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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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RADIATION PROTECTION & NUCLEAR MATERIALS

SUBCOMMITTEE

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TUESDAY, JUNE 5, 2012

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 1:00 p.m., MICHAEL T. RYAN, Chairman, presiding.

COMMITTEE MEMBERS:

MICHAEL T. RYAN, Chairman

J. SAM ARMIJO, Member

DENNIS C. BLEY, Member

HAROLD B. RAY, Member

STEPHEN P. SCHULTZ, Member

JOHN D. SIEBER, Member

GORDON R. SKILLMAN, Member

NRC STAFF PRESENT:

CHRISTOPHER BROWN, Designated Federal Official

TAE AHN

KEITH COMPTON

DARRELL DUNN

BOB EINZIGER

MIRELA GAVRILAS

CHRIS JACOBS

BANAD JAGANNATH

YONG KIM

TIM MCCARTIN

ABY MOHSENI

JAMES RUBENSTONE

DOUG WEAVER

ALSO PRESENT:

JOHN KESSLER, EPRI

ROD MCCULLUM, NEI

MARC NICHOL, NEI

JEFF WILLIAMS, DOE

T-A-B-L-E O-F C-O-N-T-E-N-T-S

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

(1:00 p.m.)

CHAIRMAN RYAN: The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Radiation Protection and Nuclear Materials. I'm Michael Ryan, Chairman of the Subcommittee.

Committee members in attendance are Sam Armijo, Harold Ray, Dennis Bley, Dick Skillman and Jack Sieber. Oh, I'm sorry and Steve Schultz. The Subcommittee will hear presentations by and hold discussions with representatives of the NRC Staff, EPRI, NEI and DOE on extended storage and transportation, technical information and information needs.

The subcommittee will gather information, analyze relevant issues and facts and formulate proposed positions and actions as appropriate for deliberation by the full committee. Christopher Brown is the designated federal official for this meeting.

The rules for participation in today's meeting have been announced in the Federal Register as part of the notice of this meeting, previously published in the Federal Register on May 24th, 2012.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice. It is requested that speakers first identify themselves and speak with sufficient clarity and volume so they can be readily heard. We ask at this time that you silence your phones or other electronic devices. Also understand that staff from the center will be listening in on the briefing.

This is the second subcommittee briefing on Extended Storage and Transportation. The first one was on September 22nd, 2011, in which the staff discussed a four-phase approach for regulating extended fuel storage. Also brought up fuel cladding integrity and other type performance were also discussed.

The ACRS full committee briefing is scheduled for July 11th, 2012. We will now proceed with the meeting and I call on Jim Rubenstone, Branch Chief at NMSS to begin. Jim, welcome and thank you for being here.

DR. RUBENSTONE: Thank you, Mike, for having us here. We're glad to have the opportunity to talk about a recent report that the staff has put out for public comment, and I think the Committee has seen that.

CHAIRMAN RYAN: Yes.

DR. RUBENSTONE: And we'll get into that. Just before I get into the slides I wanted to make sure I introduced some of the players on our team who are here. To my right, Bob Einziger who I think most of you know is our technical lead for this project at NMSS.

And Darrell Dunn, from the Office of Research as the technical lead there. A lot of the work is being coordinated between NMSS and Office of Research. And this report I'll be speaking about is a joint product of those offices.

Also Chris Jacobs is the project manager for this effort. Keith Compton next to him, is another one of our technical staff. And Tae Ahn I think many of you know is another technical staff who's contributed and we have others in the audience who are supporting us at different levels. So that's the team.

What we're here to talk about today is primarily this report, as I said, that came out for comment in the beginning of May. A 45-day comment hearing closes in about two weeks, the 18th. And so far we don't have many comments in but we are expecting to get some. Especially from industry and some other parties who are interested in the technical aspects of this work.

I'll walk through the slides here, give you a little bit of context, but not too much, just to remind people what we're doing on extended storage and then go through how we developed our technical information needs. What we used as criteria to rank things. What the ones that rose to the top were. And a little bit about some of the other areas that we'll be pursing following this up. So if there are no questions at this point I can jump right into the slides.

So as I said, I'm Jim Rubenstone, I'm a Branch Chief in NMSS and I'm here on behalf of our larger group who has been working on this issue now for some months. Just to give you an overview of what we'll be speaking about today, we are operating in what could be described generously as a changing policy environment. It's not settled by any stretch of the imagination. There are some things that are coming together.

We're trying to position ourselves to be ready for however it moves and continue doing NRC's job. I'll talk a little bit about the existing framework that we're building on as we look at a possibility of extended storage over multiple decades, or longer. And then the technical information needs, as I said, is the centerpiece of this discussion. And then the next steps going forward.

