, because I'm being pushed here. And that is, when I read your report, I sensed that there was a lack of consideration or concern about using archeological cements and geological analog, and that these received very little attention at this meeting.

MR. SCHEETZ: They did.

MR. HODGES: And a very simple question: why is this true?

MR. SCHEETZ: Funding. There was just - I mean what the people were reporting on was basically on their research; what was going on.

MR. HODGES: It's easier to sit in front of the screen and model than it is to go out and look at the real world, which I sense you are coming from in your presentation.

With that I'll pass on.

CHAIR RYAN: Cement has always intrigued me in that we tend to focus a lot on the phenomenology around the cement. And I come at it from a different angle. I don't really care about the phenomenology. I want to know how well it contains waste. So I'm interested in the experiment where we put some waste in cement, in whatever form or fashion, and then put it in some kind of environment, hopefully a realistic one, and see how it behaves.

We've got the branch technical position here at NRC, waste form and waste classification, which is make little cement cubes, and soak them in fluids, and if it passes these relief fraction testing things, you're fine.

Help me understand who is really on the cutting edge of experimental work, or system behavior - systems - whole system, the radioactive material, the waste form, the cement, the environment it's in and all that safe, to say how they are going to perform, whether it's short, intermediate or long term? Is there a -

MR. SCHEETZ: For the leaching?

CHAIR RYAN: Well, that's where the rubber meets the road.

MR. SCHEETZ: Yeah, for the leaching, we know that Vanderbilt is doing a great deal with that model from -

CHAIR RYAN: That's a model. I'm not interested in a model. I'm interested in cement in laboratory stuff.

MR. SCHEETZ: Well, they are actually doing laboratory stuff to verify that.

In the -

CHAIR RYAN: That's a different kind of experiment.

MR. SCHEETZ: That's a different kind of experiment.

CHAIR RYAN: I'm not asking about those.

MR. SCHEETZ: PNNL and Savannah are the two major areas where there is anything going on.

Let me just share - I'll take two minutes - one minute - 30 seconds to share a quick observation with you.

In my formative years I went to the American Ceramics Society and I gave a presentation on the leaching of waste forms. And this was when we were still messing around trying to find out, glass, cin rock, super calcite, cement, glass, you know. And of course -

CHAIR RYAN: Fifteen seconds.

MR. SCHEETZ: And of course the leaching protocol turned out to be, you use glass, and you use the geometric surface area. Because on a glass the geometric surface area is good.

So I gave a presentation at this meeting, and I used real surface areas of cement versus glass. And if you looked at them on a geometric, they compared favorably. But when I used real surface areas of the cement, my leach rates were five, six, seven orders of magnitude below glass. And those were real surface areas.

CHAIR RYAN: You know I understand all that. But at the end of the day, it matters how much gets out, and how much gets to a receptor. That's the performance measure that counts. The rest of it is kind of fun with numbers.

MR. SCHEETZ: Don't say academic.

CHAIR RYAN: I said fun with numbers. With that I will pass to my colleague to the left.

DR. WEINER: Wow. I just have one question: If you were to advise - if DOE or some agency were to say to you that they would like to use some form of cement to stabilize radioactive waste for some period of time, say between 5,000 and 10,000 years, and this was what was available to them, maybe the top surface would be exposed, maybe most of it would be exposed to the ordinary atmosphere, what kind of advice would you give them?

MR. SCHEETZ: Well, A, it could be done. I think it could be done. It would be an engineered approach. It would be a multi-barrier approach. And knowing the degradation mechanisms and knowing the shortcomings of cement that we have right now, we could design this and engineer this to - and I would need to know the waste, obviously, and that. But I think it could be done. I really do.

DR. WEINER: And you would feel fairly confident predicting that this would remain stable without significant degradation for that period?

MR. SCHEETZ: Whatever, yes. Whatever significant degradation means. I wouldn't - I think we can do that. Yes. I think you can do it. I think that these things are going to perform.

We have the natural analogs, and we have the manmade analogs. And if we really understand them and study them, natural analogs only work if they are quantitative, and that's the problem. You've got to make them quantitative.

DR. WEINER: Thank you, and I'll pass to my colleague on the left here.

DR. CLARKE: I guess just a quick comment and a question. I am absolutely flabbergasted to hear your assessment that you were the only person there concerned about monitoring and maintenance.

I mean I couldn't agree with what you said more. I think those are key, critical issues in long term performance.

MR. SCHEETZ: I won't tell you that they threw tomatoes and old cabbage at me, but it was damn near.

DR. CLARKE: It may not be part of the agenda, I don't know. But at any event, I was flabbergasted to hear that.

The question is, are there plans for proceedings? Are they going to publish the papers and make them available to us?

MR. SCHEETZ: It's my understanding that they are going to put out a CD with everyone on it.

DR. CLARKE: And I just wonder, Allen, are you plugged into that? Can we get that?

MR. SCHEETZ: I haven't received it yet.

VICE CHAIR CROFF: I'll tell you what, if you could remember, just drop me an email when you get yours, and then we can go and -

DR. CLARKE: If there is a plan to do it. I can certainly get one.

MR. SCHEETZ: And I understand the DOE EM has indicated that they anticipate having follow up meetings.

DR. CLARKE: Okay, thank you.

A couple of things. First, this sort of follows on a question of Bill's. Was your sense out of this that DOE is going to try to undertake some kind of program on cements? And move forward with this? Or was this some sort of just everybody get together and have a good time for a few days?

MR. SCHEETZ: No, I think that they would like to take on a program on cement. And I think they are groping to understand what to do. I think that that's what this was.

Yes, there will be follow up meetings. My sense of this whole thing is that there has to be some lead agency. There has to be a unified national effort if you are going to do this.

And there are simple things. You take one lead agency. If it's DOE or it's NIST or whomever, you appoint that agency. You cut down on the number of models. You come to consensus on what's the best model. You come to consensus on data that's needed. You come to consensus on data collection.

None of this data is any good if it's

not internally consistent. And you know what that means is, that whoever is going to take on those responsibilities has to do it for life. And you look at Lawrence Livermore - yeah, LLNL, Lawrence Livermore Nationals Labs, and they've taken on EQ3, EQ6, and run that database. And that's been a lifelong project. That's what you need. You need somebody who is dedicated. Somebody who has secure funding to support him for - or them, you know, generic term - for the duration.

You are looking at something that is going to be 30 or 40 or 50 or 60 years out. You need that institutional support.

DR. CLARKE: Okay. Maybe one more. I didn't hear - or at least I didn't take out of it - let me back up. DOE is trying to take credit for maintaining certain chemical conditions in their grouts, reducing conditions, and a low pH in terms of radionuclide movement.

Was there any discussion of modeling the ability of a concrete to maintain those conditions, as opposed to mechanical properties or something else?

MR. SCHEETZ: To the best of my recollection there was not.

DR. CLARKE: Fascinating.

VICE CHAIR CROFF: Okay, with that, thank you very much.

Barry, thank you very much. It was really an informative talk, and thank you for bringing us that information.

We apologize again for the snow storm and all of that out of control. But we are glad you are here now.

With that we will adjourn until 1:00 o'clock.

(Whereupon at 12:14 p.m. the proceeding in the above-entitled matter went off the record to return on the record at 1:03 p.m.)

CHAIR RYAN: This afternoon we're going to hear a number of presentations on moderator exclusion from a number of different presenters. And we really appreciate everybody coming back for the second round of this session.

It was clear from our first round that we had a lot more information to gather than we had time allotted for it. So I really appreciate the Staff's patience in that. At the end of the day I ended up talking to Bill Brock and I said "I don't think we did you justice, and this is a more involved topic." And we decided to kind of reset, and not only have you guys come back, but the Staff and to have other stakeholders and participants come back so we could gather a broader range of input and information.

So, again, thanks for your patience and thanks for coming back. And thanks, everybody else, for participating today.

Without further ado I'll turn the meeting over to Dr. Weiner, who is our cognizant member for the afternoon session.

One last note, we will have to finish on time. And on time means that we'll be done by a few minutes before 4:30 because we have a briefing with Commissioner Jaczko here right after that and we want to be mindful of his schedule. So we'll plan our afternoon accordingly.

Thank you very much. And without further ado, Ruth, it's all yours.

MEMBER WEINER: Thank you, Mike.

I'm not used to these new speakers yet.

Our first speaker for the afternoon is Wayne Hodges, who represents himself. I have no idea what H3222 Consulting is. So, go ahead, Wayne.

Wayne is a retired member of NRC Staff for those of you who aren't aware.

MR. HODGES: Thank you. I am Wayne Hodges.

The H322, Dr. Ruth, that's a Soundex representation of Hodges. Hopefully, it'll be easy to remember.

My last eight years that I was with the NRC before retiring I spent in the Spent Fuel Project Office. And in that position I had a very strong interest in moderator exclusion and what might be done with it. So that's primarily the reason I think I'm here speaking today.

Anything that I say will be own views. I'm not representing anyone else. And I will primarily address moderator exclusion as it related to commercial spent fuel transportation because I don't know a lot about the DOE fuel and all the things they're trying to do there. I do know more about commercial spent fuel and issues related to that. And so my comments will be slanted in that direction.

And finally, I think an overriding question that needs to come out as part of this meeting is should transportation spent fuel be risk-informed. And if the answer is yes, you might head in direction. If the answer is no, you might head in another. And that's a question to kind of keep in mind as we go through all of the discussion today.

Because not everyone understands exactly what we meant by moderator exclusion, and it was agreed I would go first in the presentation, I want to talk a little bit about what we mean by moderator exclusion.

When a package, a transportation package is analyzed for criticality purposes, generally it's assumed that the moderate is inside the containment. And so that is an assumption that is made for purposes of analysis to demonstrate that even with water present, it is sub-critical. If you have moderator exclusion and you don't allow the water to get, then the criticality analysis is much different. And that's all that's really meant by moderator exclusion.

Now the current regulations, particularly as it's interpreted by the Staff, requires a nonmechanistic intrusion of water into the package for criticality analysis. The wording is not exactly into the package. It's more into the containment. So I think the Staff would normally view everything inside the containment boundary as being part of inside the containment, and therefore I think that leads to their interpretation. Other people would say if you've got multiple boundaries, you could still be inside of the containment boundaries but not surrounding the fuel, for example. So that's a question for interpretation and probably a major to be considered in the DOE application.

Part 71.55(c) does allow moderator exclusion as an exceptional case. But to my knowledge that exception has never been applied and there is I think a great reluctance on the part of the Staff to do that, to allow it.

There is an ISG-19 which allows moderator exclusion under accident conditions. And this gets then to the fact that the 71.55(b) basically says if you have a moderator in there under the most credible configurations and a normal fuel configuration would be a credible configuration, that's also subject to experience and loading and unloading, and so that is a configuration that is used by the Staff for moderator exclusion, whereas under accident conditions it could be slightly different. And ISG-19 allows consideration of moderator exclusion under accident conditions with some fairly stringent criteria.

Now why do you need moderator exclusion? And there's other options to doing moderator exclusion. One is burnup credit, which will be discussed. And it's my understanding that if full burnup credit were allowed, that 90 to 95 percent of the spent reactor fuel could be shipped today in large transport casks. Now as you go to higher burnup fuel, that percentage might go down somewhat. But you could ship most of it in the large transport cask. The rest of it would have to be shipped in smaller casks.

But full burnup credit is now allowed, and one of the primary reasons is that there are very large uncertainties today, particularly for some of the plants. And so the Staff applies uncertainty bounds to those various nuclides and you come up with essentially a considerable reduction in how much credit is allowed for burnup. It's not that the Staff doesn't recognize that you have a burnup effect, it's the database is slim, and so the uncertainties in the data are large.

There is one company I think that has been approved by the staff for burnup credit that goes beyond actinide-only. But that is still very restricted because of large uncertainties.

There is also an ISG that allows for actinide-only credit. And if you use that, less than 30 percent of the fuel today could be shipped in the large transport packages.

Another reason that may influence that is that as you get to the higher burnup on the fuels, the cladding properties are unknown. There's a fair amount of data for burnups up to about 45 gigawatt data at the time. But beyond that there is very little data. And if you go to even the newer fuels that have the M5 cladding or Zirlo there's simply no data. So there's a major concern about the properties of the cladding for the high burnup fuel. And if you're trying to predict a configuration of fuel, whether it holds together under accident conditions, that becomes an issue.

Now I talked about being able to ship the fuel in large casks. Well, why do you need to use large casks? And there's several reasons.

One is economy. If you use larger casks, you'd have fewer shipments.

There's also a safety reason. Because the more shipments you have, the more likely you are to have an accident on the highway or on the rails. So if you larger casks to do shipping there is some reduction from that aspect in the risk.

There's also an ALARA concern because you could get less dose from the loading and unloading. And if you do have to take the fuel out of the package or even if you use the same canister in final disposal, there would be less waste if you had larger casks.

So there's a number of reasons to use larger casks if you can.

And as I said, for high burnup fuel there's a lack of data for the cladding material properties. But the lower burnup data suggests as you get to the higher burnup, the cladding becomes ductile. And also there's an issue with the buildup of hydride. And under high temperature, as you might see during active drying and high stresses you can get hydride reorientation, which effects the brittleness aspect. And as I said, we've got no data for the M5 or the Zirlo.

Now, because this is primarily a concern for the accident conditions where you have to worry about the reconfiguration of the fuel, it may be that ISG-19 removes the high burnup aspect -- but there's one other issue that kind of creeps in, and that is oxidation of the fuel. If you've got pinhole leaks, hairline cracks or various aspects and you expose the fuel to non-oxidizing environment, you can have a swellage of the pellets. And that can lead to fuel failures, even without having an accident. So there may still be some consideration. It's a somewhat murky issue I think at this point.

Moderator exclusion is not the only option for increasing the amount of fuel that's going to be transported in a large package. You could also use burnup credit, as we talked about previously. But there are large uncertainties as to how much credit you'll ever get for that. I don't know.

One thing that would I think take care of the potential increase of reactivity if you did have fuel configuration is allowing the k-effective to go up to .95 to some higher value, for example .98. I think there have been some preliminary studies done that show that would take care of any potential increase in reactivity from a reconfiguration. Or you could use some combination of the above.

Now, what are the pros for moderator exclusion? Economy is one. We talked about it. And the fewer trips that you take as far as transportation trips, fewer accidents.

One potential consideration that maybe be moot, I don't know, because of the TAD is elimination of the need for aluminum materials inside the cask. It moots the issue of burnup criticality for the high burnup fuel.

And the next question, a pro for it would be risk-informed. If you're going try to be risk-informed, this is something that you would allow. It clearly would be probabilistic-informed. We don't really know enough about the risk I think at this point to say what the risk would be. But from a probabilistic standpoint, we would argue for it.

The cons. There's an increased criticality risk, particularly during loading and unloading. For transportation itself an accident is small, but there is some for particularly the loading and unloading.

The environmental impact statement for

transportation would need to be revised. And it does constitute a major departure from current practice except for UF_6. UF_6 a moderator exclusion has been allowed for UF_6 for some time, primarily because it was being shipped in the packages that were used before the regulations were in place. And since it had been grandfathered, although the current regulations, the latest revisions recognize it explicitly.

And probably the major con is public acceptance. If you could go through rulemaking or anything else, you're going to have probably a lot of outcry from the public because you're losing the ability to say you absolutely cannot have a criticality. Now you're going to go to a low probability of criticality, and that may be a big step from the public acceptance standpoint.

Now, I'll talk a little bit about risk considerations. And I say considerations because risk is really composed of the probability and the consequences. And I think we understand the probabilities relatively well. We don't understand the consequences very well at all. And so it's difficult to talk about the actual risk.

But the NUREG/CR-4829 did estimate the

leakage of water into a containment, there's a very low probability. Now once in 10 million years for 650 shipments. Now that was for a generic kind of a package that didn't have, for example, a canister inside an overpack. And so if you have a package like most of the vendors have these days, the number would be even lower, I suspect.

If you look at the loading aspect there have been somewhat in excess of 800 storage casks loaded in the U.S. with the same process for loading a shipping cask, basically. And essentially no problem with that 800. It doesn't tell you what the number is. It says we've had a large number of loadings without a major issue.

When you are loading the casks, generally the boron content of the water in the pool adjacent to the cask is monitored -- it's tested just before loading. And so the likelihood of an inadverted deboration is very, very low. And the tests that are required by Part 71, the 30 foot drop test, the fire test, all of these, assure a very robust design for hypothetical accidents. So the likelihood of getting water into a cask is extremely small.

Now, at the last meeting it was

mentioned that there were a couple of truck casks that were found with water. And I went back and checks the reports on those, and the reports basically said there was less than a half of liter in each one of them. And these are small casks. They're truck casks. And the water got in there during the loading operation, not during the transportation event. But, again, a very small amount of water.

MEMBER WEINER: Wayne, excuse me for interrupting. But you might give some idea of the internal volume of NAC-LWT as compared to a half a liter of water?

MR. HODGES: I don't know the number. Do any of the Staff know that number?

MS. OSGOOD: I know the number. But they're --

MEMBER WEINER: Go ahead.

MS. OSGOOD: It's about a 13 inch diameter and they're about 170/160 inches high. So I think the total volume, internal volume, was about --

MEMBER WEINER: Well, the figure doesn't matter. I just wanted to make it clear that a small cask is not small compared to half liter of water.

MR. HODGES: Right. Right.

MS. OSGOOD: Right. Yes. It's very large.

MR. HODGES: Yes. That's a very small amount of water.

MEMBER WEINER: Please, when you speak up, say your name for the recorder. It's Nancy Osgood.

MR. HODGES: And, again, continuing on the list considerations and trying to make a comparison to what's done in the reactor world. And I've got two slides in here. One it is part of core damage frequency and one for the LERF. And what you see here is the core damage -- the way I read this curve here, is a core damage frequency greater than ten to the minus four is acceptable to the Staff. I'm not saying the reactors go there. I think most of them are lower. But that would be an acceptable core damage frequency.

And if you go the LERF, basically an order of magnitude better because you got a containment around the reactor. You're talking about still something in excess of ten to the minus five, using this figure from Reg. Guide 1.174.

So we're talking about as far as the

reactor world the problem and then acceptable probability of a large early release of being greater than ten to the minus five. As far as transportation, we've got a standard that says no release. And that's quite a bit different. Again if you're going to be risk-informed, you've got to go more in this direction. If the decision is you're not going to be risk-informed, then you keep it like it is.

You'd probably have a hard time arguing just on the need for large transportation casks alone to argue moderator exclusion. But you'll need to look at it in an overall picture.

And I'm done.

MEMBER WEINER: Thank you.

We have a round table discussion scheduled for the end of this section of the meeting. I'm going to hold my own questions, but each Member of the Committee, feel free to ask one or two questions.

Dr. Hinze?

MEMBER HINZE: Pass.

MEMBER WEINER: Al?

VICE CHAIR CROFF: Pass.

MEMBER WEINER: Chair?

CHAIR RYAN: Just a couple to clarify, if you don't mind, Wayne.

MR. HODGES: Sure.

CHAIR RYAN: I guess they're not numbered. It's the why needed slide. Maybe you could snap to it on the presentation for the other folks.

MR. HODGES: You said it's 6?

CHAIR RYAN: Yes, why needed? On the burnup credit page. It says "Huge uncertainties in data for some nuclides." Tell me about "huge," and tell me which radionuclides.

MR. HODGES: Oh, okay. All right. Yes.

That one.

CHAIR RYAN: It's the second bullet. What's huge?

MR. HODGES: Huge is -- all right. If you look at the amount of credit you get with actinide-only and say compare that to an ideal world where you got full credit, you'd maybe get about half of that credit with the actinide-only.

So with the large uncertainties you're maybe in the neighborhood of 15 percent, maybe about 10 or 15 percent above that.

CHAIR RYAN: That's not my question. My

question is we're talking that a fuel burnup credit is not allowed now because there are uncertainties in data --

MR. HODGES: Right.

CHAIR RYAN: -- for radionuclides.

MR. HODGES: Yes.

CHAIR RYAN: What data, what radionuclides and how big?

MR. HODGES: Oh.

CHAIR RYAN: What is it? Is it cross sections, is it --

MR. HODGES: It's on the cross section. Some of the Staff --

CHAIR RYAN: There are neutron poisons in the fission product inventory, so is what you're telling me you don't know the neutron poison inventory well enough?

MR. HODGES: Both inventory and cross section itself.

MR. RAHIMI: This is Meraj Rahimi, NRC Spent Fuel Division.

What he is referring to is unquantified uncertainty with respect to some of the isotopes. And as Wayne indicated, there has been a case that the way to approve that has gone beyond actinide only and the applicant quantified those uncertainty. There are still some isotopes that have not been quantified. You know, the fission product technetium, some of the technetium. And samarium-149, these are some of the isotopes. There are 29 isotopes normally that the applicants go after. Fourteen actinides, 15 fission product isotopes normally.

CHAIR RYAN: Okay. Now we're getting to it. We have 15 fission products?

MR. RAHIMI: Yes.

CHAIR RYAN: And of those we're certain or uncertain by what? An order of magnitude? Five orders of magnitude? What?

MR. RAHIMI: Right. There are some isotopes like cirium-244 that you will see, you know, the uncertainty was 100 percent. They could not figure out why they were off, so they're not taking credit for that one.

We gave them credit for some of the isotopes that they had quantified with enough data over the range of enrichment and burnup.

CHAIR RYAN: But I mean a 100 percent error in americium, for example, doesn't trouble me so much because you can always deal with that as a range of values or a conservative value or whatever. So huge uncertainties in data for some nuclides doesn't really nail down to me that it's a not doable problem. I still think it's a doable problem --

MR. HODGES: Well in a public meeting, and we're in a public meeting now anyhow, and the number he's talking about were in a proprietary report.

CHAIR RYAN: Okay. No, no. I'm not asking for proprietary information.

MR. HODGES: So we can talk in terms around it. But it's going to be difficult for me --

CHAIR RYAN: But it's not -- the message I'm taking away is it's within a doable range of problem. It's not intractable?

MR. HODGES: No. One vendor has already been through the process, have gotten credit for it and it's better than actinide only. It's just not as good as if you didn't have the large uncertainties.

CHAIR RYAN: Thank you.

One last quick question, if I may. And that's on consequence and probability. I'm taking away from your presentation, Wayne, that your uncertainty is mainly about consequences as opposed to probability of an accident?

MR. HODGES: Yes. When I was with the Staff we tried to do a scoping study on the consequences. It's not a simple thing to do. It's a very dynamic problem.

CHAIR RYAN: Yes.

MR. HODGES: And I'm not aware of anyone who has done a decent analysis of the consequences. So we can talk in general terms about it, but it's just not well known.

CHAIR RYAN: That surprises me a lot. I mean, we've bashed casks with lots of stuff over the years.

MR. HODGES: Oh, yes, we've done a lot. But that was not making them go critical. But the difference is -- I mean, we know type of behavior if you run a train into it, if you drop it, you do a bunch of other things. But when you have a situation where you take away the boron that's in the canisters that you no longer are going to be subcritical, but with water in there.

CHAIR RYAN: Yes.

MR. HODGES: And so you're looking at not a current design, but a new design that's taking advantage of moderator exclusion. And now you put water in there where it can go critical. It's going to surge and likely it's going to sit there and cycle. So it's going to go critical, it's going to quick spew the water out and if water can get back in, it's going to come back in and you're going to see a cyclic phenomenon. And trying to predict what goes out in that cyclic phenomenon, and just how severe it is, that's not a simple problem.

CHAIR RYAN: Yes. And whether it blows apart or stays cyclic and all that. I understand all those issues.

MR. HODGES: Yes.

CHAIR RYAN: Okay. Well, that's enough for now. Thanks.

MR. HODGES: Yes.

MEMBER WEINER: Jim?

MEMBER CLARKE: Just a clarifying question to make sure I understand your use of risk-informed. I was trying to see if you had it on a slide, but I'm not finding it.

The question is you believe, if I understood what you said, that the moderator exclusion is risk-informed, is that --

MR. HODGES: I believe to use that would

be a risk-informed --

MEMBER CLARKE: To use that --

MR. HODGES: You're considering risk issues in what you allow and you don't allow.

MEMBER CLARKE: Okay. And just to follow up on that, as I understand it the situation now is case-by-case and you would encourage risk-informed to be not case-by-case but in every case?

MR. HODGES: Well, case-by-case so far has been zero.

MEMBER CLARKE: Right. I understand. I noticed that, yes. So there are advantages to not doing it on a case-by-case --

MR. HODGES: I think, you know, part of the problem is the arguments that you would make for a DOE canister, say, moderator exclusion are very similar to the same arguments you would make for a commercial field canister. And if you allow it in one and you don't allow it in the other, you have an equity issue. And so it may be a matter of being equally tough on everybody.

MEMBER CLARKE: That's helpful. Thank you.

MEMBER WEINER: I have just one clarifying question. What do you mean by large transportation cask? Is that a 21 assembly cask, a --

MR. HODGES: Okay. They're generally for PWRs, a 32. For BWR it would be in the 68 or so range. If you got down to 24 or less, you wouldn't need moderator exclusion.

MEMBER WEINER: I see. So this the extra large rail casks?

MR. HODGES: Well, the ones that are currently being marketed.

MEMBER WEINER: Thank you.

MEMBER CLARKE: If I could follow up on that. As I understand it, that's bigger than the TAD, is that --

MR. HODGES: The TAD is proposed to be, I think, 21.

MEMBER CLARKE: Twenty-one and 44 I think, somewhere around there.

MR. HODGES: Right.

MEMBER WEINER: Thank you.

Our next speaker -- where is he? Everett Redmond from NEI. And without further ado -- oh, I should mention that Tom Hill is on the speaker phone. And for his benefit I'll repeat what I said before while Everett is getting set up. There will be a round table discussion at the end of this segment of the program. So I've asked people to hold most of their questions until then.

And welcome. Everett, it's all yours.

MR. REDMOND: My name is Everett Redmond. I'm with the Nuclear Energy Institute. Just for a little bit of background, I've been with NEI since October. Prior to that I spent ten years with a dry cask storage vendor doing licensing work and shielding analyses.

Wayne has already given you a discussion on moderator exclusion and a little bit of information in that regard. I'm going to expand upon what he said and talk about what we view as a generic issue in the industry here.

Currently high density dual purpose storage canisters are being loaded. And for reference here, high density means 32, approximately 32 pressurized water reactor assemblies as opposed to 21 t 23 pressurized water reactor assemblies within the same canister volume. So the size of the canister is the same. So the 21/24 or 32, it's all the same physical size, same rail cask. But we're talking high density here.

Because of differences in analyses

techniques between storage and transportation, it's not clear whether these high density dual purpose canisters will be acceptable for transport.

These dual purpose canisters have been designed for both storage and transport. They've been analyzed for thermal, structural and shielding purposes. But as I said from a criticality perspective, the techniques are different in Part 72 and Part 71 resulting in the contents being unclear for transport at this point in time.

Now there's two ways to deal with this, and I'm going to elaborate on these as I go through the talk. Moderator exclusion is one, or enhanced Part 71 burnup credit is the second. And either one of these would provide an assurance that these canisters will be transportable at some point in time in the future.

Now I understand the purpose of today's talk is moderator exclusion, so I'm not going to go into detail on the burnup credit. But I just mention it here because it's important to understand the context of the issue that we're talking about.

What we see here is a comparison of loading requirements. In Part 72 when you load a storage canister, the criticality analysis is based on fresh fuel and full credit for soluble boron. Typically high levels of soluble boron 2,000 ppm plus. And that results in basically a loading criteria that says 5 percent fresh fuel any burnup. That's represented here on the right with the dashed black line. So anything to the left of that, any burnup versus enrichment combination is acceptable for loading into a storage canister at this point in time.

Now when you go to transport it, currently with the exception of the cask vendor that's already received something above ISG-8, ISG-8 require actinide-only burnup credit. And you end with a burnup versus enrichment curve which is shown in the red dashed line there.

Now, as you can see here there is a big difference between what is transportable, which is to the left of the dashed line and what is permitted to be loaded, which is to the left of the solid or the dashed black line.

Now what I've done here is to populate this figure with the Westinghouse 17 fuel data, burnup versus enrichment data. This is taken out of the DOE RW8-59 database from 2002. And what we can see here is that what's to the left of the red dashed line is 21 percent of the population. But fuel is currently being loaded into the high density DPCs from any of the assemblies that are listed here. So we have situations where canisters are being loaded now that may or may not be transportable if that red dashed line is not altered.

Now the reasons utilities are doing this is because it's really not practical to simply choose fuel assemblies from what's to the left of the red dashed line. There's requirements as far as heat load in the spent fuel pool and spent fuel pool management issues that come into play. So it's not practicable to simply choose from that small subset. So we have canisters that are being loaded now that come from the entire population here.

Now to quickly summarize the issue then, and I haven't touched on it before, but we have Part 50, Part 72 and Part 71 all have different criticality analysis requirements, different criticality analysis methods. And the result is fuel that is currently being loaded in the high density DPCs, fuel that is currently stored in the spent fuel storage racks and the spent fuel pool may or may not be acceptable for transport once Part 71 license amendments are submitted and approved.

Now how do we fix the problem? As I mentioned, one option is Part 71 criticality analysis to be aligned with Part 50, basically analyze it the same way you do in spent fuel pool. If it's acceptable in the spent fuel pool, it'll be acceptable for transporting the cask. That does not require rulemaking.

The second option would be to recognize moderator exclusion or leaktightness, and I'll talk about that in just a second, in licensing basis.

Now there's in my view here two ways to do moderator exclusion really. There's one moderator exclusion from the inner canister. So in our case we're talking about the dual purpose canisters, the welded canisters that's inside the storage overpack.

DOE Idaho is going to talk shortly about their standardized canister, which is also inside of transportation cask. So this is moderator exclusion from that canister. That does not require rulemaking, in my view, anyway. 71.55(b) requirement says that you must flood the containment system. It doesn't say you have to flood all free volume within the containment system. And then it goes on to talk about the most credible extent.

The second option would be moderator exclusion from the containment system, which would clearly in my view require a rulemaking since 71.55(b) says you must flood the containment system.

Or we could do a combination of the both. For example, apply Part 50 burnup credit methodology to Part 71, but recognize that as far defense-in-depth the canisters are leaktight and that you won't get water in it. So you're doing your analysis based on burnup credit, assuming water, but you're recognizing the fact that they're leaktight.

Now these canisters, a lot of the welded canisters for your information are considered leaktight from the purposes of radiation leading out during an accident scenario. But they're not considered leaktight for the purposes of water coming in during an accident scenario. So that's a different condition there.

And I should say -- back up for a second because I just misspoke a little bit. IGS-19 does talk about moderator exclusion and the Staff has outlined a manner in which a vendor could apply for moderator exclusion during transport, during accident scenario. But I have not seen an instance where the Staff is willing to consider moderator exclusion or consider the leaktightness of the canister when talking about burnup credit as a defense-in-depth measurement, defense-in-depth approach. And so to us if direction from the Commission is needed, for example, to be able to consider leaktightness and defense-in-depth, then that's what we would urge.