This is probably not news to anyone here. We're in transition, but extended storage and particularly dry storage, looks like it's going to be a component of wherever the policy leads us. Alternative disposal options, disposal is still the end of the fuel cycle. Disposal in a geologic medium.

We have had direction from the Commission to work on this area on extended storage and transportation and preparation. And I'm sure also most of you are familiar with the recommendations of the Blue Ribbon Commission, which came out in January of this year. And at the end I will highlight a couple of those recommendations that have some implications for storage and transportation and where they may lead us.

So again, just very briefly, I want to remind people what these things look like. Currently there's about 18,000 metric tons of commercial spent fuel in dry storage, that's in about 1,500 casks. There's a number of storage designs that are out there.

The simplest ways to group the systems are what we call canistered systems and integrated systems. The canistered systems have an internal welded canister which is then placed in an overpack. What I call the integrated are the ones with the interior metal canister and the concrete are one, and those are usually bolted shut. And then the most obvious is some of them stand up and some of them lay down.

Current regulations for storage are captured in 10 CFR Part 72. There are --

MEMBER ARMIJO: James?

DR. RUBENSTONE: Yes?

MEMBER ARMIJO: Just go back. Is there any preference from the staff related to whether it's horizontally stored or vertically stored as far as any kind of loading that would be --

DR. RUBENSTONE: I don't think there's any favorable.

MEMBER ARMIJO: -- favorable or unfavorable?

DR. RUBENSTONE: I think you have to analyze them for the conditions they are. And we'll get into a little bit about the types of analysis that are done for storage and you can see how it may make, you know, one orientation may make a difference. The difference between the canisters and the bolted systems, the welded and the bolted, do make a difference. The U.S. is increasingly in a canister welded mode. There are bolted systems out there. I think they're not as, I don't know what the --

MR. DUNN: I think about 89 percent of them are welded.

MR. EINZIGER: We don't tell the applicant whether they have to be vertical or horizontal or whether they're welded or bolted. That's up to the applicant what they want to get licensed and the utilities what they want to use.

MEMBER ARMIJO: I'm probably jumping ahead to the issue of long-term degradation under, you know, precipitation of hydrides and things like that and whether if you have horizontal loading you'll have appending loads, even though they may be very, very small, that would accentuate any problems compared to just axial.

DR. RUBENSTONE: I think maybe one answer is we're looking at that. And the other is that some of the uncertainties right now is I think those differences are within the uncertainties of some of the other material properties.

MEMBER ARMIJO: Yes, okay.

DR. RUBENSTONE: But we may learn more as we progress. So yes, fair question. 10 CFR Part 72, this covers storage, both dry and wet storage at reactor sites and potentially at non-reactor sites. The two key factors are there are certificates of compliance that are issued for the system.

And then there are licenses for the independent spent fuel storage installations, the ISFSIs. Both of these are issued for terms. The initial terms were 20 years, NRC has recently amended the rules to allow up to 40 year initial terms. And their extension, the renewal periods, again, initially were 20 and now can be up to 40 years. There's not requirement that they be issued at 40 year increments. And part of the renewal, the license renewals aging management plans are an important component of that.

Historically dry storage was put into place in the U.S. in the late 1980s, so many of the original 20 year certificates and licenses have come up and there's a wave of them coming through for renewal now. So we're involved under, our current licensing activities, in a fair number of certificate and license renewals.

For extended storage we are looking at periods beyond that and we don't have a hard and fast definition of what constitutes extended storage, but operationally we've been thinking of it as the second renewal of these systems. And as you can imagine the aging management plan that one would present at the second renewal should probably be different than the one presented at the first.

Transportation is under 10 CFR Part 71, which covers all sorts of transportation containers with some specific requirements for the transportation of spent nuclear fuel. That's also term certifications with renewals.

And one current feature is the transportation certificates are generally done separately from the storage certificates, although there are a number of systems out there that are dual certified for both transportation and storage with different configurations of the overpack.

There are also a number that have been designed for both storage and transportation but don't yet have a transportation certificate.

MEMBER BLEY: Jim, let me ask you a couple of questions about who does what if you will.

DR. RUBENSTONE: Sure.

MEMBER BLEY: In general, and I guess it's by agreements. I think it's by agreements. NRC, as far as transportation, only licenses the casks and I guess DOT and DOE regulate everything else?

DR. RUBENSTONE: The Department of Transportation for commercial materials has a role in all shipments. And maybe Bob can give --

MR. EINZIGER: For commercial shipments, you're right, the NRC license essentially the cask and in. The DOT licenses the rest of it. Now there are certain materials that can be transported and stored under DOE 8 eGIS, and they have the control over those items.

MEMBER BLEY: Okay. Back to your first one, the general topic here on long-term storage. We got a copy of a NWTRB Report that raised a few issues, but first an organizational question. What's the relationship between that board and NRC and issues such as this?