Now to quickly summarize, in our view SFST should consider all options for ensuring that fuel loaded in DPCs is approved for transport. And NEI believes that generic loading transport issue, which I described, can best be solved by permitted Part 50 burnup credit for transportation. And, as I said before, this can be accomplished by rulemaking.

We also believe that DPC leaktightness should be recognized for defense-in-depth if that helps provide some alleviation to some of the issues in the burnup credit world. And we would certainly welcome the opportunity to come back and discuss burnup credit in more detail at a later time. I know we touched on it a little bit in Wayne's area, but it's not the purpose of today's meeting so we certainly would welcome that opportunity to dive into that in more detail.

That's what I had to say for today.

MEMBER WEINER: Well, thank you. And since you've been so accommodatingly brief in your presentation, thank you. We do have time for questions.

Dr. Clarke?

MEMBER CLARKE: I don't have any.

MEMBER WEINER: Dr. Ryan?

CHAIR RYAN: And maybe this we'll save it for the round table, you can think about it. If you were to include burnup credit in your thinking, could you give us any sense of what contribution to conservatism with a lack of criticality, however you want to look at it, would come from burnup credit versus moderator exclusion? Just maybe you can think about that, and that'll be something we can ask all the panels. Because it would be helpful to the Committee to get a sense of where's the real value added for each issue and which is the one that would likely if risk-informed as Wayne suggested do a better job of making the whole process risk-informed. So just a thought.

MR. REDMOND: That's an excellent question. BE happy to discuss that.

CHAIR RYAN: Okay. Great.

MEMBER WEINER: Allen?

VICE CHAIR CROFF: No thanks.

MEMBER WEINER: Bill?

MEMBER HINZE: Perhaps this is better in the round table, but what evidence do we have that we can really achieve leaktightness?

MR. REDMOND: There's a standard ISG that talks about welded canisters for, again, for the purposes of radiation coming out of the canisters. I'm not a structural engineer so I'm afraid I'm not able to go into too much detail in that regard. The Staff could actually probably answer that better than I could. But there is an ISG that for the purposes of containment analysis talks about the canisters being leaktight.

MEMBER HINZE: And just so we're on the same page, everyone, you're saying radiation leakage. You really mean radioactive material?

MR. REDMOND: Radioactive material, correct.

MEMBER HINZE: Yes. Okay. I just want to be clear.

MR. REDMOND: Right.

MEMBER HINZE: Well, let's hold that off and ask that question.

MR. REDMOND: Okay.

MEMBER WEINER: I have one question. If you go back to your slide 4, could you please.

MR. REDMOND: Okay.

MEMBER WEINER: Would burnup credit accommodate all of these casks that are between your transportable and loadable curves? In other words, that whole bunch that's to the right of the transportable but left of --

MR. REDMOND: If I -- let me check something here. If you don't mind, I'll just jump ahead into the additional information because I have to figure the answer to that question.

MEMBER WEINER: Yes.

MR. REDMOND: Okay. What you see here is a figure that shows different loading requirements. And what we have here is, again, the Part 72 is shown here. Oh, I'm sorry. The Part 72 --

CHAIR RYAN: You'll need to use the stand up microphone.

MR. REDMOND: I apologize. Thank you. I'm sorry for that.

We have the red dashed line here which is the Part 71 ISG-8 again and 21 percent are to the left of that. We have the black line here which is Part 72. This red dashed line is the requirement that is developed in Part 50 that the spent fuel storage racks are licensed to. So a high density spent fuel storage rack, which looks essentially the same in many cases to the high density 32 canister casks that are being loaded now, covers more than 95 percent of the fuel assemblies out there.

So basically you're pulling fuel assemblies out of your spent fuel pool, your high density rack, this population here and you're putting them into your high density canister. And if the analyses methods were the same, again, 90/95 percent or more of the assemblies would be acceptable for transport. The only issue that the vendor -- the utilities would have to worry about is this population here, which in many plants are stored in like typical Region 1 style low density casks. But, again, the Part 72 requirements actually permit you to load any of those assemblies.

MEMBER WEINER: So that almost all of your assemblies that would not be transportable currently would be under the burnup credit?

MR. REDMOND: Right. And in fact I would say this but not with certainty, but I believe it is unlikely that utilities would be loading this population down here anyways because they tend to want to get the higher burnup, hotter fuel out of their pools.

MEMBER WEINER: I see. Thank you.

Our next speaker for this session is Dr. Albert Machiels. I hope I have pronounced this correctly. From EPRI, Electric Power Research Institute.

And I would point out while Dr. Machiels is getting set up, that there are additional slides in everyone's handout that we thought there might not be time for presentation. But they have additional information that people may want to look at.

DR. MACHIELS: Good afternoon. My name is Albert Machiels. I'm a Senior Technical Manager at EPRI.

And first of all, I would like to thank the Committee for the opportunity to present a few considerations related to criticality in the complex of transportation of spent fuel.

Personally I've been involved in this area since the late '90s when the NRC issues a number of circled ISG or interim staff guidance.

And for the first three year we essentially work on the storage side of the equation. And since 2002 when the storage issue was essentially resolved, we have been working on topics related to transportation.

And we have worked on topics related to burnup credits, cladding integrity, risk and so on. And we have produced one report which I have presented to the Committee on moderator exclusion that we produced about a year and a half ago. And I will not cover that report because I think it's not really technical nature, it's more of an options that the regulations have at the present time. And you will see a lot of parallel between that specific report and the content of the presentation that was provided to you earlier by Ms. Osgood.

What I would like to do then is try to tackle a number of issues related to the discussions here, but more responding to the request that were made and then emailed to me to look at the risk equation as well as some issues related to the lack of cladding integrity, the reconfiguration what roles it may play.

Now, first of all, we're going to talk about spent fuel and I would like to give a perspective here which could be a little bit maybe different from some of the previous speakers.

Spent fuel is a material which has to fulfill its function. That means when it came into the reactor it has a specific purpose, a lot of reactivity. When it came out of the reactor, most of that reactively was used. And so from that point of view when we look at criticality there are a lot of considerations which make absolute sense in a very rigorous manner when you look at shipping enriched uranium or plutonium or fresh fuel. But the same considerations may not necessarily be directly relevant or directly applicable to the same rigor to spent fuel.

Spent fuel comes with its burden of isotopes and fission products which accompany the residual reactivity. And whether you take credit or not for it explicitly, it is there. Okay. So essentially spent fuel it really doesn't have the same potential for criticality compared to some other species like highly enriched uranium or fresh fuel and so on. So that's one consideration to keep in mind.

In the U.S. there has been a number of program. Crash testing example of Sandia at the top where a train collided with a truck carrying a spent fuel waste. And there has been also included -- I basically took from a website, some information about the experience in the U.S.

And what has been always fairly typical is that the waste package itself has behaved extremely well in this process. But you can see that if we look at another part of the risk equation that we'll be discussing a little bit later and as Wayne Hodges has already presented is that there are risks which are not radiologic driven. And you can see that in the top picture as well as the existing experience is that the human body is not designed to perform very well in this type of accident should they happen. And at the present time, the only really negative impact of transportation has been one casualty which resulted from the accident involving one of those.

So the record from a radiological point of view is perfect. Obviously, there are risks which are typical with transportation.

So what I would like to do, and this is my bottom line, so I didn't know exactly how much time I had, so at least I want to leave a message is that based on NRC and EPRI sponsored study, the EPRI conclusion, I don't want to misinform you, this is not the NRC conclusion. Based on a piece of information we have taken from NRC work as well as some EPRI work, is that the criticality risk during transportation are essentially zero. And we will try to quantify that a little bit more.

And I will also argue a little bit later, that -- but the question is the reconfiguration effects, that means somebody doesn't keep geometry as a result of an accident, that those really can be dismissed because of a number of configuration is that when we assume physical unreality in representing some reconfiguration, that doesn't even lead to a criticality configuration. And also when we talk about property of cladding and so on, we are really in the realm that if we talk about high burnup fuel and if for some reason there is a lot of reactivity left in that spent fuel, it is not high burnup to start with. Is that the cladding properties obviously were not irradiated to the design level and that means the cladding property fall well within the bounds of what we know at the present time. So from that point of view if you really have a degradation mechanism that would lead to some concern about reconfiguration, it is very likely that if it's only operative when the burnup is very high at a time where essentially the reactivity of the fuel is extremely low compared to something which would have a lot of reactivity left, then obviously the spent fuel would not be classified as high burn.

So from our perspective of this, from the EPRI perspective we believe that there is an opportunity to rationalize the regulations or their interpretation which could result I believe in over risk to the general public as well as reduce the effort, time, results for obtaining regulatory approval.

This has been covered in quite a bit of details previously. And has been mentioned already, the enabling technologies of moderator exclusion and burnup credits.

I'd like to add a piece of detail with regard to burnup credit which I think may provide some information to Dr. Ryan here.

That's my perspective. There is typically a disconnect between the criticality community which is responsible for enforcing the rules of criticality and the reactor physics community that operates the reactor.

The reactor community that operates the reactor use codes and they don't necessarily look at each isotope individual. They look at groups of isotopes. And so they have a way to handle that.

Now the criticality community has a different approach. Is that they look at each species, each nuclide individually. And then you have to ascertain what is the concentration and what is cross section, the worth in some context. And systematically then you have to account for the uncertainties in those area as well as taking into account any bias of the methodology that you use.

So as a result of that this method makes a lot of sense when we talk about highly enriched uranium or plutonium, you deal with a limited number of nuclides and the potential for criticality is large, so you'd better be averse. When you talk about spent fuel, which was as mentioned, considering up to 29 isotopes, you can see that the uncertainties can overwhelm you very rapidly. Is that even if you know the behavior of integral manner when you start splitting and adding systematically the uncertainty int he same directions, you basically eat a lot of the margin that you actually have. Okay.

So this is really the challenge for burnup credit is to be able to essentially collect the data with regard to concentration and worth of those fission products and in the manner that you can build the statistical analysis coming with reasonable levels of assurances with regard to the uncertainties. And that's not easy.

Taking spent fuel, setting it in the hot cell, doing an analysis is very expensive, to start with. There are the error of the analysis itself. And so just the combination by which essentially you don't get essentially the benefits that you would like to have.

The practical approach for burnup credit has been to try to limit that to a number of fission products for transportation with basically the biggest bang for the bucks. But even thought, these are not trivial issues.

So now I would like to talk a little bit about risks. And there has been a fair amount of work which has been sponsored by the NRC with regard to risk in transportation of spent fuel.

I think that's it.

The risk has essentially focused on the radiological consequences and the normal as well as accident conditions. Criticality risks have not been tackled to any extent because the assumption has been we are going to assume that that spent fuel is actually behaving like fresh fuel. And so from that point of view this is a totally incredible event to assume criticality, so we are not going to include that in the risks.

And the non-radiological risk haven't been formally assessed except indirectly through Part 51 where there is some environmental aspects for nuclear power.

Now, know that already a hint is that under accidents conditions when we look at the risk from the point of view of releases of radio active material from the package into the environment, those risks as performed under this study here indicates that they are very low. That means that not much escapes out of the package. And if you take the logic that if not much escape, not much can get in either, okay, when we talk about the water potential, water intrusion into the package.

Now, we have presented over the past several years some basically back-of-the-envelope calculations of risk to the Staff. And more recently than last year we decided to do a better documented and also a little bit more rigorous approach. And the bottom line is that, and it's written explicitly, is that the probability of any criticality accident over a total of many shipments is that estimated to be very low, which is essentially negligible risk.

Qualifiers is that we're talking about commercial spent fuel. We're not talking about research reactor fuel and so on. We didn't look at that, obviously.

We focused on railroad shipments, which is anticipated to be by far the means for transporting spent fuel.

And we looked as a reference 32 assembly package. That means that when we'll talk about misloading, potential for misloading, there are 22 opportunities basically for misloading into such a package.

And obviously the analysis always depends on the experience of the analyst. And I think we believe that we have a very credible organizations, ABS Consulting and Dykes being the main principal investigator.

So from a risk perspective the logic is fairly simple and the numbers are there. But you basically go through a process of estimating the probability or the frequency of an accident and then in that if an accident occur, what is the probability that accident will be severe enough such that it will punch some kind of a defect through the different layer of the containment confinement. And on top of that then you have to assume that there's a probability that there will be some water present such that the water can intrude into the package.

Now having said that, if you have water which is intruding into the package, that doesn't mean that you have a criticality accident, obviously. On the contrary. You have a criticality accident only if you have something in the package that's not supposed to be there and in the quantity which is sufficient for bringing the whole system to a critical point. Because we have loaded the package in such a way that it was not going to be critical. So from that point of view then, you have to take into consideration what is the probability assuming that accident severe enough and water present, what is the probability that when water gets there that you have actually enough reactivity in the package so that you would have a criticality event?

So the analysis that we did was fairly

rigorous with regard to estimating misloading of the misload of a spent fuel cask. And that's basically by reference to the practices of a nuclear power plant, three way communication, video, a verification of whether it's independent or not making it a little bit of a difference.

The train accident per train mile, this can be obtained directly from the Federal Railroad Administration and the NRC used the same sources, obviously. This is directly from work from the NRC what is the probability of an accident which is large enough to create a defeat into the packages and water present directly from work performed by the NRC that Wayne has already referred to.

And then we also assigned a probability. Just subjective here. This number is subjective here, which says that given that we have the accident and the presence of water, given there has been some misload what is the probability that the misload will result in a criticality accident. And I will try to justify these numbers a little bit later. But we believed that those are all on the conservative side. And I'll hopefully say why later.

Then we assume a number of train miles per shipment about 2000 miles. Frequency, then you can calculate essentially the frequency of criticality accidents per shipment as well as any number per year as a total of accident. And you get those numbers, which are very low indeed.

Now let me try to justify here why if you have an accident which result in damage and water and you have misload on top of that, why this is not a criticality accident. Well, there are two things.

One is that we have done a number of calculations which shows that this is the k-effective. And you have criticality when that k-effective becomes equal to one. And then this is the value when everything is supposed to be as designed. We're talking about five percent enrichment and 45 -- so you have a k-effective between .85 and .9

And then you introduce misload. This curve here indicates that we're misloading something which has a burnup not of 45, but 25. And that means we introduce more reactivity. And then you can see the progression in the k-effective. And you can see that in this case it never even get close to the criticality level.

The biggest bang for the buck from that point of view is to be able to load essentially, to put a fresh fuel into your cask. Then you can have a substantial jump here, and that you can see that after one misload, two misload, three misload you would be over the criticality region.

CHAIR RYAN: I'm sorry. Just to be clear, the red line is fresh fuel and the blue is 25 megawatt--

DR. MACHIELS: Yes. Yes. The red line is misloading one, two, three, four, five and so on fresh fuel assemblies. And the blue line is loading one, two, three under burnup. Under burnup.

CHAIR RYAN: Okay. I got you. Thank you.

DR. MACHIELS: Now the NRC would use a different approach. They would not show a curve like this. They would say let's start to the conditions of .95 and let's see what would result into a potential criticality event. So if you move all those curve here the only time you can go beyond the criticality level, the only time is when you load a fresh BWR with five percent enrichment. If you load for something which less than five percent, like four percent, three percent, it takes several of those to get there.

And so that's the reason why we picked

this probability less than one and somewhat subjectively, but I think we really believe it's actual very conservative.

But now if you look at the picture here, this is fresh fuel assemblies here. This is once burned fuel. So from a point of view of human error, you can see that first of all that there is quite a hint to the person loading the assemblies that they don't look the same, obviously. And clearly each of those assemblies about a million dollar worth, they are special babies into the pool. On top of that in most cases is that spent fuel assembly -- fresh fuel are not present in the pool when they do cask loading. Because when you do cask loading, it's not your refueling time. It's basically prepare -- refueling. And from that point of view the fresh fuel is into its proper place, which is not in the spent fuel but into -- which is in dry storage.

So there is a number of reason, as you can see, that the fact that we have very low probability of accident resulting into damage to a cask coupled with the fact that there has to be some water. On top of that is not because you bring water into the package that is going to go critical.

Now this is the potential reduction in shipment by using a 32 versus a 24 cask assemblies. And if you instead of loading all into 24, you could load 20 percent of the -- or 40 percent or 60 percent or 80 percent or 100 percent based on this number of assemblies here. And you can basically calculate from this straight curve the reduction in the number of shipments.

Now this was as was held by my co-worker John Kessler on this one, and really it was really kind of a very rough comparison which says that this is the risk from criticality based on the number that I just showed you extracting data from the final environmental impact statement on Yucca Mountain, we basically compare basically the risk of criticality versus the radiological risk. And the risk of criticality, I mean we're talking about very small numbers here, but the risk of criticality from a public safety point of view are much larger than the risk -- excuse me. The nonradiological risk of hurting people are much larger than the risk from criticality. So this is certainly not enough in my situation. And from the point of view of reducing risk, reducing the number of shipments is really what does the trick.

All right. Now I would like to tackle the other part, which is the high burnup issues. You have heard that NRC is comfortable with transporting fuel which has a burnup up to 45. But there are some concerns about the behavior of the cladding when the burnup is greater than that.

And I will not go into the details here. But if we wanted to go in the details, that would take too much time. But let me simply say that we discussed this issue with the Staff numerous times, and we have actually a joint program to look at some of those issues. And I've documented some of the result here.

What I would like to do is just taking more or less the common sense approach by looking at a report that was sponsored by the NRC. And it says what is the maximum increase in k-effective when you assume a number of reconfiguration, first of all. So I'm not trying to even to figure out what the likelihood of those reconfiguration.

And I will warn you that there is a statement by the author that of those scenarios consider go beyond critical conditions, as you will see, they represent a theoretical limit on the effects of severe accident conditions.

Now there are three tables there with numbers, and I crossed out those two because the assumption is fresh fuel. And as mentioned, we're not talking with fresh fuel. We're talking about spent fuel.

Now if we look at the spent fuel assemblies and put water, it's close to optimum with regard to the ratio of water to the fuel. But not quite. It's under much rated. That means if you bring more water, it will actually become more reactive. So in this case what we do is that we extract one rod from the assembly, and as a result of extracting that rod the water comes there and adds some reactivity. The effect is very small.

We didn't do it, Oak Ridge did it, some kind of a random process of trying to optimize what is the biggest effect by taking multiple rods, you can see that the effect of the k-effective is still very small.

This one is very strange. This one is that you take the cladding off but you leave the pellets stacked. Okay. So that means that the cladding now is removed and you put water where the cladding was, and what additional water essentially then result in additional moderation. And that's why, you know, those go beyond credible conditions.

You can see that the effect is .03.

This one is very strange as well. This one is fuel rubble where you have the pellets of the fuel actually floating in two waters. The water is the density of about one, the pellets have a density of ten. It doesn't matter. It's arranged in such a way that they're systematic arrangement to get the maximum. So again something which is not very credible. And effect pretty small.

Assembly slips eight inches above or below neutron poison panel. This is a design consideration. I think that there's no reason to allow this and the vendors of these data -- basically have about an inch of play.

And this is a variation of pitch where you systematically pull the rods apart.

Now I'm going to cover this one in the next slide, but you can see that if you started from .95, none of those come over the threshold -- or up to one over the threshold. So even assuming reconfiguration, which doesn't belong to the real world, you don't end up with a critical configuration.

And this one is the one where you

systematically increase the pitch. You can see that the reactivity increase and then at one time the only way to keep increasing reactivity is to basically change the dimension of your cask because you're starting separating the rods, and obviously that can happen only until you reach a physical limit. And then at one time here either you have to remove some rods and then your activity goes down, or basically you have to increase the size the cask, which is again not a very realistic approach.

So my conclusion is just focusing on those two parts is what have we learned based on NRC work that we use as much as possible because the credibility that goes with that work within the NRC as well as some additional EPRI work, that the criticality risk during transportation are negligible and are the result of two factors. First of all, the intrinsic properties of the spent fuel, it's spent fuel. And second of all on the extrinsic properties of the package, which is a very sturdy package.

And I think that the reconfiguration effects has been something which has been blown out of proportion in terms of the impact that it has because even assuming nonphysical reconfiguration, we do not reach a critical configuration. And as mentioned before, is that when we talk about high burnup if you want to look at how much reactivity you can introduce, that means that your cladding obviously hasn't been irradiated to this level.

So from that point of view I think this is what I would like at least to leave for your consideration is that there is some kind of a risk framework, and obviously it would be subjective questions and these type of things which indicates that we have achieved extremely low risk at the present time. Very low. And if risk is our main perspective, there are ways to improve it by essentially trying to reduce the number of shipments. And that would reduce at the same time, not only lower risk but reduce all the factors that we indicated like economy, and this type of thing, ALARA and so on.

Thank you for your attention.

CHAIR RYAN: Thank you.

MEMBER WEINER: Bill?

MEMBER HINZE: Do your calculations assume that there's full saturation of the containment?

DR. MACHIELS: Yes.

MEMBER HINZE: Have there been any calculations for only partial, and it is a linear function or how would that change?

DR. MACHIELS: There has been a calculation in the past by the NRC and it showed some different level of saturation in terms of the amount of liquid in the water.

We didn't do that. We did -- we rely on the really obvious cases.

MEMBER HINZE: Is it strictly a linear function or is there a critical level of water?

DR. MACHIELS: I think there's a critical level of water, right? Earl would no.

MEMBER WEINER: Earl, say who you are, please.

MR. EASTON: Earl Easton.

We looked at this in the past and typical spent fuel is not as burned up on the ends, so you could conceivably get an amount of water on the bottom or top by uprighting a cask and have a critical slab. So you don't need the total volume of water. And I don't know, I think there was a foot or two of water. You might be able to get a critical slab.

Now, you haven't analyzed the effects or the consequence of what that might do.

MEMBER HINZE: Do you have any estimate of whether this would be a linear function. Have you estimated that? You're talking about -- about a ten percent filling of the container.

MR. RAHIMI: Meraj Rahimi, NRC.

Normally as part of the certification the applicant does the k-effective calculation as a function of the water density, first of all, in terms of saturation. And most of the design it shows at the full density. That's when you get your maximum k-effective.

With respect to the water height, there is for the purpose of the burnup credit calculation that has been done, but normally you would get a critical condition if you don't have any of the hardware. You've got one foot bottom under burn. But normally with the hardware in there if you look at the realistic condition, the system -- I mean two ends are kind of coupled in between the burn section. So it is subcritical under realistic condition.

MEMBER HINZE: Thank you.

DR. MACHIELS: And that's what we emphasize in our -- is the realistic conditions.

Except that we didn't take credit for all the fission products. We only took credit for those fission products that we needed to receive the biggest benefit.

MEMBER HINZE: Let me ask a stupid question. If the water can get in, why doesn't the heat drive the water out?

DR. MACHIELS: Well, obviously, you would have a vaporization of part of the water in that heat and it would come out, obviously. This is what I think that Wayne was talking about if you had a criticality accident, you might have a cyclic behavior of --

MEMBER HINZE: Oh, that's where the cyclic-- okay.

MR. HODGES: You have to have a continual source of water whether it's a river or some other source. You've got to have a continual source of water, but it will blow it out.

MEMBER HINZE: But under a slug function of water, that would not happen.

MR. HODGES: No, if you just get one thing it's going to blow it out and that's it.

MEMBER HINZE: Okay.

DR. MACHIELS: But even with

criticality, you would have that cyclic behavior.

MEMBER HINZE: Right. Yes. Thank you.

MEMBER WEINER: Allen?

VICE CHAIR CROFF: I'll wait. Thanks.

MEMBER WEINER: Since we are a little bit ahead of time, if our next speaker doesn't mind, we'd like to have Brant Carlsen present now, and then we can take a break for the round table discussion. Is that okay with you, Brant?

MR. CARLSEN: Okay.

MEMBER WEINER: Brant Carlson from Idaho National Laboratories is our last speaker in this session.

MR. CARLSEN: I'm Brant Carlsen. I work for Battelle Alliance as a contractor to the Department of Energy at the Idaho National Laboratory., And I work in a group that supports the national spent nuclear fuel program, which is actually part of the Department of Energy's Office Environmental Management. And they're tasked specifically with identifying the strategies and technologies needed to ensure safe storage and disposition of the large variety of fuels that are the purview of the DOE.

Phil Wheatley is here. He manages our

group. And Phil may be participating with me during the question and answer period.

I'd also like to acknowledge Dick Blaney back here sitting next to Phil. He's our representative from the Department of Energy.

We appreciate the opportunity to be here today and present our position. I'd like especially to thank the Commission for bringing this issue to the attention of the Committee, and thank the Committee for giving us an opportunity to present our position and participate in this forum today.

And lastly, I think it would be appropriate for me to recognize the NRC staff. They have been very patient in accommodating with us as we've worked towards trying to identify an effective regulatory path to accommodate our fuels. We've had three meetings thus far. I think we've made great progress in understanding each others issues and concerns. But we've still got work to do and we're working towards a consensus on this issue.

The objective of our presentation today is to demonstrate the robustness of our standardized canister. We really want to focus on our package and the confidence we have in that in assuring that the moderator will not intrude into the package. So we will basically spend a fair amount of the time summarizing the analysis and testing that have been done to demonstrate the performance of our package.

Our presentation will start by giving kind of a broad overview of the safety strategy the Department of Energy intends to apply for management and disposition of its fuels.

And we'll talk about package design and testing. Specifically we'll show an overview of our proposed transportation package and summarize the testing that's been done to demonstrate its performance objectives on that.

We'll talk about compatibility with current regulations. And we will suggest an alternative interpretation of the current regulation that we believe, if accepted, would allow us to credit the leaktightness of our package under the framework of the existing regulations.

And finally, we'll end up with a brief summary and recommendation.

I should point out that I also have some backup slides. as did the others, in my presentation. And I will try to refer to those as appropriate as we go through the presentation.

And by kind of an overall context of our spent fuel management issues, I wanted to show the disposition path.

Now as we retire aging storage facilities and as we prepare our fuels for disposal, we plan on repackaging them into a standardized canister. As we repackage those into a standardized canister, for each canister those contents will be dried, the package will be alerted, it will be sealed on leak check before being placed into a dry storage facility.

Now, when it's removed from the dry storage facility the cask loading operation will be a dry loading operation. It'll be transported to the repository where again they'll be unloaded using a dry unloading operation. And I think it's important to point out that once that fuel is sealed, dried and ordered a leak check and packaged away in that canister, we have no intention of reopening that canister. And we also have no intention of ever submerging that canister. All of the steps in the life cycle of that canister thereafter are done using dry operational processes.

Now, if this is were -- I'd have a little arrow right here that says "You are here." We're standing on the front end of this planning scenario. We're trying to come up with the right package for intramanagement or for management of our fuels. We want to do it right the first time in the sense that we want to be able to look down the road and understand the requirements that will be placed on this package from each of the subsequent phases of the life cycle. Because as I mentioned, we plan on sealing that package. We don't want to have to reopen it. And so we want to make sure we've look down the road and to begin with the end in mind and make sure it will meet all of the subsequent needs.

We have succeeded in licensing a dry storage facility based on our canister design. We've included the leaktightness and the robustness of the canister in the safety analysis that's included in the design and licensing to support the repository design and licensing. And what we're seeking today basically is an understanding or some assurance that our package here in this canister will be acceptable for transportation.

Specifically what we're asking is that the DOE standardized canister be recognized and credited as a leak type boundary during transportation. In short, we've got a moderator exclusion. We recognize that has not been granted in the past, but we want to point out that we are proposing a different transportation package, which I'll show here shortly, and also that the issues associated with transportation of our fuels are significantly differently than for commercial fuels.

First off, we have a large variety of spent fuel. Our fuels come from reactors over the past 50 years that span a large time period; research reactors, test reactors, production reactors and we've been very creative over the years. And the result is we have a broad distribution of different characteristics of those fuels. We have a broad range of burnups, different cladding types, different fuel types, different geometries. And I've summarized kind of the distribution of those characteristics in backup slide number 17 and 18, and I won't go much further here. But suffice it to say it's a different animal than what has been dealt with traditional or commercial fuel.

CHAIR RYAN: Is there a wide range of enrichments, too?

MR. CARLSEN: Yes. Our enrichments run from LAU up to 93 plus percent.

CHAIR RYAN: Right.

MR. CARLSEN: So we cover the whole spectrum there as well.

Now, if we need to rely upon geometry control for criticality, we expect that we would have to undertake a characterization effort to obtain a fuel specific mechanical properties needed for that analysis. That would be a very challenging undertaking, and in some cases it's questionable what the likelihood of success would be.

I also want to point out that the handling practices have altered some fuel geometry. An example there is many of our fuels have been cropped in that we have removed the end fittings, we've cut off the nonstructural material to reach into the fuel assemblies. The purpose for that was to conserve storage space, but also to minimize the nonfuel material which was destined for the dissolvers.

Similarly, our historical records, like our handling practices, were based on the intended disposition of our fuel. And up through the late 1980s that intended disposition was simply to drop a bucket of fuel in the dissolver. And under that scenario maintaining detailed fuel specific information -- to structural integrity of the fuel geometry simply wasn't a primary concern. Now as our disposition pack has changed, our fuel handling practices and our record keeping practices have also evolved.

Several years ago when we realized that we would be disposing of this fuel in an NRC regulated repository we undertook a significant effort to try to gather up the available data, preserve that to help us with our licensing and safety analyses. And we've had a considerable amount of success. And we have gathered a lot of data for these fuels. But that fuel comes from a variety of sources. These sources include everything from textbooks and reactor handbooks to safety analyses and technical reports. And this data is very useful for scoping studies and for doing defense-in-depth type calculations. But because of the non traditional sources, we believe that if we rely upon this data as our primary safety basis, that we are concerned that much of it will not lead to current QA requirements.

So based on these conditions we've developed a safety strategy. Specifically as to base on our safety or minimize our reliance on fuel specific data for our safety case. We've successfully used three different technique for our repository analyses. The first is by using bounding analyses, selecting very conservative parameters as inputs to the analyses we're able to bound the range of uncertainties such that all the uncertainties are within the analyzed envelope.

We've also groups fuels. In grouping fuels we consolidate analyses for a number of individual fuels into one analyses that's represented by a bounding or representative fuel from each group. Grouped fuels then for each analyses based on the fuel performance characteristics or properties that are important for that analyses.

And when we looked at transportation from that perspective to see what grouping might be effected there, it became very apparent that the performance characteristics that are important for transportation are radiological shielding, radiological confinement and criticality safety.

Now the shielding function is performed entirely by the transportation cask. We're not seeking any credit for the shielding provided by the canister.

But when we look at radiological

confinement and criticality safety, we find that the leaktight barrier provided by our canister does prevent leakage of radiological materials coming out, and also as pointed out earlier, that prevents the leakage of moderated coming in.

So we've concluded that the primary performance characteristics for transportation are the transportation cask and a leaktight canister that provides our second redundant boundary within the cask. So we'd like basically to shift the basis from reliance on fuel specific performance characteristics to a reliance on engineered barriers. In our case two engineered barriers, that of the canister and of the cask.