DR. RUBENSTONE: Well, NWTRB is an advisory board to the Department of Energy. And they were first setup I think as part of the Nuclear Waste Policy Act.

MEMBER BLEY: Yes, that's what I thought.

DR. RUBENSTONE: So we are certainly aware of all their activities. We've presented at their meetings, we've attending their meetings, we've discussed things with the staff, but their advise goes to DOE.

MEMBER BLEY: Okay. But from the Report one of the issues raised was the lack of experience with extended storage and the need for either further research or continuing monitoring over time as we gather the experience. What's our technical basis for extended storage and with those issues what are we doing with respect to it?

DR. RUBENSTONE: Well that's part of the main subject of this report, it's to identify what research needs to be done to put it on a firm basis. Now, one also has to realize the roles of the various participants in this.

The NRC's role, and Jim is going to get into this later, is to determine certain needs with respect to regulation. What we need to know in order to regulate. That doesn't mean developing a full database. The database necessary to put in an adequate license for extended storage or for transportation is the role of DOE and the industry.

They have to make a case that they can meet all the requirements of Part 72 and Part 71 in order to meet those requirements. Our job is to make sure we're in a position to ask them the right questions. To evaluate the data that they give us and to make sure that they're meeting the requirements.

MEMBER BLEY: And the last one, kind of along these general lines, is the Blue Ribbon Panel gave recommendations, I guess to the president, right? Since the president set it up?

DR. RUBENSTONE: To DOE.

MEMBER BLEY: To DOE?

DR. RUBENSTONE: Yes.

MEMBER BLEY: So you're going to talk about those later, but they don't have any actual force I assume. But they're -- I'm not assuming, I'm wondering.

DR. RUBENSTONE: Well, we will have someone from DOE here in the second half of the meeting. And I can give you my opinion but his might count more on that.

MEMBER BLEY: Okay. Well I mean with respect with what NRC does, is what I meant.

DR. RUBENSTONE: Yes, but I think what NRC is doing is using those recommendations as a way to evaluate where the policy may go so we're positioned properly. We certainly aren't making the decisions as to what the nation's policy for waste management should be.

MR. EINZIGER: A for instance on that is that normally now storage, we follow storage with transportation to some site. If the Blue Ribbon Panel's recommendation is put in place and they have interim site then we have to consider what the ramifications are of storage followed by transportation then by storage again. Or just transportation followed by storage. And so we're cognizant of the fact that we've got to look into these considerations.

MEMBER BLEY: Okay. So if you think of long-term storage, our thinking has to include the idea that there might be movement partway during this lifetime.

DR. RUBENSTONE: Right. And we'll get to that when we talk about, two things. One, the BRC recommendations specifically. And then just generally how we are analyzing the technical requirements, which is keeping this transportation component in mind, because the analysis that are done to satisfy 71 are very similar, but not the same as the ones you do in 72. There's different things you look at. And we can talk about that a little bit further as we get into more of the technical piece.

MEMBER BLEY: Thank you.

MEMBER SKILLMAN: What is the process of extending, life extension if you will, on a term or a certificate? What is the process for that, please?

DR. RUBENSTONE: I think Bob can talk about the process.

MR. EINZIGER: The applicant comes in with a Safety Analysis Report. We evaluate them. We grant them a license if everything is correct for an initial period of time. Before that's expired they have to tell us that they're going to come in for a renewal. They have to write an SAR essentially telling us that they meet all the requirements for meeting Part 72. We evaluate that. We determine whether we feel that the data supports a extension. And if so there's an SAR written by the staff and an amendment to the certificate.

MR. EINZIGER: Thank you.

MEMBER SCHULTZ: Is there guidance specifically associated with the extension? Or is the guidance associated with the initial safety analysis report?

MR. EINZIGER: The first two extensions that were done were prior to when any guidance was in place. Then there was a standard review plan for license extension that was drafted. Remembering that this is guidance to the staff, and what the staff should look for when they're reviewing an application. That is a public document though, so the applicants can see what the staff is going to look for. And to some extent the staff, the licensee, follows that guidance.

We're in the first application now where that guidance is actually being tested. Because it's the first one, as with most things when they first get dry runned, we are finding some things that need to be changed and corrected.

It's important to remember though, that it is guidance for the staff. It's not a checklist to the applicant that says if you do X, Y and Z you're granted a license. The applicant's responsibility is still to meet all the requirements of Part 72.

MEMBER SCHULTZ: Understood. Thanks, Bob.

DR. RUBENSTONE: I think that's NUREG 1927.

MR. EINZIGER: 1927 I think.

MEMBER SIEBER: I think I'll just wait a little bit to ask my question.

DR. RUBENSTONE: Okay, that's fine.

MEMBER SIEBER: Because sooner or later you have to touch on it anyway.