We don't believe we're giving up any safety in making this switch. In fact, we believe it a more technically sound strategy. And this is basically because the defense-in-depth that we formally provided by the nonmechanistic assumption of moderated intrusion into the cask cavity is basically replaced by the protection provided by having a secondary leaktight boundary within the cask.

So with that in mind our transportation package looks like this. Now I'll go over the details of the canister here in the next couple of slides. But we basically place our fuels in a canister that's fully seal weld but it's leaktight. The canister's been drop tested to the hypothetical accident conditions prescribed in 10 CFR 71.73 even without the protection of the cask.

We take that sealed canister and we slide it into a cask, we seal the cask up and now it's behind another barrier which has also been tested about the Part 71 criteria. And what we have is a new and different package that I don't believe has been analyzed for transportation in the past. We have two leaktight barriers, each of which is tested to the 10 CFR 71 criteria. And this package, we believe, clearly provided a basis for making a distinction for moderator intrusions past the first barrier into the cask cavity and moderator intrusion past the second barrier, which would be also into the cavity of the internal canister.

To give you a little bit of a feel for what the canister looks like, what you're looking at here is a cross section of an infitting from a canister. This is the top end section so you can see the protective features. It's fabricated entirely from 316 L stainless steel. This is the fresher boundary and the wall thickness here. It is three-eights inch. And we have a protective skirt on each end, which is basically a build in impact absorber that's also three-eight inch stainless steel.

We have on each end of the canister a two inch thick impact plate to protect the heads of the canister from the penetration loads that may occur from the contents of the canister within.

We've done extensive testing and analyses to confirm the canister will perform its function. I could talk for a day on the analyses that's been done. And what I've done is I've included in back slides number 19 and 20 a list of the references, the detailed testing that's been done. And we can provide those references and discuss those separately if interested.

To summarize very quickly, we've developed an analytical modeling capability to predict the material response. We've done material testing to confirm the behavior of modeling of the materials. Specifically we've identified critical flaw size mainly to ensure there are no preexisting flaw in the inside material fabrication error or a material or fabrication error would be significantly larger than detectable limits. So we don't have a situation where critical flaw can cause an untended barrier.

And we're looking at strain-rate and temperature effects to ensure that the material properties that we include in our models properly account for temperatures and strain-rates over the range of interest during our accident.

And lastly, and probably most significantly, we've done full scale drop testing to confirm canister performance.

We took nine full scale canister and drop tested them to the 10 CFR 71.73 hypothetical accident conditions. And hopefully I can get these video clips to work. But each of the 15 foot canisters in order to maximize the damage, we loaded it to the full 6,000 pound design capacity. We dropped it at various angles from 30 feet to find the maximum damage.

We also did the puncture drop test, which again is a fully loaded canister dropped 40 inches onto a six inch post.

And hopefully these video clips will run.

I sent this during the break and

apparently we didn't save the new presentation before we saved it again. So rather than spending five minutes resetting it up, I'm just going to let you look at this in the small video clip here.

And what you see here is it's dropped 30 feet from 45 degrees. You see the impact absorber. The skirt on each end takes a considerable amount of the impact, absorbs energy and it does protect the pressure boundary from taking that energy. Where it impacts on one end, it bounces, forms the skirt on both ends and then it settles down.

We were quite pleased with this. There was very minimal deformation of the pressure boundary. And the impact absorbing skirt served their function.

As I mentioned, we also did the puncture drop where the full impact of the drop was taken on the pressure boundary itself. And to maximize the damage there, what we did we took a fully loaded canister, we dropped so we impacted right on the center of gravity so both ends went down on it. And we also removed the sleeve inside the canister and we removed the weights from within the canister in the actual impact design so there could be no possibility of any stiffening effect from the contents within the canister.

I'll show you the video clip here. I'll show it in slow motion, a little more impact. It takes the initial impact, rolls over, bounces off the post here.

And you can also see right here the seam that we fabricated the canister with. We dropped it so it impacted right on the seam. So we did everything we could to make sure we maximized the damage and made these tests as severe as we could.

Both of these canisters, as well as the other seven that we tested, all proved to be leaktight following the tests. And we felt that that drop test was very successful at demonstrating the performance of our canisters.

In addition to demonstrating the canister performance we did something else that is very valuable to our program. We also confirmed the ability of our analytical models to predict canister deformation. What you're looking at here is the end skirt from the 30 foot drop you just witnessed compared to our predrop prediction. And you'll see excellent fidelity. I've also included in the backup slides a similar slide for the puncture drop.

Now with this analytical capability that gives us the ability to investigate other scenarios and also to investigate margin to failure based on the predicted strains. We haven't done that for a transportation scenario. We modeled the hypothetical cask loaded with nine canisters. We've put that cask through a very severe incident. And what we found was based on the predicted strains. We still had a two to one safety factor or margin of safety based on the strains even at maximum temperature and a four to one margin of safety for lower temperatures.

So we believe that shifting our safety strategy from reliance on offerings of the fuel to reliance on the barrier provided by the canister it not only significantly reduces the complexity of the criticality analysis and the data needed, but also provides us more confidence in the result. It definitely increases the surety of operations because we're relying on engineered features of the design to analyze and tested to ensure that they meet their performance standard. And by standardizing our operation or equipment and procedures we improve both human and equipment reliability. And by simplifying our safety regulatory basis, we are able to basically put procedures and processes in place that are ore easily understood, implemented and inspected.

We also believe that the overall risk is reduced because we eliminate the need for obtaining and justifying these fuel specific mechanical and chemical properties of our diverse fuel types. This would be a significant effort, if needed, and it would have attended costs both in terms of personnel exposure and radiological waste generation, all of which can be avoided if we don't move to gather that data.

And lastly, we reduced reliance upon analytical solutions that would inherit the uncertainties associated with that input data, more specifically the data that we would have to derive for.

In short, when you look at the entire risk picture we believe that safety is better served by investing in an engineered barrier than by developing or defending the data that would be needed to assure criticality safety under flooded conditions.

We're confident that our approach is technically sound. What we're proposing here is consistent with the approach that we've taken under the risk-informed regulation of Government's repository safety and the preclosure safety analysis that's been done. And we believe it's feasible within the framework of the existing regulations, although it may require reconsideration of the existing interpretation or existing step practice relative to 71.55(b).

Now I've included the full text of 71.66(b) as well as 71.55(e) and the IAEA standard in the backup slides. I believe you'll find this is a faithful rendition of the requirement. Basically the package must be subcritical with leakage into the containment system in its most reactive credible configuration and with moderation by water to the most reactive credible extent. We would like to be able to base our safety and we propose that we base our compliance with this requirement on three things.

First, nonmechanistic leakage into the containment system is assumed in that criticality analyses. Alluded to the fact that the requirement specifies that the containment must be -- leakage must be into the containment system. And we do, in fact, assume nonmechanistic leakage into the cask cavity. However, leakage beyond that is not credible in our opinion. Our DOE canisters provide a redundant leak type boundary that assure that splinter leakage is not credible. And I've done a very similar calculation of our estimated likelihood of moderator intrusion into the canister, and I've include slide 23 what we believe to be a very conservative estimate. And it concludes that there's a five to one minus 12th likelihood of inadvertent or moderator intrusion into the canister during transportation. We think that's a valid basis for concluding that moderator intrusion to that extent is not credible.

Also we've demonstrated subcriticality based on the above conditions. We assume -- got into the cask cavity and dry canisters and under those conditions we've made some bounding assumptions with regard to the degradation of the fuel. We've assumed that the canister internals are fairly degraded and optimally reconfigured and we've demonstrated that our a single canister and that our weighted canisters are subcritical under those conditions.

Now, in summary as written 71.55(b) requires that moderation and reconfiguration be considered only to the most reactive credible extent. Current practice, however, requires a nonmechanistic assumption of intrusion in all spaces within the containment system without regard to their credibility. It also allows analyses, and those analyses presented in 55(b) to be done in some cases using the as loaded condition of the fuel. In other words, current practice allows credit for maintaining configuration but denies credit for relief tightness. Given the unique needs of the DOE fuel, basically are diverse fuels, our low less package and our entrance storage in sealed containers, we believe that reconsideration to this present interpretation is appropriate. Specifically reconsideration of the credibility of both moderator intrusion and also fuel reconfiguration. Specifically by acknowledging the contribution of both factors and considering a trade off from relying on fuel integrity and reducing that reliance and increasing commensurately the reliance on leaktightness on the engineered barrier, we believe that we can assure equivalent or improved safety performance on the other objectives.

And we believe this interpretation is plausible several reasons. First of all, it's difficult to reconcile the terminology here, moderation to the most reactive credible extent with the nonmechanistic assumption of fully -- to all void spaces.

Secondly, the language in 55(b) is very similar to the language in 55(e) which I'll show in just a moment. In 55(e) credit for moderator exclusion is allowed under certain conditions based on a leaktight boundary.

And lastly, we believe it's a plausible interpretation because the underlying assumptions -- or it appears at least that the underlying assumptions behind the current interpretation of 71.55(b) is based on the presumption of a wet loading process using a traditional transportation package. Neither of those apply to our case. We have a nontraditional package with these two independently leak type barriers, and also as pointed out we don't intend to submerge the cask for either the loading or the unloading process. The canister will remain dry through all the phases of its life cycle after it's loaded and confirmed to be dry.

So with that in mind we look at 10 CFR 71.55(e). The language of this requirement is very consistent with the language in 71.55(b) with the exception of this introductory clause "following the test prescribed by 10 CFR 71.73 and consistent with its damaged condition," and from thereon it goes on to assure that it must be subcritical assuming most reactive credible configuration under most reactive extent of moderator inclusion. However, if we recall the basis for our compliance, at least the compliance that we would like to use for complying the 71.55(b), we assumed leakage into the cask cavity, we demonstrated that leakage into the canister was not credible and we used bounding assumptions for the configuration of the canister internals. Under those conditions the analyses that we have proposed to provide for demonstrating compliance with 55(b) would also demonstrate compliance with 71.55(e).

I am tongue-tied on all these numbers here.

ISG-19 has been mentioned in a couple of the presentations. And I just wanted to point out that the NRC Staff in this ISG has indicated that for demonstrated compliance with at least 71.55(e) it may be appropriate to credit a leaktight boundary for preventing leakage into a package when there is limited availability of data regarding the structural integrity of the fuel.

Now the scope of ISG-19 as it stands now it applies specifically to commercial fuel. But I point that out because we basically have an analogous situation. We have limited data availability, but our data disparity is significantly larger than it is for commercial fuels due to the number of our fuel types and the records that we have maintained.

So we're proposing a similar solution based on a similar need. And we would like to extend the solution to 55(b) as well based on the robustness and the demonstrated leaktightness of our canister.

Now to summarize, I'd like to point that criticality safety is a multiple variable problem. It's been pointed out on several occasions that it can be managed with burnup credit, with poison, there are several ways to crack the nut to solve the problem.

We would also like to point out that the nonmechanistic assumption of moderator intrusion is a simplification of the issue, it is conservative and it removes one of the variables, but it also may needlessly have costs in the sense that it limits available solutions to present and future needs.

By reconsidering the present limitations due to our current interpretation on moderate exclusion -- relatively moderator exclusion we think there are some benefits that can be obtained.

First is we can reduce the fuel specific data needs and thereby considerably simplify the compliance basis for a transportation package. And also it will allow us to focus on energy and resources on assuring safety with an engineered barrier rather than by demonstrating safety be a characterization analysis of our fuel types.

We do recognize that anything that impacts criticality safety particularly in the transportation arena is a very important issue that has potentially significant implications for safety security and policy. But we're confident that our canister will assure safety.

So to summarize, our DOE standardized canister insures leakage into the fuel cavity if the package is not credible. And we believe moderator exclusion should be considered as a regulatory option. And we go one further on that, we believe that it can be considered as a regulatory option within the current regulatory framework, although it will require us to rethink some of the existing practices.

Moderator exclusion has traditionally been viewed as an exception rather than an option. In our judgment the public interests are better served by applying our resources to developing an engineered barrier that assures safety independent of detailed fuel specific properties rather than on characterization and analyses needed to demonstrated safety under flooded conditions. And we've developed a transportation package to meet this need and we've offered an alternative interpretation of the current regulations that would allow us to proceed with our request.

Now in conclusion, I'd like to dig kind of deep into the history of the regulation. Last month when the Staff presented the background of the root of the regulation, Nancy pointed out that the roots of the current regulations go back to 1966. I went back into the *Federal Register* and found the notice of the proposed rulemaking from December of 1965 and also the subsequent statements of consideration associated with that. And there's some interest in their quote there I'd like to read.

It says: "The proposed revision of Part

71 to a large extent suggested that:

(1) The regulation should emphasize performance standards insofar as possible rather than detailed design specifications for shipping containers and shipping procedures, and;

(2) The method of shipment to satisfy those performance standards should be left to the ingenuity of the shippers."

And this is precisely what we're requesting. We recognize that our request does represent a departure from past practice. We would like to point out that we have a different package that has been evaluated in past practice, and we have different needs.

The current practice would provide no credit for the additional barrier provided by our proposed package, and if retained could result in a new consistent standard of performance. It may also have the effect of disincentivizing new solutions that may provide added safety, current and/or future needs.

We believe we've proposed a technical sound solution that meets the unique needs and objectives associated with management of DOE spent fuel. And we're requesting that it be evaluated on its own merits.

That concludes the presentation I have with the exception that there were four topics that the ACNW asked us to address. I believe two of them are addressed at least briefly; our estimate of likelihood of moderator intrusion into the canister and our view on the compatibility of the existing regulations. And number two had to do with the leakage between moderator exclusion and burnup credit, which has been talked to by other presenters. And the last one is our own experience. And I am prepared to at least talk to those briefly if the Committee requests.

MEMBER WEINER: We'll save the further discussion for the round table.

We have a little bit of time if somebody, anyone has specific questions. And then we'll take a break.

MEMBER CLARKE: I just have kind of a basic clarifying question. It seems that there are two parts to this. You're referring to a DOE standardized canister and you've shown us the results of drop testing of that canister.

You also said you have a wide variety of spent nuclear fuel. So is it fair to assume that canister will accommodate that wide variety? We're just talking about one standard canister, is that correct?

MR. CARLSEN: Yes. We've developed a standardized canister. Now there's a couple of different flavors of that canister. It comes in a ten foot length and a 15 foot length.

MEMBER CLARKE: Yes.

MR. CARLSEN: And there are two different diameters.

MEMBER CLARKE: Understand.

And then the other piece is the redundant transportation package, the way you're using those canisters in a transportation cask.

MR. CARLSEN: We've drop tested those canisters to the criteria of 73 without placing them in a cask. But that was in a cask itself, which was also tested.

MEMBER CLARKE: Understand. Understand. Thank you.

MEMBER WEINER: Is there --

CHAIR RYAN: Just one quick one. I'm on your slide 5. You talked about bounding analysis, grouping fuels and two of your strategies.

MR. CARLSEN: There?

CHAIR RYAN: Yes, that's it.

MR. CARLSEN: Okay.

CHAIR RYAN: There's a lot of ground covered in those first two sub-bullets.

MR. CARLSEN: Yes.

CHAIR RYAN: Okay.

MR. CARLSEN: And I can talk to those specifically. Most of that work has been done to support repository analyses, but it's been successful and we would like to apply some of those principles to our transportation safety analyses.

CHAIR RYAN: Well, if you're in the -- you know, less than three up to 90 something percent enriched, you've got a really wide range of materials you're dealing with.And I can imagine, just tell me if I'm right or wrong, that some shipments you'll have a wide variety of total amounts of fuel by whatever measure you want, kilograms or uranium-235 based on its configuration enrichment and all that.

MR. CARLSEN: Let me give you an example of how we would apply that to transportation as far as bounding analyses. We have done our transportation criticality analyses based on our most reactive fuel, our highest fissile load. And we've assumed no credit, we've basically allowed the fuel to levelize. So we've allowed it to fully degrade and we've optimally reconfigured it. Now we have credited moderator exclusion. So under those situations we can go to a full bounding criticality analyses and demonstrate criticality safety. So the criticality safety becomes almost entirely independent of the configuration and condition of the canister contents. It becomes dependent upon the fissile loading and maintaining the leaktightness.

CHAIR RYAN: So you did a more realistic loading instead of a bounding analyses. You might actually come up with less shipments than you're planning now.

MR. CARLSEN: Well, our loading configuration we don't intend to load up to the maximum fissile loading basically. We have a loading configuration that's restrained by our canisters. I didn't go into the canister, but our canister that we proposed for our moderator exclusion exception has ten fuel positions. And we load based -- we can stack two or three of those canisters in a cask. So we have a limited number of fuel assemblies.

Now when we compare the fissile loading of the configuration based on that limitation on the number of fuel assemblies, we're significantly less -- the fissile loading is significantly less than the bounding loading we've analyzed. So our intent is not to load up to that. It's basically just to show that the loading in its as-loaded configuration comes in under the analyzed scenario.

CHAIR RYAN: Okay. Thanks.

MEMBER WEINER: Allen? Bill?

I only have one brief one. Did I understand you to just say that really in your case it wouldn't make any difference in the number of shipments that you're planning whether you have moderator exclusion or not?

MR. CARLSEN: No. No. What I was saying was is we would not be seeking to reduce the number of shipments by maximizing the fissile content per load.

MEMBER WEINER: Thank you for that clarification.

We can take a break now until 10 after the hour, and then come back to the round table discussion.

CHAIR RYAN: And again, I'd like to stay

on schedule for 3:10 and then we can finish up at about 4:10 or so. And that'll give us time to get reorganized for our last effort for the day.

Thank you all. That was great. Terrific.

(Whereupon, at 2:54 p.m. a recess until 3:09 p.m.)

CHAIR RYAN: I realize we have some participants on the conference call. Could you please identify yourselves so we could include that in our record?

MR. HILL: This is Tom Hill with the Idaho National Laboratory

CHAIR RYAN: Thank you.

DR. WEINER: Anyone else on the speaker? Okay. Well, welcome. And to reconvene, Gordon Bjorkman has a brief statement with emphasis on brief, because we'd like to give everybody a chance to ask all the questions they have.

MR. BJORKMAN: Okay. One of the things that was missing --

DR. WEINER: Please use the microphone. Does he have a microphone?

CHAIR RYAN: It's right in front of him.

DR. WEINER: Oh, there it is.

MR. BJORKMAN: One of the things that

was not discussed in our last presentation, although we mentioned ISG-19, was basically the philosophy behind ISG-19. And the philosophy behind ISG-19 is not even written into. You sort of have to garner it from reading.

ISG-19 was written about 2003, that's four years ago. And ISG-19 deals with moderator exclusion under accident conditions. It is for commercial spent nuclear fuel. If we go and look at the essence of the regulation, that is 71.55(b) and (e), which is what we've been concerning ourselves with mostly today, basically it says, "Demonstrate no criticality for as-loaded fuel in water", that's 71.55(b), "and for reconfigured fuel in water", that's 71.55(e), that's the accident. "If the fuel does not reconfigure then you have the as-loaded condition, you've satisfied the criticality condition through (b).

EPRI and others have talked today about the extremely low probability of water getting into the cask, or beyond the containment bound. That is absolutely true. These are extremely low probabilities; however, the regulation does not begin with the low probabilities, it begins with water already in the cask. And this is where the staff begins its evaluation, with water in the containment boundary.

What does ISG-19 attempt to do? It's a risk-informed balance between two things, and those two things are the increase in the probability of criticality due to fuel reconfiguration in the presence of water versus, on the other hand, the added assurance for the structural integrity of the containment boundary to exclude water under accident conditions, so we have this balance. What is the increase in the probability of criticality, versus what is the added assurance on the other side that the containment boundary's structural integrity will be maintained?

For spent nuclear fuel, we know the geometry quite well. We can discuss its reconfiguration reasonably well, and the staff has, over the years since 2003, begun to understand its reconfiguration characteristics much better. EPRI explained some of those reconfiguration studies that they have done, as well. So the probable increase in criticality due to reconfiguration now gets smaller and smaller, so the added assurance would be less and less that we would require.

The added assurance in ISG-19 right now

is to do some additional testing, but that's only guidance. We have applications in-house in which the added assurance comes from a double lid reconfiguration, Highstar 180. That would be balanced against the increased probability of criticality, versus the added assurance of no water getting into the containment.

We have before us, also, the Idaho National Lab, or will shortly, the Idaho National Lab White Paper. Now we're beyond commercial spent nuclear fuel 5 percent enriched. Now we're up into the potential for 90 percent enrichment. Now the probability of criticality becomes greater, so on one side the probability of criticality becomes greater. What is the added assurance that we can maintain the integrity of the water boundary, or the containment boundary?

Idaho has presented us with basically two independent containment boundaries, both tested to the conditions of 71/73 hypothetical accident conditions. Now what we have to do is weigh that additional assurance against the increased potential for criticality.

In this process of what is the increased probability of criticality come other factors, which have not been factored in, or were not factored into the original ISG, which was four years ago. We've got additional studies. We've got high burn-up, burn-up credit, we've got reconfiguration studies that also lower the increase in the probability of criticality; and, therefore, would say now you need less added assurance. But what is that balance? Well, that balance is a risk-informed balance, and this is really what this whole thing comes down to, I think, is this weighing the two. And I don't know how we actually do that, whether it's subjective, or quantitative. Ultimately, it's going to be a combination of both, I think.

Okay. So I just wanted to clarify what the philosophy of ISG-19 was, and the fact that that same philosophy can also move forward beyond commercial spent nuclear fuel, as well.

DR. WEINER: You want to start with --

CHAIR RYAN: No, let's get the panel together.

DR. WEINER: Everybody up together?

CHAIR RYAN: Yes.

DR. WEINER: Thank you. I'm going to start with questions from the Committee, if I could. Bill, you had some very basic concerns, as I recall.

DR. HINZE: Well, I think this last presentation was very helpful to me, extremely helpful in terms of what some of the technical issues are, and how they interface with really the regulatory issues. I did raise the question about the leak-proofness of the container, and I'd like to ask Mr. Carlson a couple of questions that might help me, at least. I'm just wondering if in your modeling of the damage of the canisters, if you saw that the weakest point was in the welds of the lids? Is there anything in your analysis that would focus us in on the welds?

MR. CARLSON: The welds are all full penetration structural welds that are done per ASME code, so we don't expect there to be any weakness, or issue associated with the welds. You did note during the drop testing when you saw that to the extent we could during our drop tests, we tried to drop them such that the welds were impacted, so we did get some of the most severe testing. Now in our modeling analyses, what we have done is, in one of the references that I showed in the backup slides, we have an engineering design file where our structural analysts went through a derivation of what they felt was an acceptable failure criteria based on strain. That's not out of the code. What they did is they looked at the maximum strains that we saw in our test canisters, and from that, and based on some code-based limitations, they derived a failure criteria, which was significantly less than the strains that we saw in our canisters, or the deformations. And that's what we used when I mentioned that our modeling showed that we had a safety margin of 2-1, or 4-1 relative to our failure criteria. It was the criteria we derived in that engineering design file.

DR. HINZE: There are a number of these canisters that will be used. How do you achieve zero defects in the welds?

MR. CARLSON: I don't think you ever achieve, or at least you ever want to claim to achieve zero defect in anything.

DR. HINZE: How do you evaluate the number of failures then?

MR. CARLSON: A couple of things I can add there. I mentioned the critical flaw size testing. We did evaluate what we -- did some testing and analyses, or analyses supported by testing, to identify what the size would be of a pre-existing flaw that could cause failure under the test conditions. That flaw size turned out to be substantially larger than detectible limits, and we also have, I believe it was Everett that alluded to interim staff guidance, ISG-18, which provides guidance from the staff, on welding stainless steel canisters. And that guidance, if I'm not mistaken, it states that if they're welded and inspected per ISG-15, for all intents and purposes, no significant flaws would remain. So I guess it's a two-pronged approach.

We've tested flaws that are significantly larger than what we can detect, in fact, and seeing that the canister will withstand deformations well beyond what we saw in our drop tests, even with that pre-existing deformation. And we would also fall back on the ISG guidance that shows that if you weld it, and test it, and inspect it to certain specifications, flaws that would cause failure are not expected.

MR. WHEATLEY: This is Phillip Wheatley from the Idaho National Laboratory. Let me add to that - we also have an inspection system that goes along with the welding. We've developed the inspection system to be real time, ultrasonic testing. It does a pass by pass ultrasonic examination of the weld, so we can spot defects as we do them in each pass, if they should be there. And we have grinding tools and technology to take them out, re-weld without providing too much heat to the area, and so we have a high confidence that we can detect the defects in the welding as we go.

DR. HINZE: A further question, if I might. You showed the angle of the drop variable. Did you ever drop with the pin on the end of the canister?

MR. CARLSON: Yes.

DR. HINZE: And what was the result?

MR. CARLSON: That's an interesting drop.

DR. HINZE: Yes, right. You have to hit the pin. Right.

MR. CARLSON: No.

DR. HINZE: No?

MR. CARLSON: The puncture drop. Okay. The puncture drop, we did the one puncture drop for this CFR 71.73 criteria, which is 40 inches on to the six inch steel pin. And what we did to maximize that drop is we made the impact right at the center of gravity at the maximum load with no internal stiffening at all, but we didn't drop it on the head.

DR. HINZE: You didn't drop it on the head. Did you ever move to failure? Did you ever put the canister under conditions to failure and see what those failure conditions were?

MR. CARLSON: No. We drop tested per the 71.73 criteria, and we leak tested, and we did not push them to find the margin to failure based on drops, although we have done some work in that area based on analyses.

DR. HINZE: The history of this goes back into the 60s, as we've heard. Have there been any change in the canisters? Is this canister that you're talking about a new canister? You talked about, Jim Clarke's question, you talked about the two different types. Is this designed for this purpose, or is this the normal canister that is being used?

MR. CARLSON: It's a purpose-built canister we've designed specifically to fit into our safety strategy. And the objective was to come up with a canister that would provide a sufficient boundary to allow us to effectively de-couple our safety basis to the extent possible from the material within the canister. So the canister we have designed has not been used or analyzed to-date. It's on the table for handling and transporting DOE spent fuel. And it's also the canister we intend to use for interim storage and disposal.

DR. HINZE: That's all I have on this leak aspect.

DR. WEINER: Well, since this is a round table, feel free to ask any other question.

DR. HINZE: Well, one of the things --

DR. WEINER: And, by the way, please everyone should feel free to answer.

VICE CHAIR CROFF: I'm going to try. There's an awful lot of moving parts in these presentations taken as a group, and somewhat different directions for the various presenters. First, a specific question of Wayne Hodges. In your slide on pros for moderator exclusion, one bullet says, "Eliminates need for aluminum-based materials inside cask." What's the issue with aluminum-based material?

MR. HODGES: Well, it's just a matter that I think for final disposal, if you -- it's less desirable to have those kind of materials in a cask than the stainless steel and the cladding. That's a fairly minor point.

VICE CHAIR CROFF: This is a repository impact issue?

MR. HODGES: Well, if you're going to use the same canister for storage, transportation, and disposal, then you would need to worry about it for the whole range. And so it's strictly a disposal concern.

VICE CHAIR CROFF: What bad thing does aluminum do?

MR. HODGES: Well, it's not going to stand up as long as some of the others will.

VICE CHAIR CROFF: Oh, I see. Okay. It's the corrosion rate.

MR. HODGES: And it's also, so your boron that's in there won't have the same reconfiguration.

VICE CHAIR CROFF: Okay. Going back into Part 71, is my understanding correct, that at the time Part 71 was originally developed, there wasn't any contemplation that the spent fuel would be canistered? In other words, anticipated that during spent fuel transport, there would be the cask, there would be a basket inside, fuel would go in the basket, the lid would go on, and off it would go. And now we're talking, I think in both cases here, about the fuel being canistered. Is that correct? Anybody at all.

MS. OSGOOD: This is Nancy Osgood. I'll answer that question. It is an interesting question, the history of Part 71, but basically, the regulation that exists today governs the transport of all fissile material, including spent fuel, but also including things like Plutonium, low enriched Uranium, oxides, pellets, fresh fuel. So the regulations are not specific to, I'm going to say, the purpose of the end-use of the contents. They're generic safety requirements that should be applied to all packages. And I think that that's one of the things that has come to light. And as we become more mature and there's more shipments, there are certain parts of the regulation that probably should be examined with respect to risk, because the regulations are old, and they are generic, and developed for safety of all fissile materials.

VICE CHAIR CROFF: But I want to be clear on this specific point. When Part 71 was first developed, spent fuel, in general, was not going to be canistered.

MS. OSGOOD: That's correct.

VICE CHAIR CROFF: Okay. On burn-up

credit, I know this isn't on burn-up credit, but I was struck by - whose slide is this, Mr. Redmond's - noting that the criticality analyses in the three different regulations are rather distinctly different. And if I understood correctly, Part 50 presently allows, or takes into account the effects of burn-up, or burn-up credit; whereas, 71 does not.

MR. REDMOND: Part 71 takes into account partial burn-up credit. I mean, there's actonide only burn-up credit for IFD-8. Part 72 has no burn-up credit at all. Part 72 is fresh fuel with soluble boron. There's basically two burn-up credits, one full burn-up credit Part 50, one Part 71, which is dictated by interim staff guidance. And then Part 72, which is not burn-up credit.

VICE CHAIR CROFF: I'm, I guess, perplexed about - I don't know - how that came to be. Is there some technical reason behind this, why you should be able to do it in the pool, but not in the storage cask or something like this?

MR. REDMOND: Nancy will probably have to address that, but in my view, there should not be any technical reason why spent fuel is different, be it in a spent fuel pool, storage cask, or transport cask. I mean, it's the same fuel, same reconfiguration, essentially the same reconfiguration.

MR. RAHIMI: Let me answer that question, as well. Meraj Rahimi, NRC. The reason there are differences that you see on the Part 50 side, and Part 71 side - Part 71 were shipping fuel, spent fuel out on the public highways, outside. It's not in a controlled area, like reactors. On one side reactors, for criticality for the rack, is in the borated pool. So reactors, they always have that boron, PWR. And, normally, burn-up credit is for PWR. They have that boron to rely on. It's a defense-in-depth. Therefore, for burn-up credit, they don't go into a level of details in terms of benchmarking, quantifying uncertainties for each isotope, that Dr. Machiels mentioned that the approach methodology is different on the Part 71 side, because the environment is different, because these casks are in public highway. When we say the k-effective of that cask, we have to say with a high confidence, quantifying the uncertainties of all those isotopes, calculating k-effective. But on the Part 50 side, they always have that boron, that defense-in-depth, so in terms of benchmarking, they said well, these codes have been benchmarked against the reactor core. Every time they do restart, they use that code, so it is risk-informed on the reactor side. It is adequate, their methodology for Part 50 side.

VICE CHAIR CROFF: Are BWR pools also borated?

MR. RAHIMI: No. No, but we don't - to-date, no burn-up credit is needed, at least for the transportation, for BWR.

MR. REDMOND: Right. If I may, though, in regards to BWR spent fuel pools, the analysis in Part 50, though, does take credit for a limited amount of burn-up. BWR fuel is unique from pressurized water reactor fuel, in that it's reactivity increases with burn-up slightly, until about 15 gigawatt days per metric ton, and then begins to decrease again, so you have to analyze those spent fuel pools at the peak reactivity. And that is done with the same codes that we analyze PWR fuel, and taking credit for the fission product build-up up to 15 gigawatt days, so it is a form of burn-up credit that is done for the BWRs.

MR. RAHIMI: I do want to add that, again, on the Part 70 side, we are hopefully -- we are on the road to get full burn-up credit, but the data has to come in. In one case, we had a Holtec which presented more data. And in that application, we went beyond actinide-only. We provided credit for some fission products commensurate with the data they presented. So where already there is -- I mean, the staff is on the road to look at all these isotopes, and hopefully some day, if the data comes in, give the credit for those isotopes.

VICE CHAIR CROFF: Okay. I think I understand, sort of. There is, I guess, as I understand, in the existing regulation, there is already an exemption provision, a moderator exclusion. I'm back on that now. But there seems to be some reluctance to go in that direction, I guess, if I could state that, in sort of wanting to look at other alternatives. Is there a problem with the exemption?

MR. REDMOND: I believe the indications that vendors have received from the staff is that 71.55(c) has never been applied before, and that there would be great reluctance in an application coming in trying to use that. So it just hasn't been pursued because of the --

CHAIR RYAN: Can I pick up on that for a minute?

VICE CHAIR CROFF: Be my guest. That was my last one, so I'll pass.

CHAIR RYAN: All right. Great. Well, that's a segue.

DR. WEINER: I really would like Nancy to answer that.

CHAIR RYAN: Well, I'm going to ask a follow-up question.

DR. WEINER: Okay.

CHAIR RYAN: When we met last time, we talked about this exact point, and the idea that you needed rule making to somehow address it. Is that right? I haven't heard anything that tells me that's so, and here's what I've heard. And, again, I open it up to all the vendors to tell me, no, you've got it wrong, or yes, you've got it right. I heard strategies from DOE and from the commercial sector saying that they have strategies to take advantage of that current regulation, and how to assess their circumstances and situations, and offer packages to staff to say here's how we meet that obligation, and all the attendant obligations that reach out and beyond that one exemption clause. And again, having sat in the licensee applicant's seat years ago, I can tell you that guidance is a whole lot more helpful than a regulation, which is a few lines in 10 CFR somewhere. So why can't this be handled with more detailed guidance?

MS. OSGOOD: We searched for options with respect to dealing with moderator exclusion, and we came up with, I guess, a range of possible approaches going from keeping our staff practice, the way we interpret the rule now to allow the, I'm going to say, exception provision to be applied for specific shipments with additional risk information, all the way from allowing interpretations. You can see that there's a wide variety of possible interpretations of the regulations, and allowing moderator exclusion under some new interpretation of the rule, or to do this in a very methodological and risk-informed environment --

CHAIR RYAN: Just to add a thought here. I mean, you can add risk-informed guidance to how things get done. That doesn't mean everybody gets everything. I mean, you could decide on these are the top three that we really need to address, and hit one, two, and three, and take the approach that we're going to look at case one, two, and three, whoever that might affect, or whatever. I'm not trying to pick on any one example we've heard today.

And, again, thinking about a rule making process is years, and it's real clear to me in listening to all of you folks that the staff and the regulated community have a real clear understanding of all the issues, and coming to effective guidance. I mean, I heard one - well, we've talked three times, and we're now sensitive and aware of each others issues, and we're moving down the road, and so forth. I mean, why won't guidance work?

MS. OSGOOD: I'll let Earl Easton answer that.

MR. EASTON: Can I give you a little different perspective?

CHAIR RYAN: No, I want to get an answer to my question.

MR. EASTON: Okay. Why guidance won't work? I think for 10, 15, 20 years we have been implementing this regulation in a consistent concerted fashion, and I think our stakeholders have come to depend on that. And when I say stakeholders, states, they make routing decisions based on the fact that a criticality is not possible, because in the end, it's like --

CHAIR RYAN: That' just not good thinking, because not possible means zero? We heard it's not zero, even though it's very small.

MR. EASTON: Well, we've told them, basically, that if you penetrate a cask from a safety or security event, and fill it with moderator, you still don't get a criticality. Okay. That's what we've told them, and I think that message is important because here you have an activity that is not protected by site boundaries, and is in the hands of unlicensed people, carriers. When you turn these things over, it's a carrier, it's not an NRC licensee.

CHAIR RYAN: I understand all that.

MR. EASTON: Okay.

CHAIR RYAN: I know about shipments, trust me.

MR. EASTON: So what I'm saying is, when you change the rules of the game to make this the rule, not the exception, I think stakeholders need to have an input, because we have basically told people, this is the rules that you play for by all those number of years.

CHAIR RYAN: I hear you, Earl, but I'm struggling with the fact that none of these other presentations have given me any indication whatsoever - in fact, they've given me indications to the contrary, that if there was credit for moderator exclusion, nothing would change with regard to that transportation decision making in terms of risk.

MR. EASTON: Well, I think --

CHAIR RYAN: It would meet all the requirements in all the parts.

MR. EASTON: I'm not sure we know about risk, because I tell you why. We have another major organization come in with a thing called TADS. TADS are smaller, which means --

CHAIR RYAN: On the table today. I want to keep aside what we've heard about today.

MR. EASTON: Okay. All I'm saying is with moderator exclusion, you heard the case that you have larger casks, less shipments. This does not comport with the future policy of the way we're going to ship material.

CHAIR RYAN: It's a policy for down the line. That's tomorrow's problem. Yes, sir. Tell us who you are, please?

MR. CAMPBELL: Larry Campbell, Spent Fuel Storage and Transportation. If the industry comes in, if you look at the regulation, it's an exception. If the industry comes in, it will no longer be exception, it will be the majority of the shipments which following that. And I think that's why we're looking at rule making, is because now we're going from exception to possibility 100 percent of future applications would go with moderator exclusion. The intent of the rule was on a case-by-case exception basis, and I believe that's why we need rule making.

CHAIR RYAN: That's a good point, but a case-by-case exception basis that hasn't been exercised is not 100 percent everybody going with the exception. So maybe it's not today to decide to do rule making, maybe you do three, or four, or five, or whatever number to get some experience on what is the range of this exception, how is it applied? And somewhere down the line, maybe it's two, or three, or four cases down the line, then you've got the basis to decide does this need to be generalized in a codified rule. And I appreciate that point, that's a good point, but I just don't see the evidence today to say jump into rule making, at least satisfies me.

MR. BJORKMAN: Gordon Bjorkman, again. I think that rule making was the preferred option of the staff. What we're moving forward with is with a commission paper to inform the commission about various options and possibilities. And I think that the rule making is one of those options. If the commission decides that given the evidence of the low probability of these events, and given additional information based upon reconfiguration and burn-up, that rule making is not important, or rule making is not necessary. The commission would then basically leave it to the staff to provide guidance. So we're just moving forward in a process at this point.

CHAIR RYAN: Still, I get a little twitchy when I hear well, we're going to say the preferred option is new rule making. Again, from the regulated community standpoint, that's a multi-year deal.

MR. HODGES: But even if you don't do rule making, if you go out and say we want to get the commission's approval to follow this other approach, the one that's proposed, and we'll use an exception basis everything that's out there. You still have an environment impact statement out there that's going to have to be changed.

CHAIR RYAN: Okay.

MR. HODGES: And you're going to

probably have numerous meetings with the public, and so the process may not be drastically different whether you go with the simple change, and now use the exception, or go with rule making. It may be a little bit cleaner to do it with rule making, but the time frames may be very close to the same.

CHAIR RYAN: I guess we haven't talked enough about the environmental impact statement side of that, so I've got a good feel that I either agree or disagree with you; although, I hear your point.

MR. HODGES: All right.

MR. REDMOND: If I may, for a second. I'm just a little confused, I'm afraid. DOE is talking about a standardized canister which, in their view, can be done within -- cut inside a cask, which is the containment boundary. And then within the context of the regulation, which says flood the containment boundary, and then talks about the most credible extent, DOE is saying that they have their system which remains dry, and they've done drop tests. That, in itself, to me, meets the regulation 71.55(b), not the exception part. To me, the exception part is talking about the containment system, and an exception to that, which is different.

In regards to the issue of, if DOE gets it, everybody's going to want it. Well, that's not true, necessarily, either, because there's certain constraints that the staff would put on DOE, granting DOE to do that, that well, if industry as a whole can meet it, sure, we want it, but we're not likely to be able to meet those same constraints.

What industry is looking for, though, in terms of burn-up credit, for example, is we'd like to be able to do burn-up credit, but just have the staff recognize as defense-in-depth - Meraj talked about defense-in-depth, you've have soluble boron on the spent fuel pools, PWRS, anyway, BWRs you don't. But you have that as defense-in-depth. We'd like recognition for the leak tightness of the canisters for the defense-in-depth part that he's talking about. But what I'm hearing is that staff may need, in order to make that leap, which I view as a relatively small one, they still may need direction from the commission to do that, or they believe they may.

CHAIR RYAN: Just to add one last question. Thank you for your patience. My question of burn-up credit versus moderator exclusion. What happens if you put both of those babies in the same baby carriage and figure it out?

MR. REDMOND: Industry's perspective is burn-up credit solves our problem. Burn-up credit fixes - if we are going to analyze the same as we do our spent fuel pools, our problem goes away. And that takes care of our high density DPCs, which one thing I forgot to mention when I was talking, it slipped my mind, we have over 60 - actually, over 80 of these high density canisters already loaded, and there are more continuing to be loaded annually, so the Part 50 burn-up credit fixes our issue, if we need defense-in-depth, which I understand we all want defense-in-depth, and it is necessary, look at the canister.

MR. BJORKMAN: I think that Meraj put it quite eloquently, when he talked about you can take advantage of burn-up credit when you're on the reactor site in one way, but you have to look at burn-up credit, and reduce the uncertainties when you look at burn-up credit when the fuel is being transported in the public domain.

CHAIR RYAN: Something magic happens when it crosses the gate, huh?

MR. BJORKMAN: Doesn't the canister do that?

CHAIR RYAN: I mean, I don't buy that, tell you the truth. I mean, I understand that 50 applies on the reactor, and 70 applies on a public highway, but I find that to be not a compelling argument.

MR. RAHIMI: Well, because Part 50 - Meraj Rahimi, NRC. On the Part 50 side is the level of details. I've sat down with the staff on the Part 50 side, looked at their review of burn-up credit for racks, and how they do the review. They are being risk-informed, rightly so. They've got boron in the pool. They're not asking for the data for each single isotope. That's what I'm talking about.

With respect to Everett's comments, actually, staff's preference is burn-up credit. You bring the data, we'll be more than happy to give you the level of credit that you need. With respect to the DOE's issue, they're not asking for burn-up credit. They don't want burn-up credit, because they cannot really tell you what the burn-up of these foreign research reactor spent fuel are and how they were operated --

CHAIR RYAN: Question - DOE has a tougher hill to climb on that score. I'm done, Ruth. Go ahead.

DR. WEINER: I'm sorry. Excuse me.

DR. MACHIELS: Clearly, when a vendor goes for a certificate to the NRC for transportation, the vendor has, obviously, no idea what specific fuel that will go into that container. And so, from that point of view, there has to be a certain conservatism built into the system, but when a utility does an analysis using their methodology, they actually do it on the fuel that they know, so it's very well characterized. And so I think that's the option, at least, if it were available, for doing criticality calculation using utility methodology. The utility has a value given that they doing on a very specific number of assemblies, and they know exactly the power history of those assemblies, compared to somebody who has to apply in a fairly generic manner, doesn't have the same level of detailed information.

CHAIR RYAN: Thank you.

DR. WEINER: Jim.

DR. CLARKE: I have a couple of questions. Hopefully, both of them will be quick, although I'm concerned about the second one. I'm still framing it. Just to follow-up on Bill's line of questioning with the Idaho folks, and I interpret how do you assure no defects in terms of quality control, and quality assurance, and what are you doing to learn about the likelihood of defects? You said you refer to tests, you refer to inspections and things of that nature. Is it fair to assume these are 100 percent quality control, all of the welds are subjected to these tests, and other pieces?

The second question that I'm kind of struggling to frame, and I don't want to get us into distraction, or a discussion that doesn't need to take place. Much of this is very new to me, but here we go. I get the impression in listening to all of you that we are interpreting risk in terms of probability. And one of the things I haven't heard from any of you, and maybe I don't need to, and maybe it's well in-hand, and you've looked at it extensively, is consequences. And I guess my question is, where does that fit into this?

MR. MACHIELS: I have alluded to that in one of the slides, and what we did in order to compare risk associated with a criticality event, and risk associated with non-radiological events, like accident --

DR. CLARKE: I saw that.

MR. MACHIELS: So we have to transform the probability into a common basis.

DR. CLARKE: I saw that, and I liked that. I mean, that's what I would call risk balance when you're looking at --

MR. MACHIELS: And so we did --

(Simultaneous speech.)

MR. MACHIELS: -- analysis of the criticality event by doing very straightforward calculations. We assumed that the contents of the 32 assemblies were to come up with a dose.

DR. CLARKE: Okay. So you have looked at this, and this is --

MR. MACHIELS: Yes. But when you have probabilities of the ten to the minus whatever --

DR. CLARKE: I understand.

MR. MACHIELS: -- you can release a gazillion curies, it will still come up to essentially zero.

DR. CLARKE: Okay. I was just surprised that we didn't hear more about it, but maybe we don't need to.

MS. OSGOOD: I would like to make one

comment, too. As part of any kind of rule making program, that that would be part of the equation, because I think you're exactly right, we've concentrated and focused on these probabilities during the transportation phase, but the risk from loading, unloading, and looking at the consequence part, I don't think is well understood, and that would be part of any kind of rule making plan.

DR. CLARKE: I just like the definition of risk that puts the two together.

MS. OSGOOD: Exactly.

CHAIR RYAN: Although, we had, what was it, 800 casks that have been loaded from --

DR. WEINER: Brant had a --

CHAIR RYAN: We do have an awful lot of loading experience.

DR. WEINER: Brant had a comment on the question.

MR. CARLSON: I was going to respond to at least the initial question that was posed here with regard to quality control. Our canister design specification, the design fabrication and inspection would all be done per ASME code.

DR. CLARKE: My point was it's 100 percent.

MR. CARLSON: Well, again, in the risk-based or risk-informed, you never say 100 percent, but it will be a code-stamped vessel so, I mean, it's made to full quality control. There are a couple of other issues that were brought up with regard to our fuel that I probably ought to address while I've got the floor here. And one is this, with regard to moderator exclusion per the exception in 71.55(c).

What we tried to point out is that through a change in thinking with regard to 55(b), and making a shift in reliance on putting all our credit on knowing that we're in the as-loaded condition, and we kind of assured that the fuel reconfiguration has not occurred, under that condition, you can assume - take a bounding assumption with regard to leakage. What we said is there's two factors that requires you to assume only to the most reactive credible extent, so there is, at least, a foot in the door to start thinking about being risk-informed in the current regulation, that talks about the most reactive credible extent for both the fuel configuration, and the moderation. And what we're saying is we want to take less credit for fuel configuration, but more credit for rendering the moderation to be improbable. And that's the approach that we're going, and we think we can do that, as Everett mentioned, within the existing 71.55(b), without asking for the exception. Although, if the staff chooses to go that way, I believe we meet the requirements that are specified for granting the exception, but we don't like the implication that that would leave, that we don't meet 55(b), as stated, because we believe we are at least as safe with our demonstration of leak tightness under 55(b), as we would be if we did the analysis based on the fuel configuration.

DR. WEINER: Thank you for that clarification. I think that was fairly clear from the slide, but that was necessary. I have a sort of wrap-up question really directed at the staff. If you were to go to rule making, I assume that the tenor of that rule making would be that you would either allow - either require moderator exclusion, or show that there would be no criticality if there were water intrusion. In other words, you would - the rule would include those two options. Would it also include burn-up credit?

MS. OSGOOD: I think with respect to moderator exclusion, we haven't really formulated what that final rule might look like. It would be part of the rule making process, and certainly, the regulatory analysis would guide us that direction. But I think from today's presentations, you can see that there's ambiguity in the regulation, and wide variation in interpretations, and so I think that there are ways that we could give, I'm going to say, regulatory relief and clarity under certain circumstances to allow that as an option.

CHAIR RYAN: Why can't you do that with guidance? Why do you need a new regulation?

MS. OSGOOD: I think - and my slide is gone now, but I think there are some compelling reasons. And I think that we've talked about the use of an exception as a routine approval. Remember my last talk, I talked about everything is licensed under a general license, so it's not the same thing as issuing a specific license. And I think, also, we can't minimize Earl's earlier points with respect to the public's understanding, and the way we do business, and the risk assessments, and our generic environmental impact statement that have always provided the infrastructure for transportation.

DR. WEINER: Let me ask a follow-up question. We, essentially, give technical advice.

What technical work would need to be done to support the decision of going for a rule, or not going for a rule? And just to expand on that a little bit, are you planning to do a comparative risk assessment of these various options? And it seems to me, that's a risk assessment that should be done. You can't assume -- to get back to something --

CHAIR RYAN: We're losing track of your question, Ruth.

DR. WEINER: I'm losing track of it myself. To get back to Dr. Hinze's point, you have to - you can't ensure moderator exclusion. You can't be 100 percent sure that no water will ever get in. So would you be doing a comparative risk assessment of these various options, and would there be other technical bases for a rule, or for saying no rule?

MS. OSGOOD: I think one of the things is - and maybe we're getting a little bit of the cart before the horse - because I think that when we evaluated the range of options that we might propose to the commission with respect to kind of reaching a resolution on this topic, we identified rule making as an option. And how that would develop into a regulatory analysis, I don't think we have concluded exactly what we would do. But I would envision some kind of relative risk evaluation, but Earl is more familiar with the risk assessments that have been completed to-date. He might have a better --

CHAIR RYAN: Just before Earl answers that, I guess I would offer you, again, the view that five or six case-by-case kind of studies or analyses, or individual efforts would give you the meat on the bone to help you design the rule making. I just - jumping right into rule making, I know what's going to happen, or at least I have a feeling what will happen. You'll write a rule, you'll get a rule approved, and then you'll write guidance that you could write right now and do on a case-by-case basis, so that's just my thoughts.

MR. EASTON: I think that all of the risk studies in the EIS that support this rule, rule out criticality from the get-go, saying it can't happen, it doesn't even consider it. And I think the fact that we do this by a general license, the public does not have an input. And if we --

CHAIR RYAN: Wait a minute. We just heard about all sorts of criticality analyses these folks are doing.

MR. EASTON: No, the public, like in 72

they do a rule making, in Part 50 they have a license, in Part 71, the public does not have an input to the certification, so if we start changing the exception to be the rule, I think you'll get a lot of challenges maybe to how we implement the rule, because of the risk studies and the environmental impact statement.

CHAIR RYAN: It's very circular, Earl. There are exceptions in the regulation now because it was deemed to be helpful to deal with different cases.

MR. EASTON: Right. And I think --

CHAIR RYAN: So I don't get the circular argument. It doesn't fly, for me.

MR. EASTON: And I'm in favor of doing the least risky thing on a case-by-case basis. I mean, that's the bottom line. And if we have things that are already loaded, and you don't want to unload them, we ought to consider case-by-case basis. If you have things that you don't know about, and it's safer in the end to double-contain it, we ought to consider that as an exception. But I think before we turn it into the general rule, we have an obligation to stakeholders to go back and explain to them why what we've been telling them in risk studies and EISs for decades is not really the rule.

CHAIR RYAN: Again, I'm not saying rulemaking shouldn't happen at some point, but I think that to meet your goal, three or four, or whatever small number of cases evaluated and brought through the process would give you the information that would help in that process that you're talking about.

MS. OSGOOD: Dr. Ryan, you also asked about burn-up credit.

CHAIR RYAN: Yes.

MS. OSGOOD: And I think with respect to rule making, so --

MR. RAHIMI: I would like to answer your question about a rule making, would we include both moderate exclusion and burn-up credit? I would say that we should leave burn-up credit - burn-up credit comes in the implementation of the regulation, and it shouldn't go into the regulation. I mean, there are appropriate words in the regulation, most reactive credible reconfiguration consistent with material --

CHAIR RYAN: So you agree with me that guidance should be where that gets addressed.

MR. RAHIMI: Burn-up credit. And we have guidance, and ISG-19, moderator exclusion is there is a guidance, so we've done --

CHAIR RYAN: I've heard people criticize 19 so far.

DR. WEINER: Well, I have to get back to something Earl Easton said about public input. If you have public input on moderator exclusion, wouldn't you want it, as well, on burn-up credit?

MR. RAHIMI: Yes. In terms of public input, when we put out ISG, there is a public commenting period. ISG-8, that there was on burn-up credit, that we did that. But to go back to your question, why rule making with respect to moderator exclusion - on a case-by-case, the regulation intended to do it like a per shipment or a case-by-case basis. But here, we have --

CHAIR RYAN: It doesn't say that.

MR. RAHIMI: It doesn't say that, but it's in that regulation. But here we have DOE coming in for a design approval, so it's not a sort of a shipment, per shipment, single shipment, one time shipment. They want a general design approval moderator exclusion.

CHAIR RYAN: And, again, I think we've

recognized that there are some aspects of DOE's case that are very different than the commercial power reactor case, so let's don't pick on DOE, although, I think the case you made was pretty compelling from the technical perspective, that there are issues there that could be evaluated under the exception, or within the context of the existing 71.55(b).

DR. WEINER: Aren't they always design approvals? I mean, you just said DOE came in with a design approval, but they're always design approvals, aren't they?

MS. OSGOOD: In general, that's how we do transportation approvals. We approve a design, and that's one of the beauties of Part 71, is once we approve a design, any licensee is authorized to use that package. They can build one of that package design, they can build 100 of that package design, and any licensee is authorized to use that package for basically, shipments to anywhere.

CHAIR RYAN: All right. I want to ask a question on rule, or using these various -- how many casks have you guys approved over time?

MS. OSGOOD: How many spent fuel casks? Hundreds.

CHAIR RYAN: Hundreds.

MS. OSGOOD: Hundreds. Hundreds.

CHAIR RYAN: Now you've approved hundreds of individual casks under the existing rules.

MS. OSGOOD: Hundred designs, yes. A hundred designs.

CHAIR RYAN: A hundred designs.

MS. OSGOOD: Some packages, they have a thousand units, or multiple thousands of units.

CHAIR RYAN: Not worried about the multiple units.

MS. OSGOOD: Okay.

CHAIR RYAN: Because I used to work with guys that brought you in design packages.

MS. OSGOOD: Okay. Oh, yes, I know that.

CHAIR RYAN: Lots of them. Oh, yes. So the point I making is that one, two, three extra packages doesn't add a lot to that load. I just don't see the arguments of where we're doing a better job of informing the public, when we've been doing this under these existing rules for decades. I mean, by the way, that does not diminish my desire to fully inform the public about everything the agency does. I think that's a great, absolute goal.

MR. HACKETT: I was going to try one. This is Ed Hackett from SFST staff, too. I think, to me, listening to the debate and trying to make some observations here, I think to take a step back, I think the common theme I'm hearing is risk-informing this area.

CHAIR RYAN: Exactly.

MR. HACKETT: And how we go about it, whether it's through rule making, or guidance enhancement, or any number of mechanisms, I think is what we're looking at as our going forward approach.

CHAIR RYAN: And I think we have maybe some different views on where's the horse and the cart.

MR. HACKETT: Exactly.

CHAIR RYAN: Okay.

MR. HACKETT: But I see a most -- everyone has presented today aligned with the idea that risk-informing in this area would be a benefit pretty much to everyone, to the industry, and Idaho's got a special case, certainly to the staff, because we've been - just by virtue of the three meetings Brett referred to, we've been learning and looking at our guidance going forward. I think there is need for some enhanced clarity, that I think would come through risk-informing this area in a more -- and one way, as we've been talking about, is through rule making, in terms of framing it. But I think that's --

CHAIR RYAN: You're absolutely right. And, again, my plea is that we step back and think more about that, maybe evaluate a few more cases before you make a commitment that rule making is at the top of the list of what things we need to do. Sir?

MR. WHITE: Yes. This is Bernie White. I'm in NRC SFST, and if I could address the rule making versus issuing guidance.

CHAIR RYAN: Guidance.

MR. WHITE: Yes. I think what we've seen over the past, and now this goes back - I've been working 15 years. When one applicant comes in and asks for something and they get it, like when the fresh fuel people went to 5 percent, they all kind of came in and went for 5 percent, so we tend to see applications come in in bunches over a couple of three years.

I think one thing the staff was trying to avoid is to have an applicant come in, or two applicants come in, ask for moderator exclusion, and then we go, oh, what do we do now? We've never done this. Then we see three, or four, or five more wanting to come in for the same issue, for a generic approval. And then we go well, what do we do? Well, maybe we've got to ask the commission? And then we're kind of in the part where we're doing the rule making, or not doing the rule, but we're asking the commission at the same time we're supposed to be doing the licensing, and we were trying to circumvent that, and get up to the commission, and kind of get their views on this prior to applications coming in. I think that's where we saw this going long-term.

CHAIR RYAN: And I appreciate that, but there is the other side of the coin, which is, are you going to have one or ten? So I wouldn't want to embark on a multi-year rule making until I had a better feel for that.

MR. WHITE: And I don't think we have a feel for that.

CHAIR RYAN: Fair enough.

DR. WEINER: Could I ask one final thing? So I understand it, Bernie, from what you just said, that what you're looking for is to prepare for - do some preparatory work to decide whether or not there should be a rule making. And that's where your cases are going to come in, and that's where your comparative risk assessments are going to come in. Is that a correct reading of where the staff is going?

MS. OSGOOD: I think so, because in NMSS rule making space, of course, before we would even have a proposed rule, that we would issue guidance contemporaneously with, we would do the regulatory analysis, even before we go down that path, so that's exactly right.

DR. WEINER: Does anyone else have any further comments, questions? Anybody? If not --

CHAIR RYAN: I want to thank again the staff and all the participants today. We had a really breakneck session last time trying to cover this entire space, and I think it seemed like 20 minutes, it was way too short. And I want to thank Bill Brock for helping reorganize all of his staff, and again, all the participants here today. We have a much fuller picture, and I think a much better picture of your intent, what some of the issues are with other stakeholders, and hopefully, we'll do a better job of formulating our views in detail in a letter to the commission, but again, I want to thank everybody for putting up with another session with us to give us a lot more insight, which it was obviously a very complicated topic, and I'm glad we all came back together, so thanks very much.

DR. WEINER: I want to add my thanks to the participants, the speakers for keeping within our time schedule. Thank you so much. I know that many of you had other slides, and I would encourage everybody to look at the additional material that was submitted along with the slides, because I know that, especially Dr. Machiels and Everett cut-back their presentations a great deal, because we kept telling them there's no time. So thanks again to everyone.

CHAIR RYAN: That's great. Thank you all very much. We really appreciate it.

I guess with that, we're scheduled to visit with Commissioner Jaczko at 4:30.

DR. WEINER: Yes.

CHAIR RYAN: And we can take a short break until say 4:25.

(Whereupon, the proceedings went off the record at 4:06 p.m., and went back on the record at 4:27 p.m.)

CHAIRMAN RYAN: I thought we would just

take a minute to try to summarize. And I think we are going to prepare a letter on now the full presentations on the issues of moderator exclusion and the transportation staff's presentations to us. So, Ruth, do you have any initial thoughts or --

MEMBER WEINER: Well, I talked to Chris. And I would like to take a look at the transcript before we embark on the letter just to make sure we know who said what and actually what was said.

CHAIRMAN RYAN: Okay.

MEMBER WEINER: But the staff that --

CHAIRMAN RYAN: Have you got any themes you might think about? Can I offer you one?

MEMBER WEINER: You're about to anyway. So please.

CHAIRMAN RYAN: The one theme that I thought that everybody sort of agreed on that we caught a couple of times, many times, actually, during the presentation was risk-informing.

MEMBER WEINER: Yes. And this --

CHAIRMAN RYAN: So that's one general thing we need to make sure we cover of what people's views are in risk-informing whatever is the activity that comes later.

MEMBER WEINER: And Bill just made an

interesting point. If there is a basic change in approach, it needs to have broader optics than guidance.

CHAIRMAN RYAN: And I think the alternative view of that, which I would offer, is -- and I think that is right -- that maybe some case by case sorts of work would better inform how generally what specific issues need to be in the more generalized regulation.

So I always wrestle with what is the split between what is in the regulation language and what is in guidance. And I think that's something we will have to think through in our letter as we study the transcript.

Frank?

MR. GILLESPIE: But they might not be mutually exclusive.

CHAIRMAN RYAN: Absolutely.

MR. GILLESPIE: So you might want to consider that it makes sense --

CHAIRMAN RYAN: Yes.

MR. GILLESPIE: -- while you are considering a typical two-year rulemaking schedule, --

CHAIRMAN RYAN: Right.

MR. GILLESPIE: -- a year to propose, a year to final, which is kind of typical, that the staff should, in fact, entertain the case-specific ones to inform that process.

CHAIRMAN RYAN: Right.

MEMBER WEINER: I think that came out.

CHAIRMAN RYAN: Thinking about that and then how that all winds up we will need to understand a little bit more, but I think that is certainly something we need to cover.

MR. GILLESPIE: Because there was a temporal nature to at least three of the cases here.

CHAIRMAN RYAN: Right.

MR. GILLESPIE: I mean, obviously the people came. So they felt it was very important in the near term with them.

CHAIRMAN RYAN: Right. And again, I don't really have a good feel for how long such a rulemaking might take, but the length of time of rulemaking versus interim guidance now and rulemaking later on, all that needs to be thought through.

I wouldn't propose that we have an answer. And I think we need to try and lay out what we heard from everybody about the variables involved and then what our views as the Committee might be on those variables.

MEMBER HINZE: It might be useful to the Committee and to the staff to encourage the NMSS or the NRC to prepare a position paper which outlines all the pros and cons of these various approaches and look at some of the risks involved in these --

CHAIRMAN RYAN: I think we heard that that would be in the regulatory analysis part. So that would all be something that would be covered. So I think that that is certainly --

MEMBER WEINER: I thought that Wayne's explication of the pros and cons of a rule on moderator exclusion was a very good framework for that.

MR. HAMDAN: Can I add something on the risk? I think it would be a good idea to initiate a study for converting risk with and without the moderator exclusion. I think I would start that tomorrow.

MEMBER WEINER: Yes.

CHAIRMAN RYAN: Well, there are several elements of that that we heard about. And we didn't intend to dive into all of these. So it's by no means a criticism that we didn't cover the full breadth of all of these. But there are obviously probability issues which were covered. And then there are some consequence issues, which were covered, in part.

I am a little bit interested in some of the details of whether the consequence assumptions are risk-informed or not risk-informed. Probabilities I think tend to be risk-informed just by the very nature of how you calculate probabilities.

And then on the transportation side, you know, we have wrestled with before -- and we have talked about it before. What are the different databases that have been used to calculate transportation accident rates?

MR. HAMDAN: If it could be done, can you imagine if you calculated the risk with moderator exclusion and without it for a few case studies --

MEMBER WEINER: I think that's --

MR. HAMDAN: -- and you get some numbers back?

CHAIRMAN RYAN: Certainly something to think about.

MR. HAMDAN: They could tell you the

difference is very small or they could say the difference is huge.

MEMBER WEINER: Well, the problem is that in any case, the radiological risk is always very small. But the question is, what is the difference?

MR. HAMDAN: Yes.

MEMBER WEINER: Is there a significant difference? And I think that that was touched on in the transcript.

MR. HAMDAN: You did it.

CHAIRMAN RYAN: Anything else?

MR. GILLESPIE: Just that I saw Jack Strohsnyder in the room. I would like to give an "Attaboy" to the transportation people since we have an office director here.

(Laughter.)

MR. GILLESPIE: And if you observed the discussion, I know it might be the wrong office, but it was a great presentation we just had, I think, on the technical aspects of the technical questions.

CHAIRMAN RYAN: We kind of left an hour for last month. And we decided last month we needed more than an hour. So we had a whole bunch of folks and had a really good afternoon on the topic of moderator exclusion and new casks and new transportation months for spent fuel.

MR. GILLESPIE: And, Mike, tomorrow is Jack's last day.

CHAIRMAN RYAN: I Know that.

MR. GILLESPIE: And he is coming here.

(Laughter.)

CHAIRMAN RYAN: Let me congratulate Jack on his just highly successful career in NRC and his highly successful career in the days and years ahead. Jack, thank you. On behalf of the Committee, I think I want to recognize that Jack has really been very helpful at working with all of the offices to help the Committee get information and access to the staff and really make our work easier and better for your participation.

So, Jack, congratulations again. And we really appreciate your being with us. Thank you.

MR. STROHSNYDER: I will just quickly thank you. And, as I said many times before, we really value the input from the Committee technically. And you help us a lot, make sure we get the right quality products. So thanks. Thanks for everything.

6) ACNW MEETING WITH COMMISSIONER GREGORY B. JACZKO

CHAIRMAN RYAN: Welcome. Commissioner Jaczko, it is a great pleasure to have you with the ACNW. We are looking forward to your views and opinions and information and guidance.

So, without further ado, let me turn over the podium to you.

COMMISSIONER JACZKO: Well, I thank you for that. And I appreciate the opportunity to speak here today. I have an opportunity to interact with some of you periodically. And I thought it would be nice to have an opportunity to interact with you as a group.

I really look at this as an opportunity for me to talk to you about some issues that I think are important to me and then hear from you about what you think of those things certainly or other things that are on your mind. And I would certainly welcome any kind of a discussion that you would want to have.

CHAIRMAN RYAN: Thank you.

COMMISSIONER JACZKO: And there are a couple of things that I thought I would start out with. And then certainly we can discuss anything you would like to discuss.

I think the first thing that I wanted to say is that as I have been here now, been a commissioner about two years and I have become familiar with the ACRS and the role that ACRS plays and I have become familiarity with the role that you all play, I think that there is opportunity to work on the role for ACNW and to put that I think on more of an equivalent footing for ACRS, just dealing with a different set of issues.

I think sometimes -- and I have been guilty of this -- that we have a very overworked and sometimes under-appreciated staff. Well, I guess maybe you could say always under-appreciated. And I think sometimes given the workload of the materials area, that we have asked you oftentimes to to some degree be a surrogate staff to develop policy kinds of things and policy issues. And I don't think that that is often the most effective use of your skills and talents.

And I really think that the Commission should really look to working to making the Advisory Committee truly an advisory committee in the sense that they're really providing a review, an independent review, of staff issues, from really primarily I think on the technical side and looking at those things and working on those things and giving us an independent look at some issues, pointing out to us what is important.

I think that that has certainly happened in a lot of areas. I think on the high-level waste area, I think that has happened quite a bit and the Committee provides a tremendous asset in that regard. And I think it would be nice to see that expanded in more areas.

I think that involves two things. I think, one, it involves us making sure the staff has resources to be able to implement the things in the policy arena that they need to implement as well as making sure that you have the flexibility in your charter or other appropriate guidance to be able to do that as well and to solidify that relationship.

So I think I just thought I would start with that because I think that for me really is how I see the ACNW playing a role. And I think that is a role. I think I would view that as perhaps a little bit of an expanded role from what you have now. If it's not seen that way, I would certainly appreciate your feedback because it's intended to be seen that way.

You know, no matter where we go and what we do, I think the NRC will always be viewed as a power reactor agency. One of the first things that I learned when I got here -- of course, when I got here, I wasn't too familiar with all the other things we do. But it is really in the materials area where people are harmed on, unfortunately, I would have to say, you know, on a weekly or a daily basis, if you will.

It's in the use of nuclear materials. People get real exposures. They get acute exposures. They get exposures that have real immediate health consequences.

I think that it's unfortunate to some degree that we don't focus as much or this agency isn't known as much for the work that we do in controlling that aspect of our regulatory authority or in implementing that aspect of our regulatory authority.

So I think there are a tremendous number of things that can be done in that area and that there is a lot that we can do, whether it is looking at improvements in human performance or training or other kinds of things to really reduce the incidence of medical exposures, of industrial exposures, of these kinds of things. I think that certainly is an area that is one of tremendous interest to me.

Another -- and these are just some areas that I think are important and where I would certainly -- again, I view this more as an opportunity for me to throw some ideas out there. And then I would really like to hear from you all what you think about some of these and your thoughts.

Another area that I think, a scenario that I know very little about but have just enough knowledge about based on past work that I have done to be able to comment on -- and I think that is sometimes the most dangerous position to be in. And that has to do with the use of models.

Again, I think this is an area where ACNW can really provide good guidance to the Commission is on the use of models in a variety of applications, whether it is decommissioning and dose analysis and dose assessments or even all the way in an area where I think there has been a lot of information. And that is on high-level waste.

I always remember that when I was a graduate student, I had an opportunity to do some modeling. And the modeling I always did was particle physics modeling. So the modeling was a relatively easy thing to do from the standpoint of you could control, really, the interactions that you were dealing with.

And the results of your models were really well-defined by a set of mathematical equations. I mean, you had a good theory. The difficulties and challenges weren't so much in understanding the theoretical basis, but it was in the actual limitations of calculational ability to take those equations and actually do analytic solutions or develop analytic solutions to these equations. So you used modeling as a way to replace that. And you could do that in a very rigorous and I think refined way.

What I see often in the work that we do here from a regulatory standpoint is that the theoretical basis isn't always as clearly defined and clearly understood. And so not only do you get into challenges, actual computational challenges, with modeling, but you get into challenges of are the models an accurate reflection of whatever physical processes we're actually trying to make predictions on and then throw on top of that the fact that you are trying to do this for a regulatory standpoint.

So I think modeling is really an issue

that we don't spend enough time doing. And then, of course, from the Commission's standpoint, when we present information, we want to present information I think in a way that is accessible to policy-makers, policy-makers outside of this agency.

And it's easier to talk about things when you can talk about a number. So there is a tendency to want to take numbers and use numbers that we have derived from models, but it's really important, I think, in particular, to hear from you all about what those numbers mean, what the limitations of those models are. Is this an appropriate use of these models?

Those are all the kinds of questions that are much more difficult than challenging but really go to the heart of whether or not that number that we are using really has any meaning in a regulatory, even just in a physical context. So I say that, as I said, with enough information to be somewhat knowledgeable and with probably not enough information to be totally accurate.

Another issue that I think -- and, Mike, you and I have talked about this, and that is really this issue of I think how we do this whole framework of waste. We have waste that is defined, by and large, by function or origin and not by dose or not in a risk-informed way or in a -- I like to think of it more in terms of the health and safety implications of that waste. I think that is clearly an area.

The one issue that particularly hit home for me was a cleanup that we were doing at the Heritage site in New Jersey. And there you had uranium and thorium that were contaminating certain areas of that site. Some of that uranium and thorium happened to be licensable material because it happened to meet the .05 percent by weight definition. Some of it was not.

Well, from the standpoint of I think what our agency's broader mission is, our mission is really to look at that from a public health and safety standpoint. And the .05 percent by weight definition is not a health and safety-based definition.

So we were making arbitrary -- well, not arbitrary but a decision about what material was licensable, then going through a process and determining doses from that while neglecting other material that may have had dose implications but, nonetheless, was not material that was licensable and, therefore, wasn't involved in our cleanup activities or, for that matter, was included in the dose calculations, more importantly. So, again, it gets back to kind of that idea of the models and how we use and do these calculations.

So that is a specific area where I think the Commission could make some changes and perhaps move to a definition or an understanding of those materials that is based on the public health and safety definition, not what I understand is a definition that really had to do with whether or not this material could be useful in a commercial source. And I don't think it ever really was envisioned that we would wind up having to use this as a cleanup standard to some extent in the future.

A couple of other areas I will just touch on briefly. And this one I will raise perhaps as more not so much a comment but just to say that I think this is an area where I think that the Committee has done a lot of work. And I think that is really in the issue of low-level waste and how we get -- a lot of this is in conjunction, too, with the National Academy of Sciences and how we deal long term with the issues of low-level waste in getting good regulatory framework and really to some extent a good national policy for low-level waste disposal in this country and greater than class C waste as well, I think, going into that category.

The last point perhaps I will raise is -- and I will leave this perhaps more as a question -- the staff has done a lot of work recently on looking at a risk analysis toward dry cask storage, which I think was a very good product that the staff worked on to take a look at what the risks would be associated with moving fuel to dry cask storage and the risk through the whole process, from loading a cask to storing a cask, or to transferring a cask, to ultimately storing the cask.

And I think that is a very good piece of work that the staff has done and is I think to some extent laid at the doorstep of the Commission an important issue that I think we really need to think about. And that is whether there is information in that that tells us that we need to maybe more proactively and from a regulatory standpoint move towards requiring or encouraging the movement of fuel from wet into dry cask storage.

I was surprised by that particular report and really even that the integrated risk was really so low, even when you consider the transfer, the risks associated with transfer, because that was, as I had always understood, really the area where there was the most concern.

And taking into consideration that as well as the long-term risk issues I think I was surprised to see that numbers were so, so low that, you know, while the risks from spent fuel storage and wet storage are comparably low from an accident standpoint or not comparably but are themselves somewhat low, I think the Commission has always been in a position that that is, to some extent, safe, but I think there is such a dramatic reduction in risk from the movement that it may warrant an examination on the Commission's part of maybe doing some things to encourage more movement and more dry cask storage.

So those are a couple of issues that I had on my mind and Greg suggested that I talk about.

(Laughter.)

COMMISSIONER JACZKO: So I will leave it to you, however you would like to do this, if you would like to ask me questions, or however you want to proceed.

CHAIRMAN RYAN: Well, thank you very much for your list. I think it is a thought-provoking list. I am happy to hear several things that will come to you and the other commissioners in our revised action plan and charter.

I think we, like you, recognize that we have shifted from kind of a really heavily weighted high-level waste program to now a more materials and other issues kind of program for the ACNW as well as the high-level waste piece. And I think we can add value. So I am pleased to hear that you want to enhance that.

So you will see that in our action plan, which responds to the SRMs that the Commission has given us as well as in our charter. So that is kind of a general comment that much of what we have talked about you will see parts of it fed back in those two documents.

First of all, let me ask each member to maybe introduce themselves and say where they are from just so you get a better feel for everybody. So let me start over here with Professor Clarke.

MEMBER CLARKE: Jim Clarke, Vanderbilt University.

CHAIRMAN RYAN: And do you want to say a minute about your background, areas of expertise?

MEMBER CLARKE: I joined the faculty at Vanderbilt in 2000; prior to that, 25 years of experience in the private sector. A lot of that focused on investigating and remediating contaminated sites initially and then chemically contaminated sites and then expanding into chemicals and radionuclides and risk assessments using the EPA approach.

MEMBER WEINER: I am Ruth Weiner. I spent up until 1993 almost 40 years in the academic world. And my last position was as dean and professor of environmental studies at Western Washington University.

And I am now at Sandia Labs. And I am the principal investigator for RadTran, which is the model -- and I'm glad you mentioned models -- for assessing radiological risk of transporting radioactive materials. And we actually do all radioactive materials.

I am also an adjunct professor in the Department of Nuclear Engineering at the University of Michigan.

COMMISSIONER JACZKO: Do you spend most of your time in Michigan or --

MEMBER WEINER: No. I live in

Albuquerque when I'm not coming to Washington. Once a week fall semester, I go to Michigan. You have hired a number of my students --

COMMISSIONER JACZKO: Oh, yes?

MEMBER WEINER: -- at NRC.

COMMISSIONER JACZKO: Oh, good. Good.

VICE CHAIRMAN CROFF: I am Allen Croff. I worked at Oak Ridge National Laboratory for 30 years and retired a few years back. By training, I am a nuclear chemical engineer. And my work was in nuclear waste management, EM cleanup, and nuclear fuel recycle.

MEMBER HINZE: I am Bill Hinze. I spent my academic career walking over Bascomb Hill between Science Hall and Sterling Hall.

COMMISSIONER JACZKO: Oh, yes.

MEMBER HINZE: So you know where I am coming from. I have taught geophysics at Michigan State and spent the last 25 years at Purdue and am emeritus professor there and interested in both the geological -- all the geos.

CHAIRMAN RYAN: And I am Mike Ryan. And my background is health physics and nuclear engineering. I think I am the only member of this Committee that was a licensee at one point.

MEMBER WEINER: Yes.

CHAIRMAN RYAN: So I always have that perspective to offer. I graduated from Georgia Tech and University of Massachusetts at Lowell.

MEMBER WEINER: I should mention that both Dr. Clarke and I are graduates of Johns Hopkins University. We got our Ph.D.'s in the same department.

CHAIRMAN RYAN: We won't hold that against you.

(Laughter.)

CHAIRMAN RYAN: Anyway, that's kind of just a brief introduction to the staff. I think with the broad range of skills that we have, we can certainly address a broad range of issues.

And I would be remiss to not immediately mention the ACNW staff, many of whom are here today, both our technical and support staff. Without all of them, we would be ineffective at our job because they are here all four weeks of the month. And we come in one week of the month and work remotely from that point.

Without their concerted efforts and their real dedication to the technical excellence of our work, we wouldn't be doing as good of a job as we are doing. So they are really kind of a key backbone to our effort. So I wanted to recognize all of them who are here today.

I would also be remiss not to recognize Frank's predecessor, Dr. John Larkins, who I won't say departed -- who retired --

(Laughter.)

CHAIRMAN RYAN: -- in December of this year but is still helping in the HR area in the agency.

Okay. With those introductions, boy, this is a terrific list. First of all, I guess I will offer you my views. And I would ask the Committee to jump in as they might want to offer.

I really resonate with the idea that this isn't just the power reactor agency. There are 20,000 licensees in the agreement states program, something like that. And I agree with you that there is a lot of opportunity to d better job of radiation protection and material management in that arena.

You know, there are 34 or '5 agreement states now with a couple in the mill. And that has got a direct connection to this agency through the agreement states program and the MPEP oversight program and all of that.

So I think there is a lot of good connection that can be made where the agency's skills and abilities can translate to the states. And that is not to say it doesn't already because the Conference of Readiness of Control Program Directors, the Organization of Agreement States, both of whom interact with the Commission and the staff at a variety of levels. But I think there is a lot of power in maintaining and actually increasing that synergy.

You know, you mentioned industrial. There is just one little study done in Texas on the group of folks who received the highest and most frequent overexposures. And that is industrial radiographers.

Bob Emory is at the University of Texas, the other big school in Texas besides A&M, who looked at the hiring dates and the incidence of these overexposures. And guess what? The curves overlap. It is a training issue for new entrants into the profession. And with the ups and downs in the oil industry, he saw three of these spikes over the last 20 years. So it's real clear that it is a training issue. And now Texas is working on that new training requirement kind of question for that industry segment.

So there are lots of opportunities to take that as a lessons learned and share that with everybody. So that is I think something where we could provide some input and help.

The modeling and monitoring question is also near and dear to my heart. I'm always interested in people's perception of what's a good answer.

In internal dosimetry, you know, I inhale or ingest something. If I calculate an organ dose to within 100 percent, that's a great answer. That's a win. But, you know, if I am doing a criticality calculation, .006 percent error could be a real bad thing.

So the context of uncertainty I think is really what we have addressed. And I think we are continuing our work on modeling and monitoring for the purpose of feedback. How are things behaving? Are they behaving like you think they are or are you just having what I call numerical narcosis events, where you are just calculating stuff? And, you know, is it really serving a useful, informative purpose? So we will continue to I think address that.

COMMISSIONER JACZKO: No. I would say, I mean, I think that is really one of the issues and I think one of the challenges that we have as an agency, how you communicate that kind of information to people who are maybe not from a technical background but, nonetheless, have an important role in policy.

I think that is one of the challenges because it is easy, I think, to fall into the perspective of not giving that aspect of it, the error aspect of it.

CHAIRMAN RYAN: Absolutely.

COMMISSIONER JACZKO: Yet, sometimes then, you know, particularly in a policy arena, giving numbers that don't have precision to them can have its own challenges. So there is a real balance there in terms of how you do that and how you communicate that. But it is an important thing that we have to get right as an agency.

Well, it is an interesting one. And if you look at different applications, I think the timeline aspect of it is the critical issue. If I have a medical test, they inject or I ingest radioactive material and they measure it somewhere and immediately we know if things are right or wrong based on how much goes to where they're looking for it to go.

In an environmental model for a decommissioning site, we might have, you know, some radioactive material, we are trying to predict its future behavior. And that may be over literally hundreds of years.

So one strategy that we are thinking about more and more is how do you couple the monitoring requirement for a long-term with modeling exercise that gets you started to say, well, it seems like things are okay, but, you know, what's the obligation to make sure they're okay as time progresses and even into longer time frames.

So we are thinking more and more about that as we deal with decommissioning and legacy sites and low-level waste sites and things like that. So that's a topic we will probably address in future letters and so forth.

Anybody else have particular points?

MEMBER WEINER: Can I jump in?

CHAIRMAN RYAN: Please? Ruth?

MEMBER WEINER: I got interested in transportation about 15 years ago, when I first went to Sandia as a summer faculty fellow, but it has come home to me that this is the most visible part of the entire nuclear endeavor.

People see the trucks, and they see the trains. And they see the big casks with the trefoil on them. This has always seemed like the red-haired stepchild of the whole nuclear industry.

And I was just curious as a new commissioner and with -- you were a Congress science fellow, as I was; so you have ties to Congress -- what the Commission's view is of the role of transportation and transportation analysis.

And to date everyone has focused on transportation of spent nuclear fuel, which is a small chunk. I mean, most packages are not spent nuclear fuel. So I would be very interested in your view.

COMMISSIONER JACZKO: I think there are a couple of things. And I will say this is definitely my view and not necessarily the Commission's view.

I think you are right. I think transportation is a very visible aspect of a lot of the nuclear fuel cycle. And I think the focus has been on spent fuel because I think from a risk standpoint, there is a -- well, I don't want to say from a risk standpoint, but there is a lot more activity in spent fuel than in a lot of other shipments.

So I think there has been a lot of focus on that. And I think the Commission has put in place a set of requirements to address accidents involving that or I guess -- well, I guess I want to say high-level waste. Is that DOE requirements or they're NRC, they're NRC requirements? The NRC requirements for the cask.

You know, I bring this specific example up because this is something that happened when I worked on the Hill. We started looking into whether or not testing had been done but whether the NRC allowed for full-scale or required full-scale testing of casks in transportation campaigns. And the answer was no. I mean, there was allowance for reliance on scale modeling or scale model tests and then modeling.

And the person I worked for at the time suggested that, well, maybe we should take a look at actually doing some tests. And out of that came the package performance -- well, I don't want to say out of it came the package performance study. That was going on somewhat simultaneously. And I think it helped move that in a slightly different direction when it came to actually doing testing in that case.

So I think spent fuel transportation is a very visible thing. I think it is a challenging area for the NRC because of our relationship with the Department of Transportation.

So with the exception of spent fuel, you know, a lot of what we do from a safety standpoint and really even a security standpoint, we have tremendous relationships or established relationships with the Department of Transportation, where they have, by and large, the responsibility for those shipments. And we have a responsibility in our cask certification, but safety of shipments is really a DOT responsibility, as we have established.

So it is a challenging area I think for us as a regulatory body because of that shared responsibility.

MEMBER WEINER: We know almost nothing about, we have done almost no testing of packages other than spent fuel casks. And this is an area that has always concerned me. You know, we assume that if it is Type A package, everything goes, but we know that that is not the case.

COMMISSIONER JACZKO: And that is an interesting point. And I think this was the reason that I think that when I worked on the Hill in this particular scenario, I mean, I looked at this and I thought, "Okay. Well, you know, we can do tests of these. And we can subject a spent fuel canister to an immersion and a 30-minute fire."

You can do these things. It's not technically limited, you know, your instrumentation and what kind of results you get. There might be some limitations there in designing a good experiment. But, by and large, it's something we can do.

I always try to compare it with the analogy of nuclear weapons tests. I mean, there we have made for policy reasons a decision not to conduct tests of weapons but that we would rely on modeling as a surrogate to figure out what the performance and behavior are.

Well, in the case of casks, you can do it. There is no technical limitation, really, to doing it. So it is something that it makes sense to do, where we don't need to model, you know, we shouldn't model, we should do testing.

And I think that is generally a philosophy that I have tried to bring to this, not to say that modeling isn't important and modeling can't be useful but it is a surrogate. And we shouldn't use it unless we need to in that sense.

I think, again, it goes back to the point perhaps that I made earlier that, by and large, what we're known for is the reactor side of things. So when it comes to transportation, the thing that people are most interested in is the transportation of the reactor things, which is the spent fuel and, you know, to some extent even on the new fuel.

But shipments of other materials, it's not really, again, as much of a focus, certainly from my perspective at a Commission level, as some of the other things. And I think it is an important point.

CHAIRMAN RYAN: Go ahead, Allen.

VICE CHAIRMAN CROFF: I was interested in your mention of the source space waste classifications and the dysfunctional impacts and ramifications of it.

The Committee has had contact with the high-level waste issue, where you want some kind of a floor. And in low-level waste, there are difficulties at the very dilute end, where it is almost not waste, and at the very concentrated end, where it goes out of low-level waste burial greater than Class C and some sealed sources and maybe the depleted uranium issue, but we will see what comes forth.

So far the system and even Committee recommendations have approached it on trying to fix it without changing the definitions per se of low-level waste or high-level waste because that seemed to be sort of almost a lightning rod or too difficult.

But looking into the future, there is the inventiveness of people. They always seem to be coming up with something new that doesn't quite fit. And if we were to go to recycle and reprocessing, there would be a whole bunch of waste that we haven't faced if it's done anything like what DOE currently envisions.

Do you have any thoughts at what point you sort of stop trying to patch the existing system and say, "Okay. We sort of need a blank piece of paper. Let's try to do this right on a risk basis"?

COMMISSIONER JACZKO: Well, I think we

have passed that point.

(Laughter.)

VICE CHAIRMAN CROFF: Oh, boy.

COMMISSIONER JACZKO: But the practical realities are it is difficult to do, I think. And we have done it. You know, the reclassification of waste at Savannah River and Idaho is an example of that, where people looked at a definition that was source-based and said, "Well, that may not make sense from the standpoint of health and safety or activity or whatever other kind of basis you want to categorize waste as." So waste was reclassified in Savannah River or will potentially be reclassified in those places.

So I think on an ad hoc basis, it has started to basis. But I think, as I said, the shorter answer is I think we have reached the point at which we really need to do it. But it's a very, very difficult thing to do because fundamentally it is, by and large, it is a legislative change that needs to happen.

I mean, that's why I bring up the issue of the uranium and thorium. In that particular case, the Commission has the full discretion to do that. We regulate uranium and thorium at all levels. And it is an exclusive NRC or federal government material. So we license that.

The definition of the .05 percent by weight definition is a regulatory definition. So I kind of focus on that one because it is one we can change simply by action of this agency. So it gives you an opportunity to start to try and develop a system for dealing with uranium and thorium specifically in this form and start to show that you can come up with some reasonable definitions that aren't really source-based in the same way.

I mean, I fundamentally think that it's something that needs to happen, probably should happen already, perhaps might help bring some coherence to this system.

It's there. You know, you think of places like Heritage. These were not people who were in the nuclear business. And, yet, they found themselves in the nuclear business because of the processes that they happen to have been using.

And that has implications, then, for decommissioning. It has implications for a wide variety of things. And there is really no coherence, then, to how we look at waste, how we look at the original source material because that definition of thorium isn't a waste definition. It's the source definition.

But they are related. And the thing that ultimately seems like from our agency's perspective that relates them is their public health and safety consequences.

So I think, as I said, I think the time has already passed for us to have done that, but I think it will be challenging thing for the Congress to try and do because it has such a technical basis to it. And everyone wants to make sure that their facility isn't being or their cleanup isn't being redefined legislatively from being a cleanup to a non-cleanup or whatever the case may be.

The other case -- and I think, Mike, this is something you and I had discussed, that this may have implications for things like *in situ* leach mining, you know, where right now we regulate because of the fact that ultimately we are processing or milling this material underground. But if you looked at this perhaps from a risk-based standpoint, we may have a very different regulatory approach for dealing with that kind of activity.

But, again, it's not really a waste issue necessarily there. It's a processing issue.

But, nonetheless, the processing is intimately tied to the waste issue, to the decommissioning issue.

So I think these things really are not separable in the way that we have separated them. You know, radiological material has health and safety ramifications, whether it is in a way stream, whether it is in the initial product stream, you know, or, you know, in the middle of its industrial application.

CHAIRMAN RYAN: I think that's a terrific view. You know, if you look at just the waste side of it, take cobalt-60, which is a five-year half-life and from a disposal management point of view, it is fairly easy to deal with.

It is immobile. It is insoluble. And it's a five-year half-life. You don't have to work too hard to get it isolated until it has decayed away. Yet, it is the driver in greater than Class C irradiated hardware. It is the principal radionuclide.

So it gets down to a couple of interesting questions. One is quantity. And the other is concentration. We tend to regulate based on concentration when, in fact, risk is more related to quantity and concentration based on the particulars of the setting. And you gave a few, *in situ* leach mining and others.

So I think there are some fruitful areas for us to think about and maybe think about it in the context of okay. Where is the low-hanging fruit? Maybe uranium/thorium is the one.

And then the other approach, which I would be happy to get your reaction on, is, for example, in waste disposal, small, tiny sealed sources, which on a mass basis or a volume basis calculate up to huge numbers, are now managed by exception.

You take it, put it in some special container and capsule and average over the volume of the mass. And it's clearly a small source. And it's disposed as Class A waste right on up to the Trojan reactor vessel, where averaging was an appropriate approach and it's used in hardware, you know, hot stuff and cold stuff in the same package and on down through the list.

Those are approaches to take a step. Maybe it's not a big enough step or maybe there ought to be three of them, but, you know, we could think more about how do we better risk-inform those aspects? Maybe there is a middle ground. Maybe we don't throw out the definitions right away. That will happen later on its own.

But think about how could we change certain aspects of the regulation to allow applicants, licensees, or whoever it might be to take risk-informed approaches to taking some exercise with the definitions and offering alternative views. Maybe that is an approach to think about.

COMMISSIONER JACZKO: Well, you know, one of the things that I have thought about and raised in that context is really the interrelationship with RICRA Subtitle C facilities and some very low-activity Class A waste.

And there I wonder if there isn't an opportunity for us to do something with EPA where we sit down and think about what are the requirements that you have on those facilities compared to what kinds of requirements we would have for that low-activity waste from a health and safety standpoint.

And would it be possible to open up those facilities through an MOU through some kind of relationship where we establish that those facilities would be viable for -- you know, if licensed under Part 61, they would meet a certain set of performance objectives for low-activity waste. And if they meet it because it's RICRA Subtitle C material, that should be perhaps acceptable from our perspective to have those as an alternate disposal site but formalize that and regularize it in a way so that we're not doing it by exemption, you know, we're not on a project-specific basis taking waste and fighting alternative disposal pathways but we formalize that in a way that opened it up.

CHAIRMAN RYAN: Well, I think you will see that in our action plan as one of the activities we have thought more about and kind of formalized the plan on. And I think Jim Fark will have the lead and I will be helping him with it a bit, but I think that is right on target.

If you really think about it, fly ash is used as a stabilization agent in RICRA landfills all over the country. Well, fly ash has more radioactivity than anything else in the landfill. It's just naturally occurring uranium and thorium radionuclides.

So the addition of some small quantity concentration-based or quantity-based or both in that setting doesn't necessarily upset the risk equation for that facility. And certainly when you look at the other constituents that will be permanent, that's a fruitful area to plow.

What we are doing, I think -- and I just might preview this -- is we are trying to collect up any information we can on cases where that has been done. So we can pull all that in one, kind of similar to the low-level waste white paper, and then explore. The EPA has had a rulemaking and there is some provision in states and other places for where people address this.

So we can least gather the information and say, "Well, here is the starting point." Now, maybe there are some options we will see out of that. Maybe we will pick them up as we go through it. But we are hopefully on the path to have that as a part of our activity the next year.

MR. HAMDAN: Mike, can I add something to that?

CHAIRMAN RYAN: Yes, Latif?

MR. HAMDAN: The re-creation in Appendix A of --

CHAIRMAN RYAN: Latif, would you mind telling the commissioner your name and --

MR. HAMDAN: I am Latif Hamdan. I have been with ACNW for 3 years and 15 years with NRC. And I am glad to see you here --

COMMISSIONER JACZKO: Thank you.

MR. HAMDAN: -- with Greg also, Greg.

I just wanted to say that the regulations for the hearings in 40 CFR Appendix A are derived from the EPA standards in 40 CFR 192. The groundwater prediction standards in 40 CFR 192 are derived almost verbatim from the solid waste, the hazardous waste regulations, 40 CFR 264.

So the regulations for groundwater prediction that are controlling the milltailing regulations at NRC and the EPA are the exact same standards in 40 CFR 264 for solid waste.

CHAIRMAN RYAN: That is an interesting basis. So I think you are trying to draw a string and see what that well looks like and then from there hopefully develop interesting avenues to pursue further works.

COMMISSIONER JACZKO: I look forward to seeing that.

CHAIRMAN RYAN: Yes. Anyone else?

(No response.)

MEMBER HINZE: If I might?

CHAIRMAN RYAN: Please?

MEMBER HINZE: A question. Being interested in the natural Earth systems and, thus, very much interested in doing the right thing for Yucca Mountain and for the country, we have a limited time going up to June 30th, '08.

And I'm curious as to and I think our Committee is as to how we can be of most help to the Commission leading up to that June 30th date and subsequently. And I would really appreciate your comments on this.

COMMISSIONER JACZKO: Well, I think in a broad sense, I mean, obviously it's all modeling. I mean, the reality is it's -- well, I don't want to say it's all modeling, but --

MEMBER HINZE: Let me make a comment on that.

COMMISSIONER JACZKO: Yes.

(Laughter.)

MEMBER HINZE: Your interest in modeling parallels very much that of the Committee. And in the Earth sciences, oftentimes our theoretical basis and our parameter, our database is insufficient to give us a singular model that we can validate in the face of other models. And we end up with professional judgments.

And one of the things that I think this Committee has been trying to do is to make it clear that there are alternative views that must be considered and must be validated and put into this scrutiny and the scrutiny of geological analogues as well as the theoretical and quantitative bases.

And that is one of the things we are trying to emphasize in our letters but also in this white paper on igneous activity that we are in the midst of preparing.

COMMISSIONER JACZKO: Well, I mean, by and large, I don't think I could have said it as well as you did, but that is, by and large, one of the areas where I think the Committee can be most helpful, helping us understand what the limitations are, what the -- well, I guess that's the best way to say it, what the limitation in the modeling is.

And, I mean, again, it is a very, very difficult situation because we have developed a regulatory framework for the licensing of the geologic repository at Yucca Mountain which is based, by and large, on the answer that comes out of that model.

And looking at it, there is some

question in my mind whether that is really a viable framework to make a regulatory decision because you can get an answer. And that is absolutely true. You can go and calculate. And run various scenarios, do some sensitivity analysis, variety parameters, and based on that say, "Okay. We're going to pick a mean value" or "99th percentile" or whatever value we are going to take for what we get and use that as the number to say whether we need 15 millirem or not or various other regulatory standards.

Looking at it, I don't know that that is valid. I don't know that you can really do that if there are uncertainties in the model, if there are parameterizations in the model that are not based on empirical data but our judgment.

And if that's the case, then you have to realize the judgments going into it and how do we then make regulatory decisions when we have a framework that, by and large, says, "Look at the model, and you'll get an answer." I think that is the challenge, really, that I see for the Commission going forward as we deal with this.

MEMBER HINZE: Well, as Mike mentioned previously, you know, the uncertainties are a part of our mantra --

COMMISSIONER JACZKO: Yes.

MEMBER HINZE: -- and will continue to be. And by constraining those as much as possible but not over-constraining them, if you will, you know, realizing that there are these differences -- you know, that is part of the sequence of letters that you have received from us. But we have a short time frame here.

COMMISSIONER JACZKO: Yes.

MEMBER HINZE: We have a little over a year that we can be of assistance, probably less than that, really. Are there any holes that you see where we might spend more of our time or our interest?

COMMISSIONER JACZKO: I am reluctant to suggest any because I think that there are -- I have not gotten too far into the details, by and large, because of the ultimate role that the Commission will play. I think it is always a balance between trying to get too much information ahead of time and getting enough information to know that the process can work.

MEMBER HINZE: I don't want to leave the impression that we don't know where we are going.

COMMISSIONER JACZKO: No, no, I don't get that at all. I didn't get that at all.

(Laughter.)

MEMBER HINZE: Because, frankly, we do have some very interesting topics as a result of conversations with NMSS and our own thinking.

COMMISSIONER JACZKO: Perhaps I would suggest I would be curious as to what you think what those topics are, what you think are the most important things that you need to focus on for the next --

MEMBER HINZE: That can be helpful right now. I think igneous activity is one. And one of the things that I can think of we can do and can be very helpful to the Commission on is making certain that we look at this from a risk-informed standpoint because there are some differences of opinion that, in my view, without having run the whole analyticals of performance assessment, I suspect there is really no risk-informed difference between these.

And so are we just -- I don't want to say wasting our time, but we could be putting this in a more effective way on some things.

CHAIRMAN RYAN: There is probably one area, Bill, where I think we are ready to understand what the EPA standard finally comes out to and then what NRC regulation will look like because obviously that time frame is an area where we have not spent a huge amount of time either gathering information through the staff and what their analyses are all about.

So the 10k to 10^6 year time frame is where I think we will probably focus some effort once things get finalized as we get closer to the L.A. However that timing works out I don't know, but that's an area of interest.

MEMBER HINZE: But the answer to that is seismic --

COMMISSIONER JACZKO: Seismic, right.

MEMBER HINZE: -- both in the pre and the post-closure and very closely associated with that. What you have ramifications in several areas is the whole item of drift stability, whether you're talking about 10,000 years versus a million years. It's a great deal of difference.

And drift stability, as we all know, can have an impact far greater than just, for example, venting the canisters and accelerating the corrosion, et cetera. And then these are simple topics that I think are within our purview that we can be of assistance.

COMMISSIONER JACZKO: Well, I mean, I think those are all good areas. I mean, I think -- and, again, I have not looked in tremendous depth at the analysis, but there is a tremendous amount I think of areas in which better information would always, I mean, in terms of the Commission having more information can -- and that is not to say that I don't want that to be interpreted at all that I think the staff is not doing a good job.

I think the staff is doing a very good job in this area. But I think there is just a tremendous amount of information built into the model, the SPA or whatever the name is, that is extremely important information.

And some of it may seem subtle and less intuitive in the sense that it may not intuitively have a ramification on the final outcome, but some of it may, in fact. Some parameters, there may be tremendous sensitivities to variations in those parameters that it's just not known analytically or a priori.

And I think those are the things that I worry about as we go forward that we haven't missed some of those and that, you know, as you said, that there may be some that we spend a lot of time discussing that in the end may not have real impact on the final outcome.

MEMBER HINZE: Well, hopefully an advisory committee can bring in a certain amount of experience, which in an intuitive way helps to zero in or suggest areas that can be most productive.

COMMISSIONER JACZKO: Yes, yes. I think --

CHAIRMAN RYAN: If I could shift gears a little bit, Bill, you mentioned the ACRS and the ACNW and us maybe looking at little bit more alike as time goes forward. Do you have any thoughts about the new reactor licensing efforts and activities as things that we ought to begin our thought process about?

COMMISSIONER JACZKO: Well, I think one area in that regard which I think you are already looking at is the 20.14.06 area.

CHAIRMAN RYAN: Yes.

COMMISSIONER JACZKO: I think that is an area where I think there is real ramifications for -- this is something that I heard. I can't tell you how many times I have heard it. And it's mostly from decommissioning managers.

And they have said the best thing you can do for decommissioning is deal with cleanup when it happens. It has tremendous ramifications for how we actually have to decommission.

In every facility I have ever been to that has legacy contamination, it's usually a spill. It's usually somewhere in the process that -- well, not always but often it's there was a spill at some time and that spill wasn't remediated and now you have a contamination plume somewhere that is migrating that is now much more challenging to remediate than it would have been had you cleaned up the original spill.

So I think that is one area, to provide technical and other support to the Commission and to the staff as they go through and look at how they are going to apply that particular provision to new reactors. I think that is an area that is tremendously important.

And I think just in general on the waste management side and the long-term look at how we are going to do decommissioning -- and we have -- people are talking about today, you know, I think an issue that was never really envisioned, of course, when reactors were originally built, which was that they would be replacing steam generators and other large components.

Well, we have done that. That has ramifications, then, for decommissioning. What are we going to do with these steam generators that are sitting at facilities now, some of them in vaults, which now you have taken something, rather than disposing of it immediately, you have taken it, you have put it on site, you have now contaminated concrete through activation or whatever happens.

So now not only do you have to dispose of the steam generator you have to dispose of the vault that it was in. And what do we do with all of that material? Are there better ways to deal with that to begin with?

And that gets more in to not really the licensing but the decommissioning and ties back in, of course, to disposal and do we have disposal sites for these kinds of things.

So I think that that is an area that would be important for us to make sure we are getting right going into it because I think, really, we have seen obviously the issues with tritium have been -- well, not from a health and safety standpoint problematic.

They have been problematic from a public perception. And that has created challenges for this agency. And a lot of those are issues that could have been dealt with better had we gone into this with a better understanding of how we're going to mitigate and deal with spills and how we are going to deal with those kinds of things, if nothing else, from a decommissioning standpoint, not tritium.

The half-life is short enough that, by and large, I think most tritium, you know, if a spill happened early enough in the life of the reactor, that tritium is mostly decayed by the time you get to decommissioning or it could really migrate off site, but there may be other radionuclides where that is not the case. And so thinking about those things ahead of time and really forcing us to focus on those things now I think will have long-term benefits when we get to decommissioning and those kinds of things.

CHAIRMAN RYAN: That is kind of consistent with our thinking as we have thought a little bit about it and recognizing those issues.

Jim, do you have a comment?

MEMBER CLARKE: I thought it was a great

list, too. And I was especially interested in items 2, 3, and 4, the use of models and how we could advise you there. And we have been working in that area, as you know, and within a decommissioning context, the value of a model and the value of a conceptual understanding of the site is something that needs to be moved up as well.

So it's not just when you get to the end, what do you have and how do you deal with it? It's more how do you prevent that problem, as you know, in getting there? So that is an important piece in the RICRA landfills, the low-activity waste.

And it struck me in listening to the discussion that RICRA isn't all that risk-informed either.

(Laughter.)

COMMISSIONER JACZKO: I will thankfully say that we don't have any responsibility for that.

(Laughter.)

MEMBER CLARKE: I know, but it may be a piece of it. And, you know, while you could argue, I guess, that the characteristics of hazardous waste might have some tie to risk with extraction procedures and MCLs and ignitability and things like that, certainly being on the list with hazardous waste, being mixed with hazardous waste doesn't have a whole lot to do with risk. So that is a piece.

And then I think the especially challenging issues are when you put very long time horizons into the equation.

COMMISSIONER JACZKO: Well, you know, I think -- and you have raised the issue of modeling. And I go back, too, to the issue of this issue of 20.14.06. And, you know, again, the modeling, if we don't ever have to get to modeling, that would be great.

I go back as you were talking about that. And I thought, you know, wouldn't it be better if we remediate these issues early so we don't have to find ourselves from a decommissioning standpoint where we are having to model the behavior of a plume and how to remediate that.

This isn't to denigrate modeling, but I think computers have made modeling far too easy. And, again, I think back. I was a graduate student for five years. And then I left kind of a scientific career. So all I know about science, I learned in school, I guess, not through actually really practice to some extent.

But my adviser at the time, my thesis adviser, was a traditionalist from a computational standpoint. He could calculate everything. I mean, it didn't matter what it was.

(Laughter.)

COMMISSIONER JACZKO: And I would try and model everything. And I would come back to him with some results and talk to him about it. And, you know, he would think about it, and he would do a little something and say, "Well, that doesn't make sense to me."

You know, that modeling has become so easy that there is a temptation to want to use it a lot because it does give you concrete answers, but I always keep in mind the thing that he used to tell me because also often in the physics department these days, it seems like if you are a graduate student, you also somehow wind up maintaining the computers. It seemed to be a common practice. And I always used to worry whenever our computers were crashed I would have to go tell him, "Oh, you know, our computers are crashed."

And he would say, "Great. Now we can actually get some work done."

(Laughter.)

COMMISSIONER JACZKO: So, you know, he was not a fan of modeling. And I always try and keep that in the back of my head. Then, again, it's not -- I mean, people who model, I think it's excellent work.

And it's not to denigrate modeling, but it is something that I think because of the ease of it, people that are then put into a policy arena, we tend to not always look at what the limitations are of the models, what uses the models were developed for, and are they applicable for the kinds of questions we are trying to answer. And it is very easy for us just to gloss over that.

And I think that is why your insights can be extremely valuable to keep us on track when we are doing that so that we don't get too far into doing something that looks attractive because we can get an answer that we can go talk to a member of Congress and say, "Well, see, this is why we made that decision, because we took this model and it said X and X is determined to be okay."

That is a very tempting thing to want to do and to be able to do because it gives us an ability to explain our answer, rather than having to try to explain, "Well, you know, we made a judgment.

We had a model, but we weren't quite sure that the model was appropriate."

And they would say, "Well, what did the model tell you?"

"Well, it said that this was safe to do."

They say, "Well, why didn't you think it was?"

And then you would say, "Well, why don't -- you know, but the number is such and such." That is a much more difficult conversation to have, but in the end, I think it is a better conversation to have.

MEMBER CLARKE: During your opening comments, I was reminded I was in a theoretical chemical physics group. And I was reminded that we had the arrogant way of looking at things that went like this. If the model and the experiment don't agree, then the experiment must be wrong.

(Laughter.)

COMMISSIONER JACZKO: Absolutely.

MEMBER CLARKE: I am afraid some of that still persists.

COMMISSIONER JACZKO: Yes.

MEMBER CLARKE: And, in addition to

improving our model confidence, I think we need to find ways -- as Dr. Hinze mentioned, we have natural analyzed things that can support these models.

COMMISSIONER JACZKO: Absolutely. And I think particle physics these days is all about trying to get nature to justify the models to tell us that these particles that we have predicted that are out there are there.

And some of that is theoreticals. It's not just modeling. But there is a lot of that that goes on now. Modeling has allowed the theory to get out in front of what the experimental data supports. And so there's a lot of work now and a lot of things when I left the field where they were learning that the modeling was wrong.

MEMBER HINZE: Looking at very simple systems and the equations were well-defined, a lot of the solutions were analytical, if not solved by simple series expansions.

And now the systems are incredibly complex. The conceptual model may even be an issue. So I couldn't be more excited about --

COMMISSIONER JACZKO: Well, thank you.

MEMBER WEINER: You made an interesting point, too, about decommissioning and cleaning it up, cleaning up things. And one of the things that we haven't really looked at is when you clean up immediately, what do you do with what you have cleaned up? And all too often, you know, you have created two contaminated sites. I think that is a point that we just seem to miss.

CHAIRMAN RYAN: One interesting view of that, Ruth -- and we have talked a little bit about it in Committee -- is what does a licensee benefit if he does all this, you know, clean up as we go?

MEMBER WEINER: Yes.

CHAIRMAN RYAN: Does he have a lower decommissioning cost? You know, there are ways to incentivize good behavior. So we can think about that.

Commissioner, I am mindful of your time. I think we are a few minutes over. I don't want to interrupt the rest of your evening. We would be happy for you to stay for a long time. I don't want to cut you off, but I sure don't want to intrude on the rest of your afternoon.

COMMISSIONER JACZKO: No. I probably should get back. I have a couple of other things to do this evening. But I do appreciate the opportunity to do this. I think it has been a very interesting discussion for me and --

CHAIRMAN RYAN: We will look forward to your action to our action plan and our revised charter. And we would welcome you back with Greg, who sets the agenda --

(Laughter.)

MR. GILLESPIE: I do have to say that --

CHAIRMAN RYAN: -- any time to have another dialogue with you. This has been very helpful to us. So we really appreciate it.

MR. GILLESPIE: This is kind of funny because this meeting went very well. We had a good dialogue. We turned a 20-minute meeting into an hour.

CHAIRMAN RYAN: Let me, add, too, that there are other staff folks here in the audience. You know, I mentioned the ACNW staff, but many folks from many different parts of this agency come and give us presentations they work hard preparing. They are always very thoughtful. They are always very open.

This is a public environment. So it is an opportunity for anybody that wants to come from the members of the public to be with us. And I would be remiss not to say that everybody who comes to this Committee every month does a very, very good job and they are very thoughtful and they are very open with us. And, again, that is part of how we can do a good job because of their willingness to come and participate fully with us.

COMMISSIONER JACZKO: I appreciate that. I think that's --

CHAIRMAN RYAN: So let me share that with you as well.

COMMISSIONER JACZKO: Thank you.

MR. GILLESPIE: I would like to say thank you not only for the Committee but for the staff. The staff appreciates you coming down and showing support for the whole organization.

COMMISSIONER JACZKO: Absolutely. Well, thank you very much. I appreciate it.

CHAIRMAN RYAN: Thank you.

(Whereupon, the foregoing matter was concluded at 5:38 p.m.)

<u>**CERTIFICATE**</u>

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Nuclear Waste 177th Meeting

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Charles Morrison
Official Reporter
Neal R. Gross & Co., Inc.

Cementitious Materials for Waste Treatment, Disposal, Remediation and Decommissioning Workshop

12-14 December 2006
Akin, SC

Barry E. Scheetz
Professor of Civil and Environmental Engineering
The Pennsylvania State University

Nuclear Regulatory Commission
Advisory Committee on Nuclear Waste (ACNW)
20 March 2007

Workshop objective:

To provide a common understanding of the issues involved with the uses of cement in order to identify opportunities to support DOE's closure projects and to establish the needs for better estimates of long-term performance of cement-based systems.

The Workshop was sponsored by Savannah River Laboratory and Vanderbilt University on behalf of DOE-EM

The structure of the Workshop built was around:

- the role of cementitious materials in meeting regulatory and stakeholder requirements DOE LLW disposal
- chemical and mineralogical properties and contaminant transport properties in cementitious materials
- water and gas transport through cementitious materials

The structure of the Workshop built was around:

- degradation mechanisms and test methods, durability criteria and long-term degradation evaluation

- long-term performance predictions and risk assessment integration of cementitious materials in performance assessment modeling

The challenge for the short-term assimilation of engineering data for Portland cement-based cementitious systems is that the focus of civil engineering applications is in a timeframe of 25 to 100 years and not the thousands of year timeframe required for DOE applications.

While attempting to integrate the discussions presented at this workshop, it is clear that there are issues that transcend the five topics around which the workshop was structured.

I will attempt to organize these cross-cutting issue into a coherent picture for you.

Issues:

- conceptual model
  - perceived needs
    - ◇ modeling
      - ◇ data
  - issues not discussed
  - observations

conceptual model

- ✓Appropriateness for long term applications
- ✓Changing regulations and technologies

  [must establish an iterative approach]
- ✓Controlling mechanisms for 10,000 yrs
- ✓ Monitoring and Maintenance

conceptual model

✓Avoid trap of taking 'conservative' approach and grossly underestimating performance of system

[apply at 'appropriate' degree of complexity]

[we don't necessarily need a numerical value but perhaps a 'less than' value that correlates with level of acceptable risk to the biosphere]

perceived needs

◇ modeling

✓Too many duplicate models.

✓Reaction/transport looks acceptable

✓Coupling reaction and transport with mechanical properties

✓ Need to be mechanistically controlled model and apply appropriately

✓Need degradation model

✓Modeling transport in vadose zone

✓Need to move to probabilistic models

perceived needs

- ◇ data
  - ✓Lack of fundamental thermodynamic data
  - ✓Lack of kinetic data
  - ✓Lack of redox couple information in alkaline environment
  - ✓Lack of speciation data for nuclides
  - ✓Lack of experience with transport in vadose zone
  - ✓Lack of common data base from known engineering and materials data

perceived needs

◇ data

✓Framework for survivability of blended cements

✓Needs for better understanding of cracking

✓Micro structural development and evolution

✓Integrated cement durability model [sulfate and carbonate currently assumed as principal threat]

issues not discussed

- Role of organics and organic admixtures in grout/concrete formulations
- Failure to understand scaling with respect to energy input into mass concrete

observations

- no one was complaining for lack of characterization equipment

Moderator Exclusion

ACNW Presentation
March 20, 2007

Wayne Hodges, H322 Consulting

What is Moderator Exclusion

- Moderator Exclusion is essentially a criticality analysis assuming No water or other moderator inside Transport package containment
- Current regulation {71.55(b)} requires a non-mechanistic intrusion of water into the package for criticality analysis
- An exception is allowed under 71.55(c) but staff has not permitted its use [IAEA TS-R-1 has similar language but does not use the word "exception"]
- ISG-19 allows moderator exclusion under accident conditions

Why Needed?

- Full Burn Up credit would allow 90 - 95 percent of spent reactor fuel shipment in large transport casks
- Full Burn Up credit is not allowed - huge uncertainties in data for some nuclides
- Actinide only credit allows < 30% to be shipped in large casks
- High Burn Up cladding properties unknown

Why Use Large Casks?

- Economy - fewer shipments
- Safety - fewer shipments
- ALARA - Less cumulative dose from loading
- Less waste

High Burn Up Fuel

- Lack of data for cladding material properties
- Lower burn up data suggests cladding becomes less ductile at high burn up
- Hydride reorientation issues
- No data yet for newer cladding material (M5 & Zirlo)

Options for Increasing Transportable Fraction

- Moderator Exclusion
- Burn Up Credit
- Increase allowed k-effective from 0.95 to larger value (e.g., 0.98)
- Some combination of above

Pros for Moderator Exclusion

- Economy
- Reduced trips ==> Fewer accidents
- Eliminates need for aluminum based materials inside cask
- Moots high burn up criticality issues - fuel reconfiguration

Cons for Moderator Exclusion

- Increased criticality risk, particularly during loading/unloading
- Transportation Environmental Impact Statements would need revision
- Major departure from current practice except for UF_6
- Public acceptance issues

Risk Considerations

- NUREG/CR-4829, Vol 1 estimates leakage of water into containment once in 10 million years for 650 shipments/year for transportation accidents
- > 800 Storage Casks loaded in US
- Boron content of H_2O tested prior to loading
- Required tests assure robustness for HAC
- Two NAC-LWT casks found with water (< 0.5 liter)

Reg Guide 1.174 CDF Guide

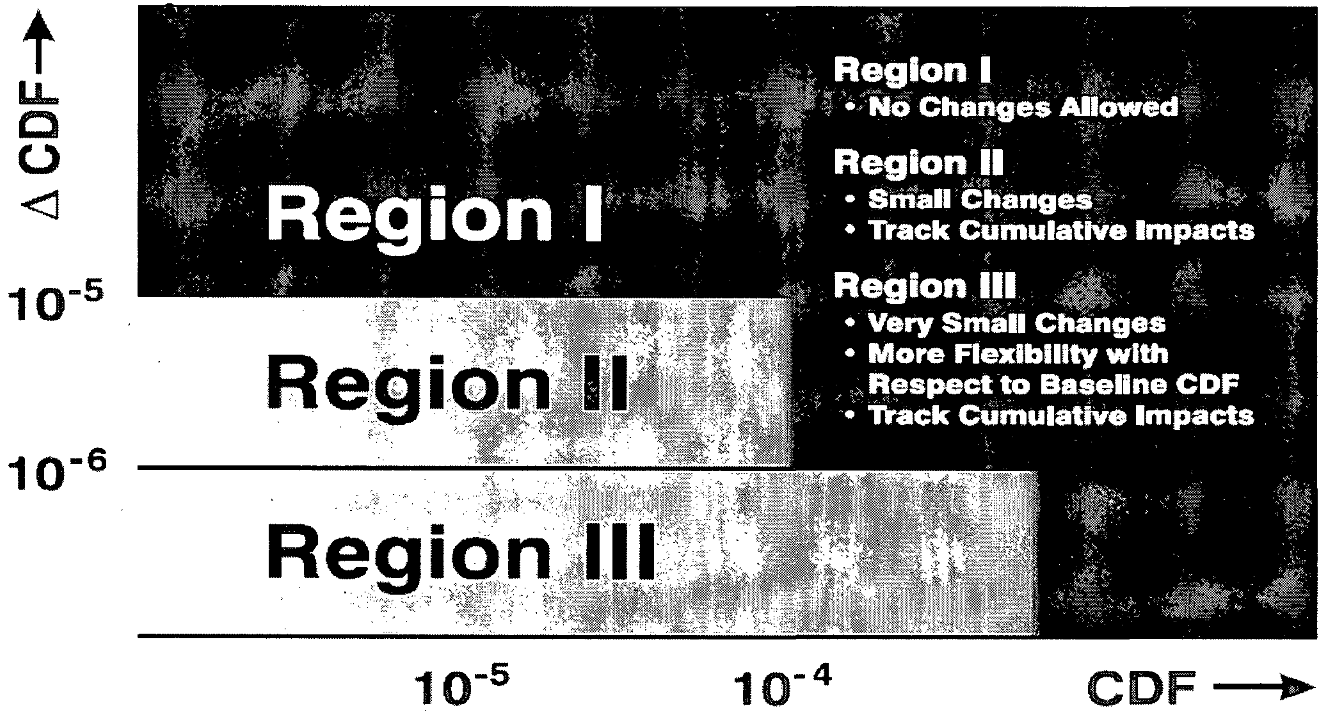

Figure 3. Acceptance Guidelines* for Core Damage Frequency (CDF)

Reg Guide 1.174 LERF Guide

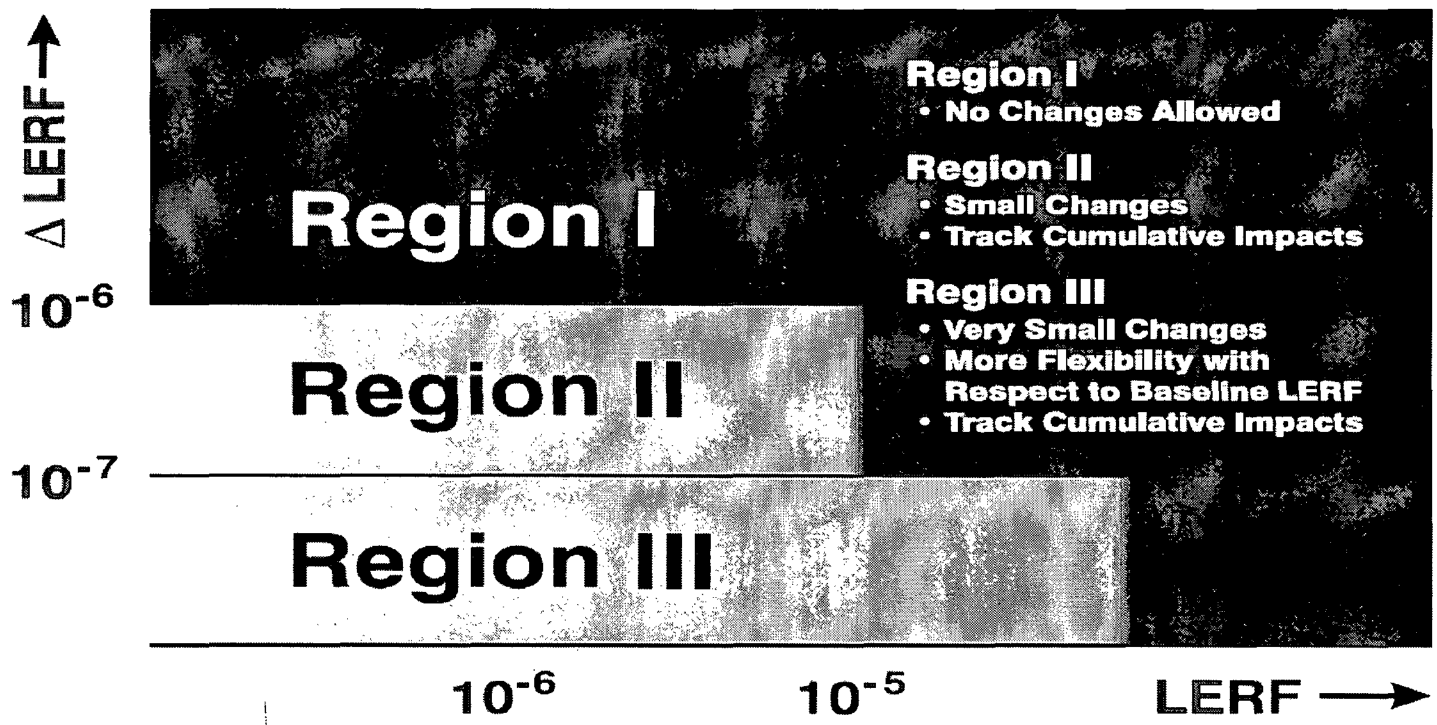

Figure 4 Acceptance Guidelines* for Large Early Release Frequency (LERF)

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Criticality Control in Used Fuel Storage and Transportation

ACNW Meeting

March 20, 2007

Everett L Redmond II, Ph.D.

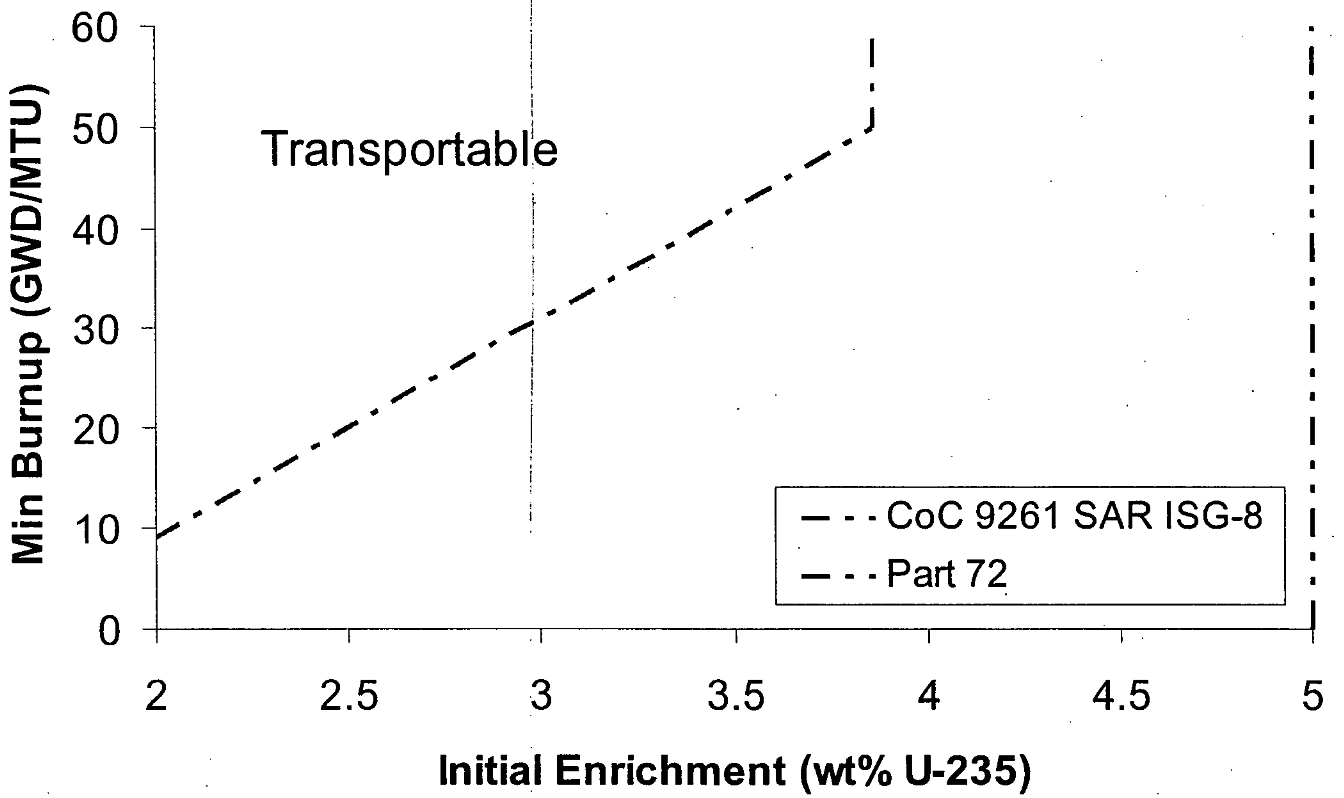
NEI
NUCLEAR
ENERGY
INSTITUTE

Introduction

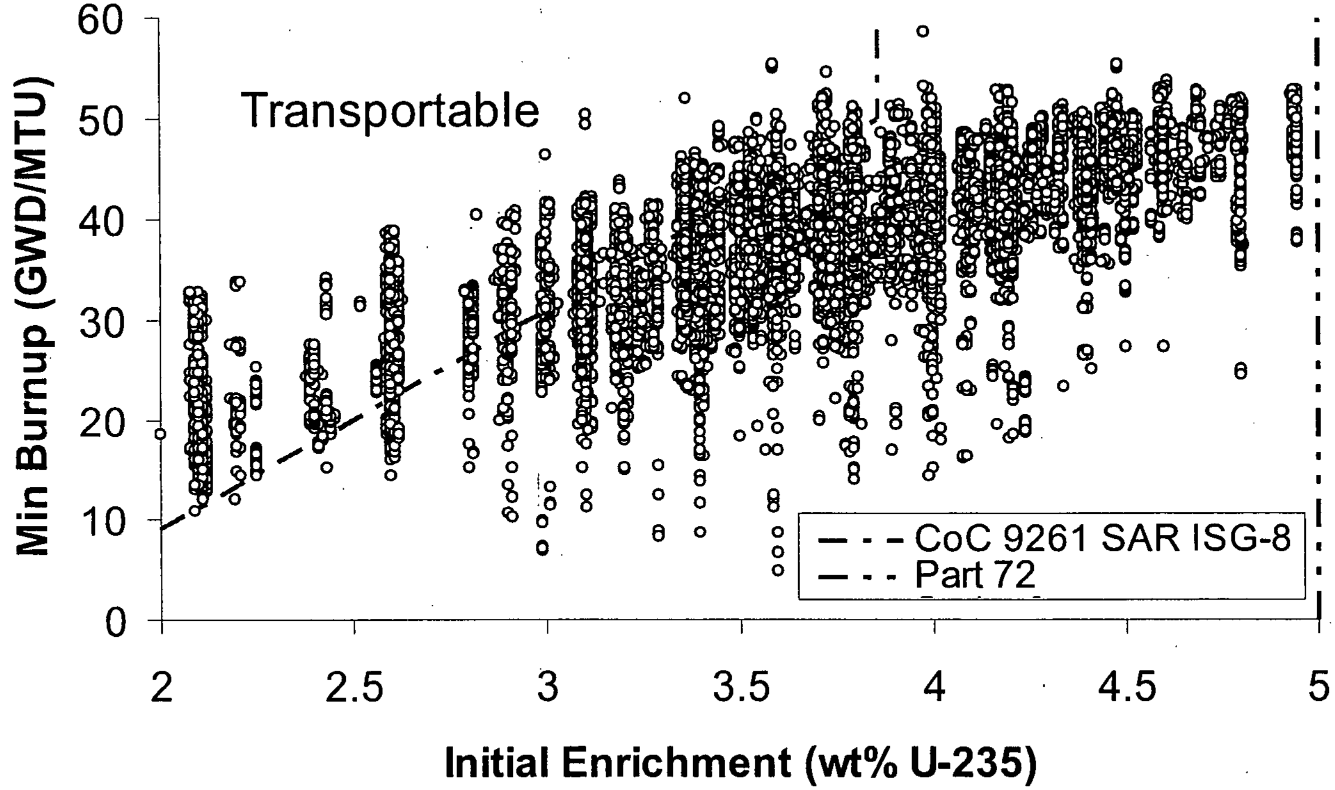
- High density dual purpose canisters (DPCs) are being loaded for storage
- The acceptability of DPC contents for transportation is unclear
- Moderator exclusion or enhanced Part 71 burnup credit will provide the assurance that these canisters will be transportable

NEI

A Comparison of Loading Requirements



A Comparison of Loading Requirements and Inventory



Westinghouse 17x17 fuel

NEI

Issue Summary

- Part 50, 72, and 71 criticality analysis methods differ significantly due to NRC guidance
- The result is that fuel currently being loaded into high density DPCs may or may not be acceptable for transport after Part 71 license applications are submitted and approved

Solution Path

- The following options are available for resolving the issue
  - Align Part 71 criticality analysis methods with Part 50 analysis methods (rulemaking not required)
  - Recognize moderator exclusion/leaktightness in licensing basis
    - Moderator exclusion from inner canister (rulemaking not required)
    - Moderator exclusion from containment (rulemaking required)
  - A combination of the above

NEI

Conclusion

- SFST should consider all options for ensuring that fuel loaded into DPCs is approved for transport
- NEI believes that the generic loading/transport issue can best be solved by permitting Part 50 burnup credit for transportation and that this can be accomplished without rulemaking
- NEI believes that DPC leaktightness should be recognized for defense-in-depth
- NEI would welcome the opportunity to further discuss burnup credit with the ACNW

NEI

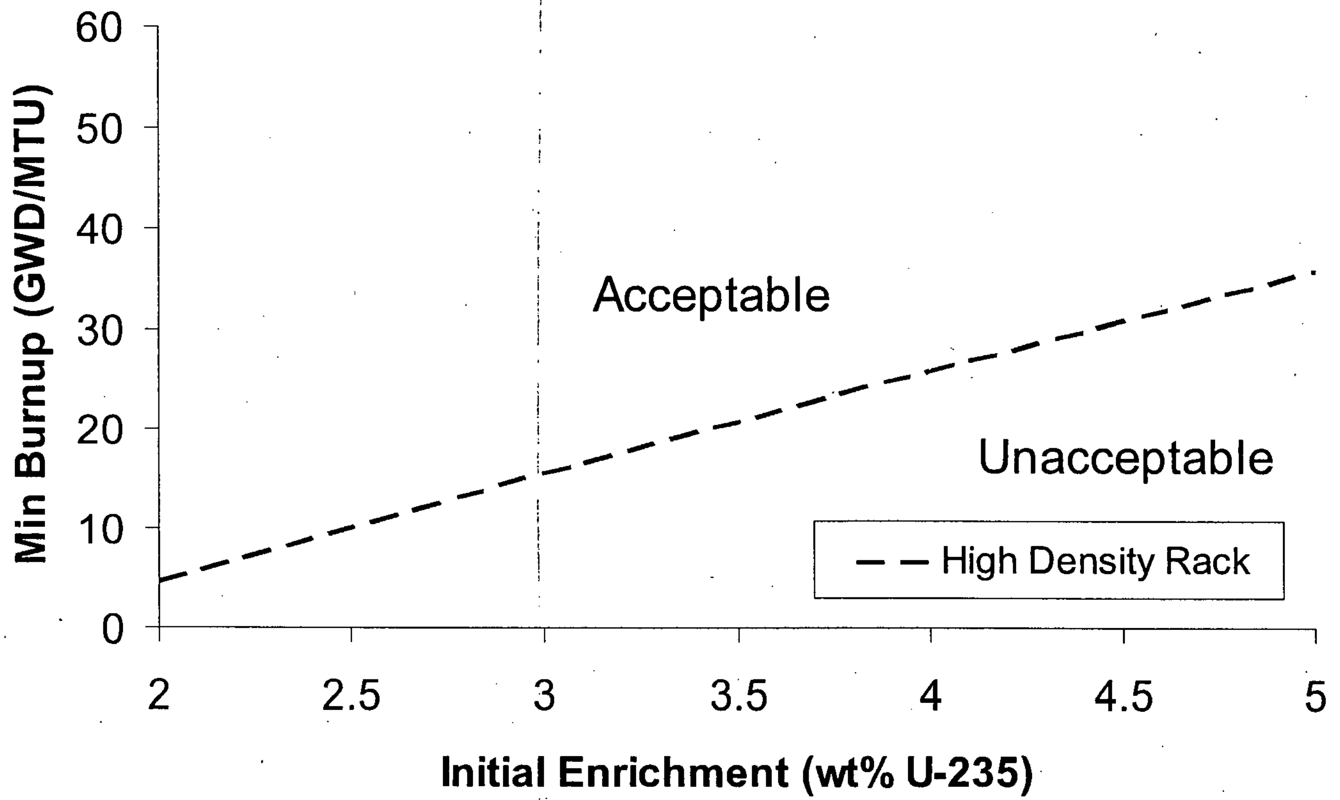
Additional Information

Background

- NRC licensing basis for criticality differs for wet storage (Part 50), dry storage (Part 72), and transportation (Part 71)
  - Part 50 – Burnup credit including full fission product credit, k<0.95 without soluble boron
  - Part 72 – Fresh fuel assumed, full soluble boron credit, k<0.95 with 2000+ ppm (typical) soluble boron
  - Part 71 – Burnup credit, actinide only, k<0.95 without soluble boron

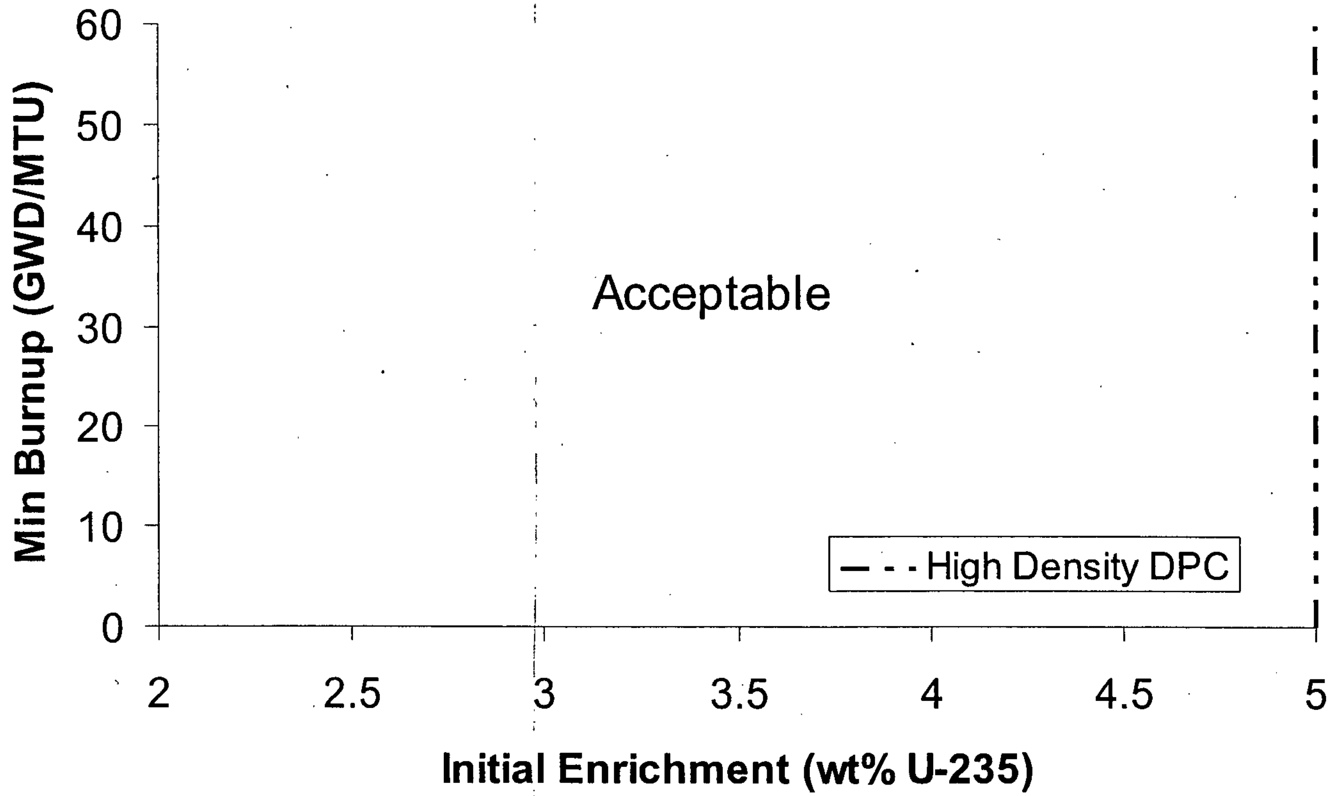
NEI

Part 50 High Density Wet Storage Rack Requirement



Burned fuel, k<0.95 no soluble boron

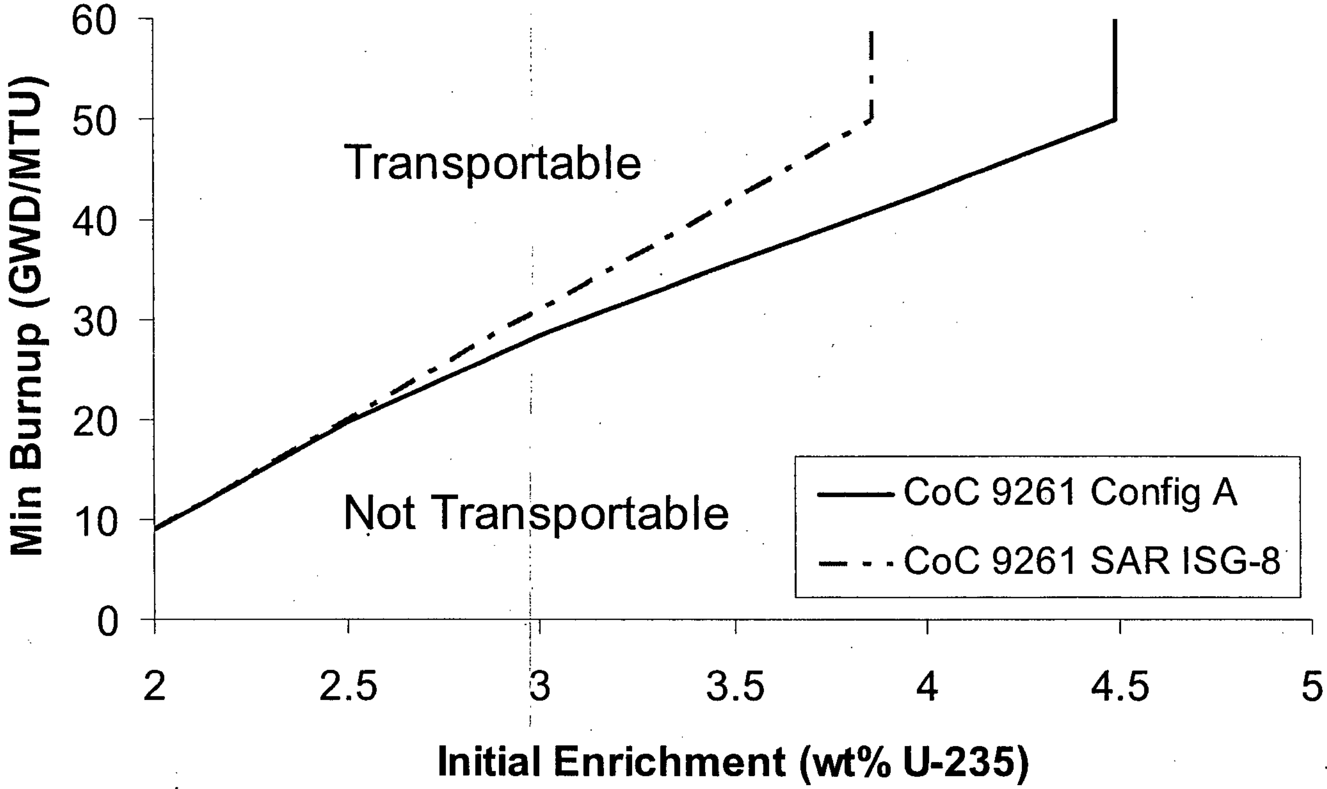
Part 72 High Density Storage Cask Requirement



Fresh fuel, k<0.95 full soluble boron (2000+ ppm)

NEI

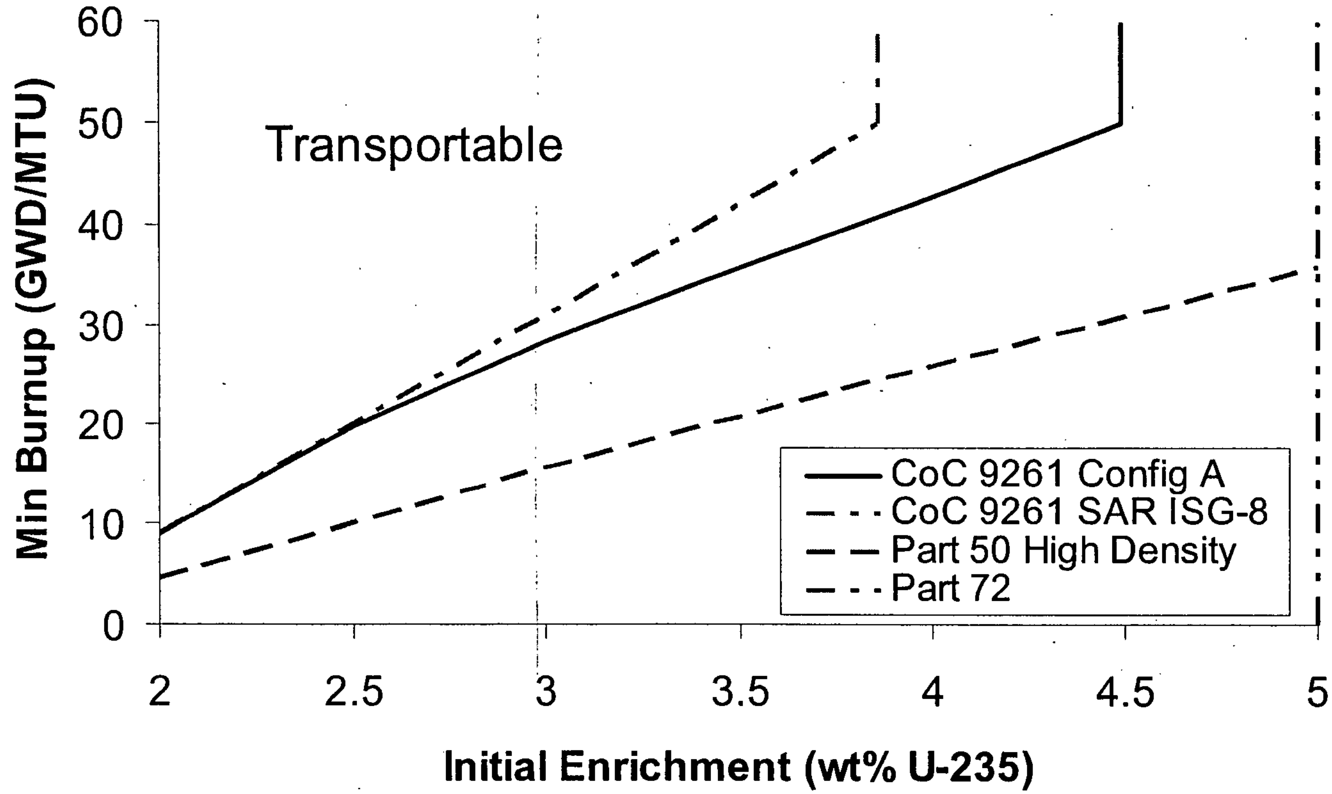
Part 71 High Density Transportation Cask Requirement



Burned fuel, k<0.95 no soluble boron

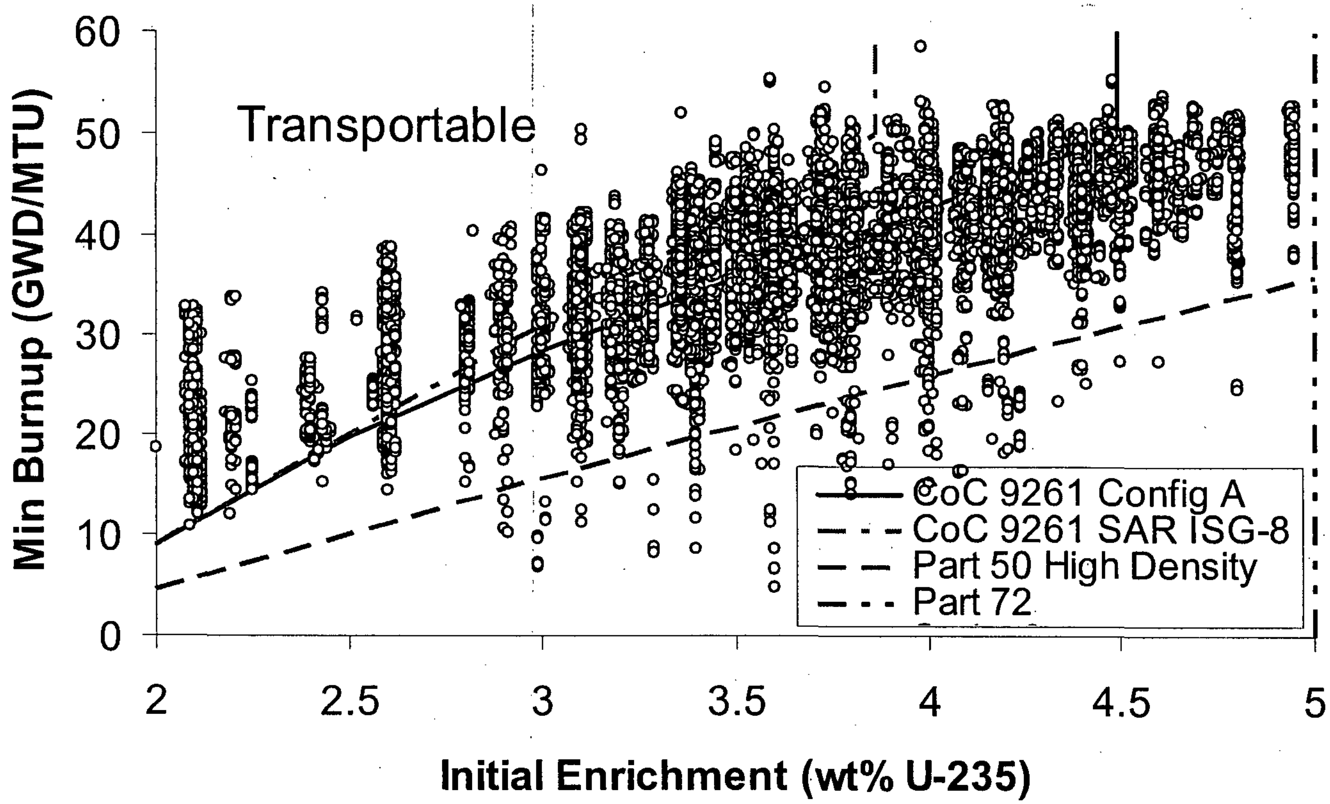
NEI

A Comparison of Loading Requirements



NEI

A Comparison of Loading Requirements and Inventory

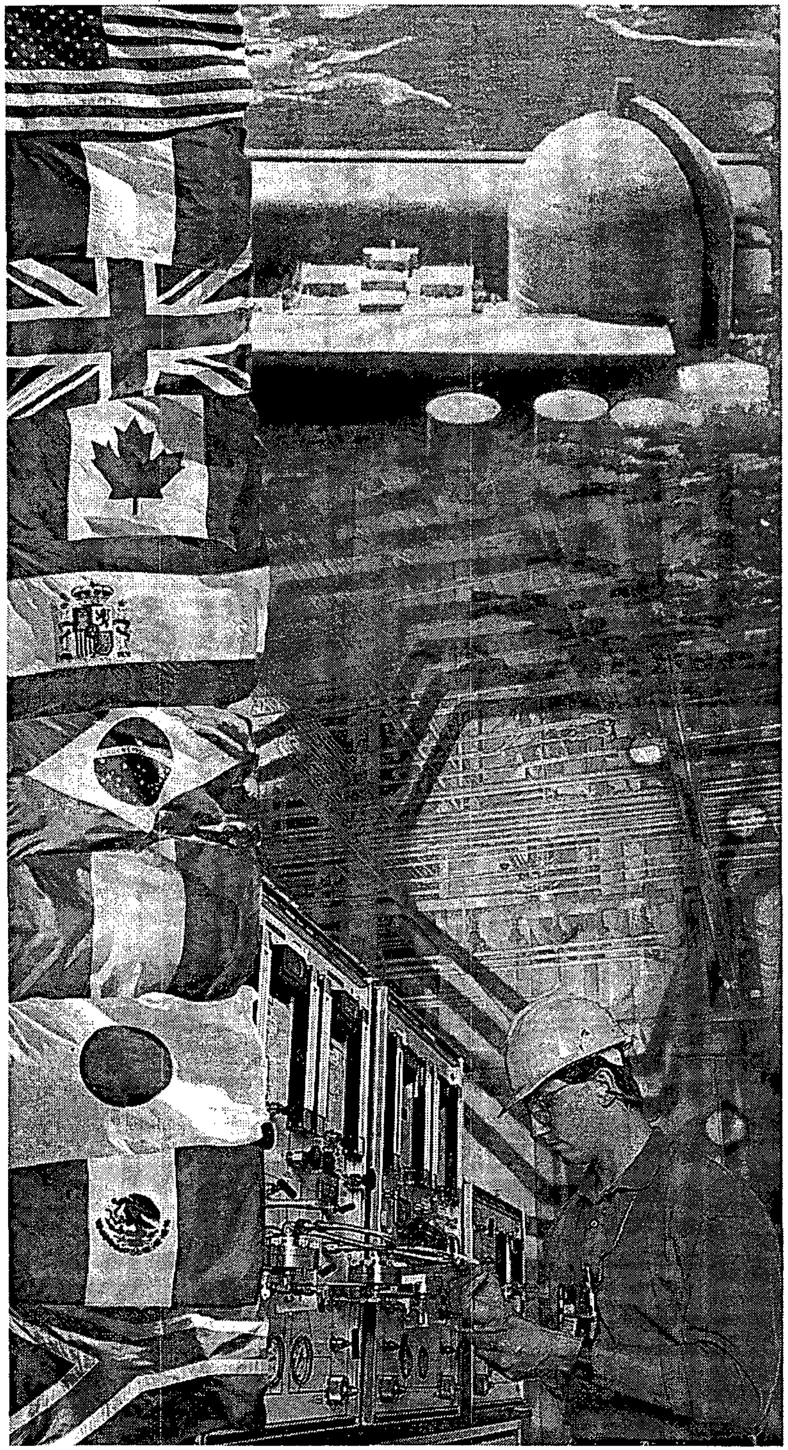


Westinghouse 17x17 fuel

NEI

Loading, Transport, Unloading

- Moderator exclusion only addresses the transport condition, not wet loading and unloading
- Use of soluble boron during loading and unloading is an option. However, the current DOE design calls for the pool at Yucca Mountain to be unborated
- Aligning Part 71 with Part 50 criticality analysis methods resolves the issue and is better way to regulate used fuel storage and transportation



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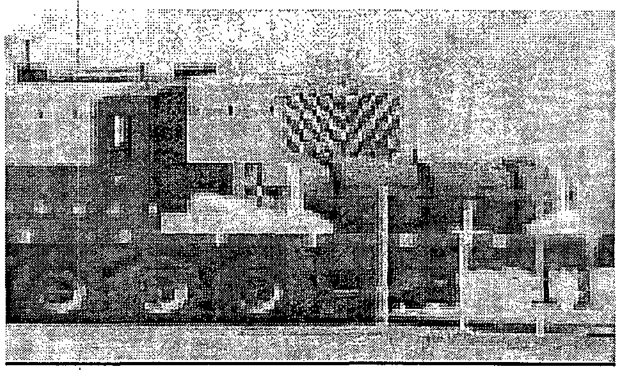
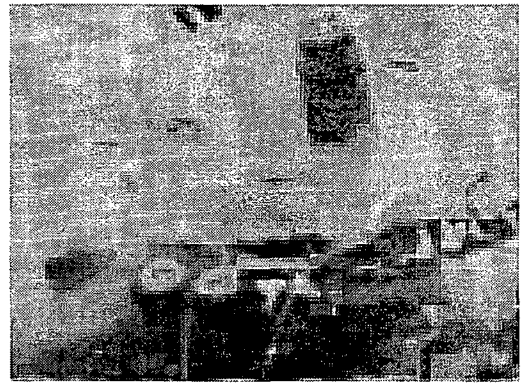
Spent Fuel Transportation – Criticality Considerations

ACNW Meeting
March 20, 2007

Albert J. Machiels
Sr. Technical Manager

Prologue: US Experience





- "Since 1960, trains and trucks carrying a total of 5 million pounds of spent nuclear fuel have traveled 1.6 million miles and had eight accidents, none of which released any radioactive material
- December 8, 1971. In Tennessee, the driver of a truck carrying nuclear waste swerved off the road in a rainstorm. The truck rolled over into a ditch, killing the driver. The cask carrying the waste was thrown off the truck. The cask was not damaged, and no material leaked."

Topics

- Risk information (NRC- and EPRI-sponsored works):
  - Criticality risks during transportation are negligible
- Postulated reconfiguration effects (high burnup fuel – high fluence cladding) can be dismissed
  - Even assuming non-physical reconfiguration does not lead to a critical configuration
  - Cladding damage is bounded
    - Elements most susceptible to damage typically have the least nuclear reactivity
- Evidence suggests that there could be an opportunity to rationalize the regulations or their interpretation, which would result in lower overall risks and reduce the effort, time, and resources needed for obtaining regulatory approvals for transporting spent fuel

Topics

- Background
- Criticality Risks During Transportation of Spent Nuclear Fuel
- Potential for Fuel Reconfiguration of Spent High Burnup Fuel
  - *Cladding Integrity**
  - Reconfiguration Effects on Criticality
- Conclusion

**Not planned to be discussed during oral presentation*

Background

Public safety (radiological and non-radiological)
  - Shielding/Confinement
  - *Criticality*
    - *Key regulatory concern*
  - Non-radiological
- Unresolved generic issue: transportation of spent fuel with discharge burnup >45 GWd/MTU (except through ISG-19)
- Enabling technologies:
  - Moderator exclusion: limited by regulations [Part 71 with partial relief from ISG-19]
  - Burnup credit: limited by regulatory practices [ISG-8], but not by regulations

Risks in Transportation of Spent Fuel

	Normal Conditions	Accident Conditions
Criticality	§71.55(d) "Preclude"	§71.55(e) "Preclude"
Radiological	§71.47(d) §71.51(a)(1) "Small"	§71.55(d) §71.51(a)(2) "Very Small"[1]
Non-radiological	"---"	"Potential for fatal and nonfatal injury"

[1] Single shipment incident-free dose risks greatly exceed (>10^3-10^4) single shipment accident dose risks [Ref. NUREG/CR-6672, page E-6]

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"Criticality Risks During Transportation of Spent Fuel" (EPRI report 1013449, Dec. 2006)

"The probability of any criticality accident over a total of 11,000 (railroad) shipments is estimated to range from 9.2E-15 to 2.0E-13, which constitutes a negligible risk."

Important Qualifiers:

- Commercial spent nuclear fuel
- Railroad shipments
- 32-assembly package

Principal Investigator:

- A. Dykes, ABS Consulting

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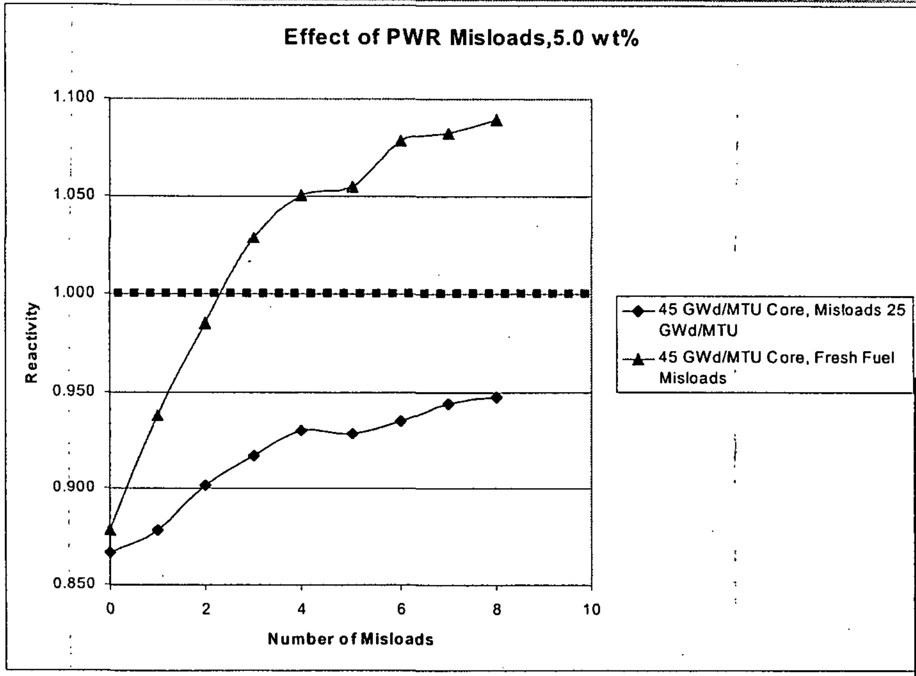
Summary of the Risk of Criticality During Railroad Transportation (Part 1)

Failure Event	Cask Loaded Without Independent Verification of Video Recording		Cask Loaded With Independent Verification of Video Recording	
	All Trains	Freight Trains	All Trains	Freight Trains
Misload of Spent Nuclear Fuel/Cask	2.7E-05	2.7E-05	2.0E-06	2.0E-06
Train Accidents per Train-Mile (All Accidents, All Speeds, All Track Classes), 2000 - May 2006.	4.3E-06	2.7E-06	4.3E-06	2.7E-06
Probability of Accident of Interest, given Any Accident (>2% Strain and Immersion in Water) per Modal Study	7.8E-09	7.8E-09	7.8E-09	7.8E-09
Probability of Criticality, given Misload and Accident of Interest	1.0E-02	1.0E-02	1.0E-02	1.0E-02
Frequency of Criticality Accidents/Train-Mile	9.2E-21	5.7E-21	6.8E-22	4.2E-22

Summary of the Risk of Criticality During Railroad Transportation (Part 2)

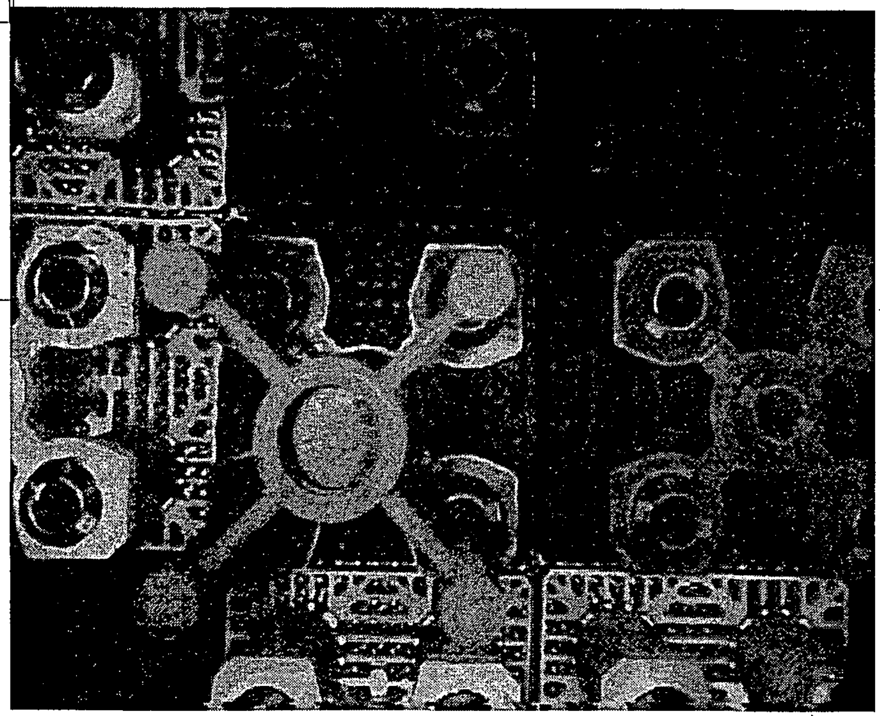
Failure Event	Cask Loaded Without Independent Verification of Video Recording		Cask Loaded With Independent Verification of Video Recording	
	All Trains	Freight Trains	All Trains	Freight Trains
Assumed Average Number of Train-Miles per Shipment	2,000	2,000	2,000	2,000
Frequency of Criticality Accidents per Shipment	1.8E-17	1.1E-17	1.4E-18	8.4E-19
Number of Shipments per Year = 11,000/24 Years (from NUREG/BR-0292)	458	458	458	458
Frequency of Criticality Accidents per Year	8.4E-15	5.2E-15	6.2E-16	3.9E-16
Probability of a Criticality Accident over all 11,000 Shipments	**2.0E-13**	**1.2E-13**	**1.5E-14**	**9.2E-15**

Probability of Criticality Given Misload and Accident of Interest – Qualitative Considerations



Misloading Impact

Fresh vs. Once-burned fuel



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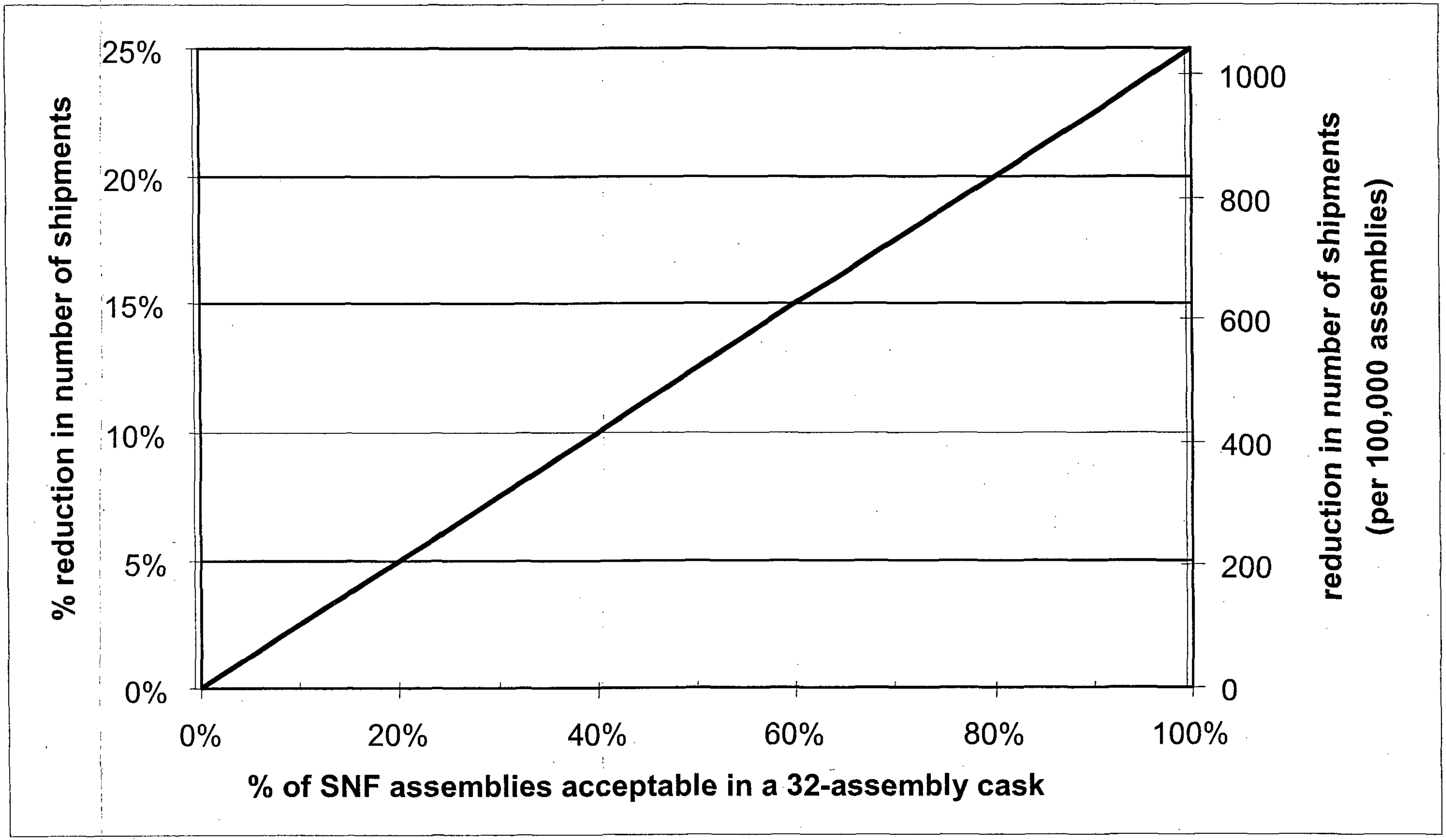
Potential Reduction in Shipments by Using 32- vs. 24-Assembly Casks



Moderator Exclusion and/or Fission Product Burnup Credit *Lowers* Overall Transportation Risk

- Current situation (assume moderator *inclusion*, no fission product BUC) will cause more shipments
  - Adding flux traps, extra neutron poison material takes space meaning smaller capacity packages
  - Or will need to "de-rate" a larger capacity package
- *Much* higher relative overall health risk from non-radiological than criticality-related radiological pathways during transportation
  - >>1E+5 times higher
- Therefore, reducing the number of shipments reduces the overall health risk

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The "High Burnup" Issue

- Increase/decrease in k_{eff} as a result of some potential reconfiguration of the fuel?
  - 45-GWd/MTU limit
- Motivation for EPRI work related to fuel integrity under transportation conditions
  - Dry storage of spent fuel with burnup >45 GWd/MTU
  - "High burnup" vs. "Residual nuclear reactivity"
- EPRI high burnup fuel reconfiguration results:
  - No guillotine breaks (*"Spent Fuel Transportation Applications - Modeling of Spent-Fuel Transverse Tearing and Rod Breakage Resulting from Transportation Accidents*," EPRI-1013447, October 2006)
  - Longitudinal tearing (*"Spent Fuel Transportation Applications: Longitudinal Tearing Resulting from Transportation Accidents – A Probabilistic Treatment*," EPRI-1013448, December 2006)
    - <2% cladding damage
    - Rod breakage: P~1E-5

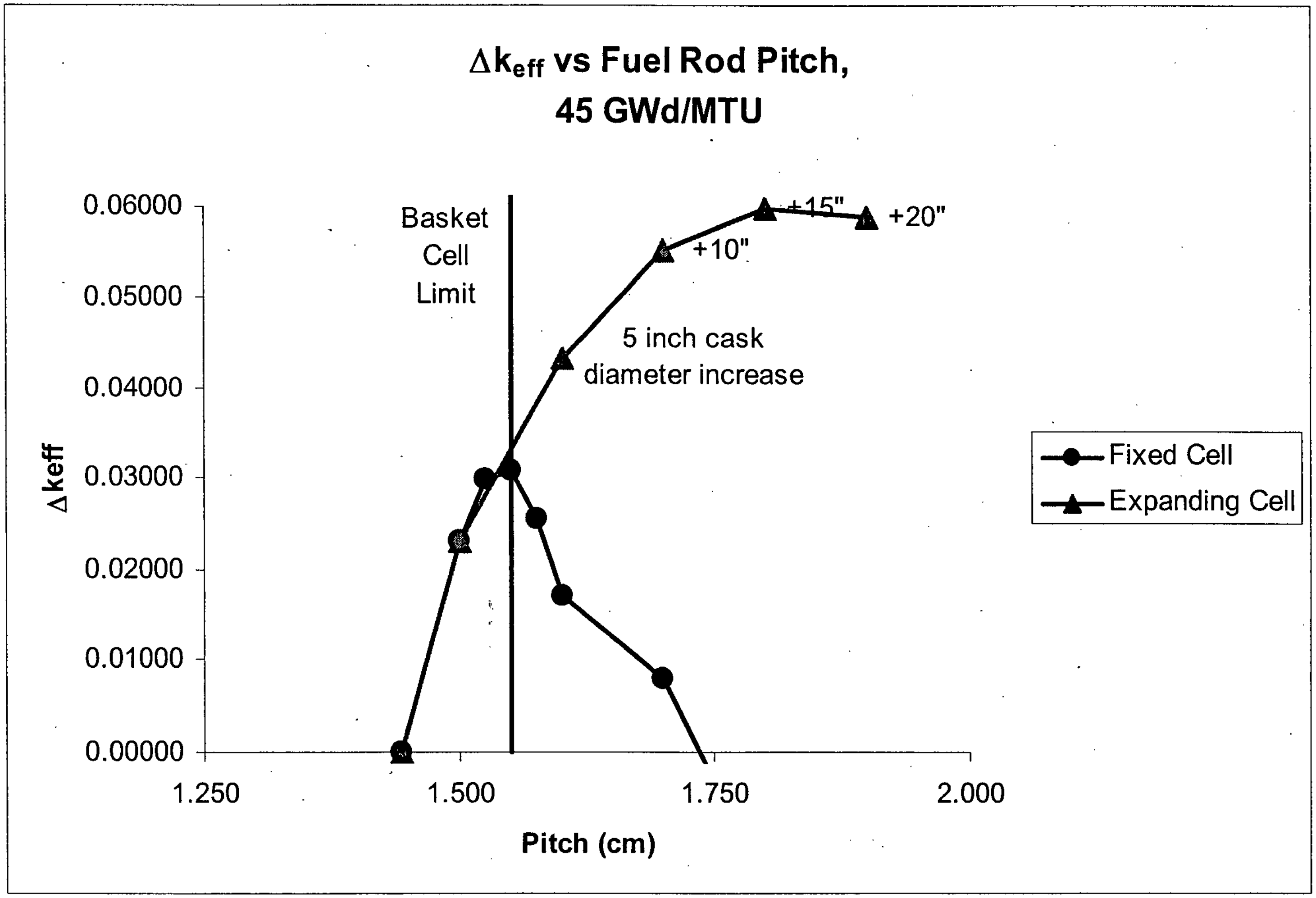
Effect of Reconfiguration on Effective Multiplication Factor, k_{eff} (NUREG/CR-6835, September 2003)

Table 6: Maximum increase in k_{eff} for each fuel failure scenario*

Scenario	MPC-24 *(fresh fuel)*	GBC-32 (45 GWd/MTU)	MPC-68 *(fresh fuel)*
Single missing rod	[redacted].001[redacted]	<0.0010	[redacted].003[redacted]
Multiple missing rod	[redacted]014[redacted]	0.0130	[redacted]012[redacted]
Cladding removed from all fuel rods	0[redacted]4[redacted]8	0.0349	0[redacted]4[redacted]1
Fuel rubble (no cladding)	0.[redacted]63	0.0233	0.1[redacted]49
Assembly slips 8" above or below neutron poison panels	0[redacted]0[redacted]1	0.0435	0[redacted]3[redacted]2
Variation in pitch (without cladding)	[redacted].070[redacted]	Not calculated	[redacted].122[redacted]

* "Although the scenarios considered go beyond credible conditions, they represent a theoretical limit on the effects of severe accident conditions" (NUREG/CR-6835, p. 1)

"Fuel Relocation Effects on Transportation Packages" (to be published in June 2007)



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Conclusion

- What have we learned?
  - Risk information (NRC- and EPRI-sponsored works):
    - Criticality risks during transportation are negligible
  - Reconfiguration effects can be dismissed
    - Even assuming *non-physical* reconfiguration does not lead to a critical configuration
    - Cladding damage is bounded
      - Elements most susceptible to damage typically have the least nuclear reactivity

Evidence suggests that there could be an opportunity to rationalize the regulations or their interpretation, which would result in lower overall risks and reduce the effort, time, and resources needed for obtaining regulatory approvals for transporting spent fuel

Leaktightness of DOE Standardized SNF Canister and Transportation Criticality Safety

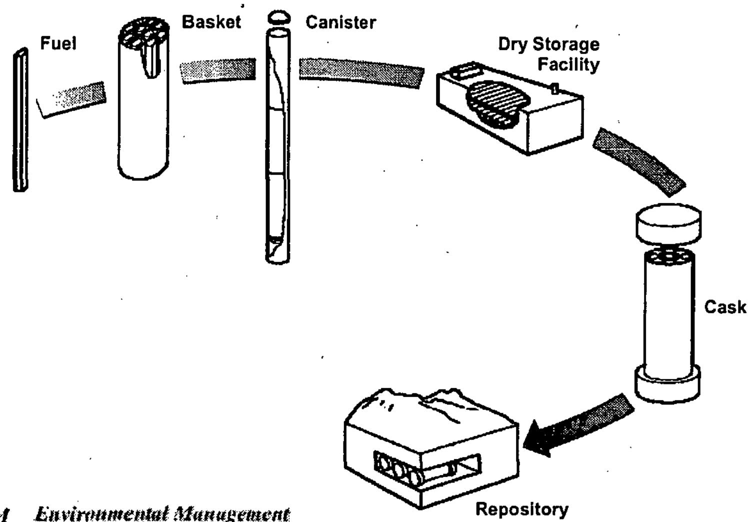
Presentation to Advisory
Committee on Nuclear Waste
March 20, 2007

by
B.W. Carlsen

Overview of Presentation

- Safety Strategy
- Package design and testing
- Compatibility with current regulations
- Summary and recommendations

DOE SNF Disposition Path



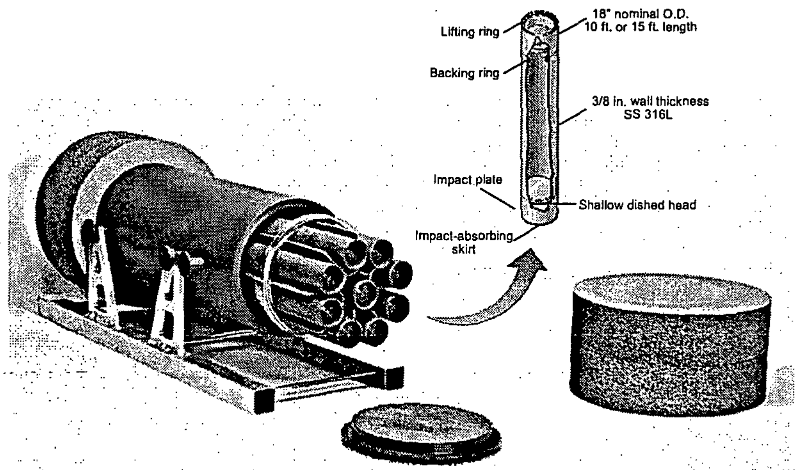
Our Request

- For the DOE standardized canister to be recognized and credited as a leaktight boundary during transportation
- Issues associated with transporting DOE SNF are significantly different than for commercial SNF
  - Large variety of SNF
  - Characterization to obtain fuel-specific mechanical and chemical properties needed for analyses will be challenging
  - Handling practices have altered some fuel geometry
  - Historical records based on intended disposition

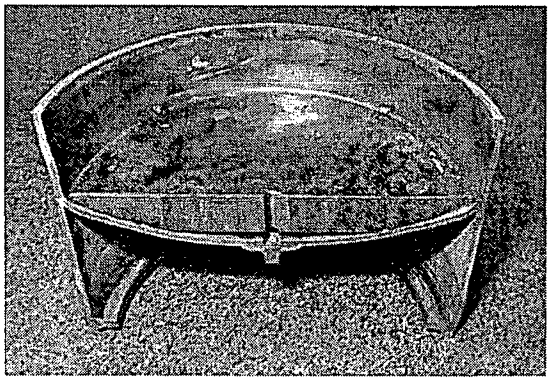
Safety Strategy

- Shift safety basis from reliance on fuel-specific performance characteristics
  - Bounding analyses
  - Grouping fuels
  - Leaktight canister
- Shift safety basis to reliance on engineered barriers

A Redundant Transportation Package



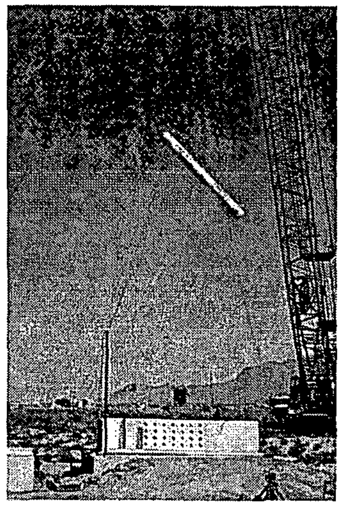
Cross-Section Showing Protective Features of Standardized Canister



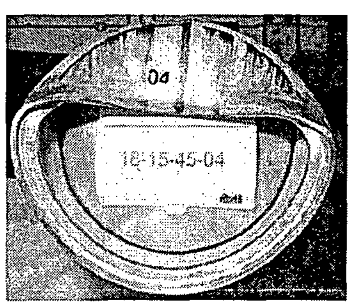
Canister Analyses and Testing

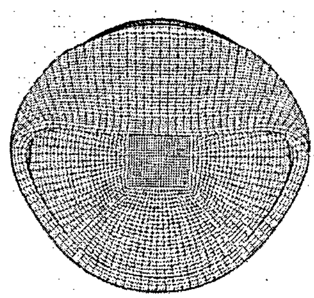
- Analytical modeling to predict stresses and strains
- Materials testing to confirm behavior
  - Critical flaw size
  - Strain-rate effects
  - Temperature effects
- Full-scale drop testing to confirm canister performance

Full Scale Drop Testing



Actual Drop Test Match with ABAQUS/Explicit Model





30 ft. drop at 45° Impact Angle

Use of the Standardized Canister

- Increases surety of operations
  - Relies upon engineered features designed and tested to meet the required performance standards
  - Standardizes operational equipment and procedures
  - Simplifies safety and regulatory basis
- Reduces overall risk
  - Eliminates the need for obtaining and justifying fuel-specific mechanical and chemical properties of diverse SNF types
  - Reduces reliance upon analyses with a wide range of uncertainty

Compatibility with 10CFR 71.55(b)

- *Package must be subcritical with leakage into the containment system in most reactive credible configuration and with moderation by water to the most reactive credible extent*
  - Nonmechanistic leakage into containment system (cask cavity) is assumed
  - DOE SNF canisters provide a redundant leaktight boundary assuring further leakage is not credible
  - Subcriticality is demonstrated with the cask cavity fully flooded and with canister internals fully degraded and optimally reconfigured

Compatibility with 10CFR 71.55(e)

- *Following tests prescribed by 10CFR71.73 and consistent with its damaged condition, package must be subcritical with leakage into the containment system in most reactive credible configuration and with moderation by water to the most reactive credible extent*
  - See compliance basis for 71.55(b)
  - Transportation cask will be demonstrated to remain leaktight following tests prescribed by 10CFR 71.73
  - Standardized DOE SNF canisters have been demonstrated to remain leaktight following drop testing prescribed by 10CFR71.73

ISG-19

- For demonstrating compliance with 71.55(e), NRC has acknowledged that it may be appropriate to credit a leaktight boundary for preventing leakage into a package when there is limited availability of data regarding the structural integrity of the fuel
  - Scope of ISG-19 is high burnup commercial fuel
  - DOE is proposing a similar solution based on similar need

Summary and Recommendation

- The DOE standardized SNF canister ensures leakage into the fuel cavity of the package is not credible
- Moderator exclusion should be considered as a regulatory option

Backup/Reference Slides

- Characteristics of DOE SNF – 1
- Characteristics of DOE SNF – 2
- Supporting Analyses – 1
- Supporting Analyses – 2
- ABAQUS/Explicit
- Actual Drop Test Match with ABAQUS/Explicit Model
- Transportation Criticality Risk, DOE SNF
- 10CFR 71.55(b) – Full Text
- 10CFR 71.55(e) – Full Text
- IAEA TS-R-1

Characteristics of DOE SNF – 1

- Fuel forms
  - Rod array, element, plate array, annulus, blocks, pins
- Fissile radionuclides
  - U-233, U-235, Pu based fuels
- Fissile enrichments
  - Ranges from depleted Uranium to 93%
- Cladding types
  - Aluminum, Stainless Steel, Zircalloy, Hastelloy, Inconel, Nichrome
- Fuel compounds
  - Alloy, oxide, carbide, nitride, hydride, metal, silicide

Characteristics of DOE SNF – 2

- Matrices
  - Aluminum, graphite, ceramic, and stainless steel
- Condition
  - Intact, cropped, corroded, disassembled
- Dimensions
  - 0.06 inch to several inches wide
  - 4 inches to nearly 15 feet long
- Burnups
  - From less than1,000 to over 500,000 MWd/MTHM
  - 0.1% to over 70% of original fissile material

Supporting Analyses-1

- D. K. Morton, *Preliminary Design Specification for Department of Energy Standardized Spent Nuclear Fuel Canister*, DOE/SNF/REP-011, Rev. 3, Volume I and II, August 1999.
- S. D. Snow, et. al., *Preliminary Drop Testing Results to Validate an Analysis Methodology for Accidental Drop Events of Containers for Radioactive Materials*, American Society of Mechanical Engineers Pressure Vessels & Piping Conference, ASME PVP-Vol. 425, July 2001.
- D. K. Morton, S. D. Snow, T. E. Rahl, *FY1999 Drop Testing Report for the 18-inch Standardized DOE SNF Canister*, EDF-NSNF-007, Rev. 2, September 2002.
- S.D. Snow, et al. *Analytical Evaluation of the Idaho Spent Fuel Project Canister for Accidental Drop Events*, EDF-NSNF-027, Rev. 0, September 2003.

Supporting Analyses – 2

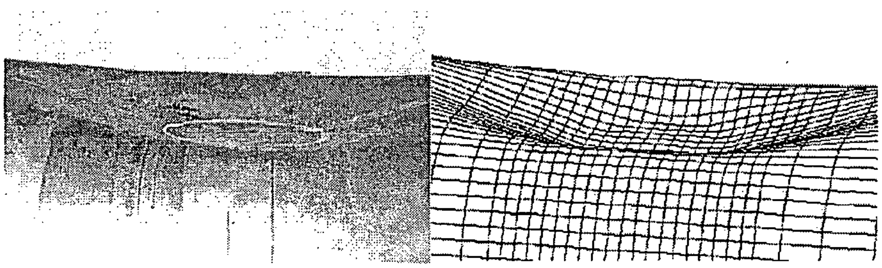
- W.R. Lloyd, *Test Results from Type 316L Stainless Steel Weldments with Simulated Defects, Preliminary Results,* EDF-NSNF-041, Rev. 0, June 2004.
- B.W. Carlsen, *U.S. Department of Energy Spent Nuclear Fuel Canister Survivability*, 000-PSA-WHS0-00100-000-000, Rev. 0, July 2004.
- D. K. Morton, S. D. Snow, *Drop Testing Representative 24-inch Diameter Idaho Spent Fuel Project Canister*, EDF-NSNF-045, Rev. 0, January 2005.
- S. D. Snow, *Analysis of the Standardized DOE SNF Canister with ATR Fuel in Type 1A Baskets Under Transportation Accident Conditions,* EDF-NSNF-069, Rev. 0, February 2007.

ABAQUS/Explicit

- Finite element software used to simulate a wide variety of dynamic and quasi-static events
- Especially well suited for nonlinear dynamic simulations with large plastic deformations
- Validation and Verification (V&V)
  - ABAQUS/Explicit Version 6.6-3
  - Extensive V&V performed by ABAQUS Inc.
  - Extensive NSNFP V&V efforts include ABAQUS example problems and NSNFP benchmark problems*

*S.D. Snow, *Software Report for ABAQUS/Explicit Version 6.6-3*, DOE/SNF/REP-107, Rev. 0, November 2006

Actual Drop Test Match with ABAQUS/Explicit Model



- Puncture test: 40 in. drop onto six-inch diameter post

Transportation Criticality Risk DOE SNF

Event	Likelihood	Source
Train accidents per mile	4.3E-06	Federal Railroad Administration, Office of safety Analysis, 2001 data (all railroads, all causes, all track types)
Estimated number of miles per shipment	1500	Majority of DOE SNF's shipments are located at the Idaho National Laboratory and Hanford sites
Probability of water entering cask given an accident	7.8E-09	NUREG/CR-4829, page 9-25 (>2% strain and becoming submerged)
Probability of criticality given water in fuel cavity	1.00	Fuel-specific characterization data is not available for many DOE SNFs. Hence, a bounding assumption is used (i.e. fully degraded and optimally reconfigured and critically unsafe under these conditions)
Probability of canister breach given an accident	2.3E-04	U.S. DOE SNF Canister Survivability, 000-O-PSA-WHS0-0100-000, Rev. 0, July 2004
Probability of criticality accident per shipment	1.2E-14	Calculated
Estimated # of shipments	450	Assumes 4 MCOs or 9 canisters per rail cask
Probability of a criticality accident over all anticipated shipments of DOE SNF	5.2E-12	Calculated

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safety ◇ performance ◇ cleanup ◇ closure

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10CFR 71.55(b) – Full Text

(b) Except as provided in paragraph (c) or (g) of this section, a package used for the shipment of fissile material must be so designed and constructed and its contents so limited that it would be subcritical if water were to leak into the containment system, or liquid contents were to leak out of the containment system so that, under the following conditions, maximum reactivity of the fissile material would be attained:

(1) The most reactive credible configuration consistent with the chemical and physical form of the material;

(2) Moderation by water to the most reactive credible extent; and

(3) Close full reflection of the containment system by water on all sides, or such greater reflection of the containment system as may additionally be provided by the surrounding material of the packaging.

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10CFR 71.55(e) – Full Text

(e) A package used for the shipment of fissile material must be so designed and constructed and its contents so limited that under the tests specified in §71.73 ("Hypothetical accident conditions"), the package would be subcritical. For this determination, it must be assumed that:

(1) The fissile material is in the most reactive credible configuration consistent with the damaged condition of the package and the chemical and physical form of the contents;

(2) Water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents; and

(3) There is full reflection by water on all sides, as close as is consistent with the damaged condition of the package.

IAEA TS-R-1

677. For a package *in isolation, it shall be assumed that water can leak into or out of all void spaces of the* package, *including those within the* containment system. *However, if the* design *incorporates special features to prevent such leakage of water into or out of certain void spaces, even as a result of error, absence of leakage may be assumed in respect of those void spaces. Special features shall include the following:*

(a) Multiple high standard water barriers, each of which would remain watertight if the package *were subject to the tests prescribed in para. 682(b), a high degree of quality control in the manufacture, maintenance and repair of* packagings, *and tests to demonstrate the closure of each* package *before each* shipment;