DR. RUBENSTONE: Well let's hope so.

MEMBER BLEY: You know it'll come up, right.

DR. RUBENSTONE: One of the reasons this is in here is because our working model going forward is that for extended storage the current framework is the basis. And it may need some small adjustments but we're not seeing, at this point, the need for wholesale changes in the current regulations for storage and transportation to address this extended period.

So one of the challenges of -- Sorry, Mike, the challenge of what we're trying to do and the motivation for what we're trying to do is can we identify anything that would lead us to change those regulations or guidance. We almost certainly will be issuing new guidance as we go into extended storage, but the regulatory framework we're starting with the assumption that we have what we need in place and will just be adjusting it if necessary.

CHAIRMAN RYAN: I was going to ask you as you go through your presentation if you could maybe point to those things that you think would be the areas where there would be some of these smaller changes are. And just give us a flavor for what those things are versus say wholesale changes. That would be very helpful.

DR. RUBENSTONE: I think the aging management is one key, because there's not a lot in the regulation about it and there may not need to be, but the guidance is going to really help get --

MEMBER ARMIJO: Do you think the regulation is worded broadly enough that aging should be taken into account, independent whether it's the initial application or follow on?

DR. RUBENSTONE: Right. I mean I give credit to the people who wrote the regulations in the first place because they left sufficient flexibility without being so vague, which as we know is the path we try to walk in writing regulatory language. So it's just a matter of whether we need to tune that at all. And as I said so far we haven't come up with specific ones but there's some areas that we might need to look at.

MEMBER ARMIJO: But as far as physical phenomenon, new phenomenon, new mechanisms of degradation of the canisters or the casks or the fuel planning itself, those things have already been addressed in the initial guidance?

DR. RUBENSTONE: No, not really. I mean

we've addressed in the initial evaluation those things that we think are going to occur during the first period of storage. And for the fuels that we think are going to be stored. The purpose of this document is to look beyond that and say, okay now we're going into and extended period of time.

Are there other mechanisms that are going to occur? What might they be? Are there things happening during the first storage period that might not really be detrimental during that storage period but might show up as an effect later on. So this is extending the thinking.

MEMBER ARMIJO: So extending it to actually include new degradation mechanisms, other than what was originally --

DR. RUBENSTONE: I don't think the regulations called out specific mechanisms, it's a performance based regulation. So it talked about the type of design criteria. And I'll get into that a little bit.

MEMBER ARMIJO: Okay.

DR. RUBENSTONE: And what sorts of safety functions different components will perform. And then the burden becomes on the applicant to demonstrate that they have considered these going forward and that those functions will be met. So that, to me that's what makes this a good platform to build off for extended storage as there isn't some prescriptive list of only look at these things. It's this is the performance you need, so if we recognize a phenomenon that --

MEMBER ARMIJO: These are the properties you want at any time during the life of this --

DR. RUBENSTONE: Right. So we need to accomplish this purpose and if some phenomenon crops up many years out, that doesn't crop up early, you need to address that when you're at that appropriate stage.

MEMBER ARMIJO: Right, okay. Thanks.

MEMBER SIEBER: I think I will ask my question. And it's not so much of a question, but my initial assessment based on what I've read, the contemplated design lives, I think that is envisioned that you obviously would not license to, but the vision for a designer is 300 years, is that correct?

DR. RUBENSTONE: No that's not. We don't have any contemplated life time. We grant an initial license now of up to 40 years and then we will grant as many licenses as the applicant can make the case that they meet the regulation. We're not intending to issue 300 year licenses or 100, only be --

MEMBER SIEBER: I understand that. That was part of my question. That's not your intention?

DR. RUBENSTONE: No.

MEMBER SIEBER: That the vision, the design life could be as much as 300 years.

DR. RUBENSTONE: I think the vision for the systems that things may need to remain in storage for 300 years is different than saying you're designing a particular --

MEMBER SIEBER: No.

MR. EINZIGER: The 300 year --

DR. RUBENSTONE: Containers will last for 300 years.

MR. EINZIGER: -- came up because we didn't want to analyze for 1,000 or 10,000 or a million years. We wanted to have some finite period of time. There is no, as of yet, there is no technical justification for that period. It may be during the course of our investigation, or DOE's or EPRI's investigation, that some phenomenon comes up that says you can't go that long. But as of yet we haven't identified it.

MEMBER SIEBER: Well that leads to my next question. You have something like 1,800 canisters sitting out there now, right? And there is no real way, particularly in the short-term, to determine every effect that is occurring that is a grading effect or the extent to which these intermingle and reinforce themselves.

And short of taking a few of these casks apart and looking at the fuel and looking at the condition of the cask, it's not clear to me that we can identify every possible degradation mechanism that will occur during an extended period of time.

And it's also not obvious to me how you would find out if that's going on short of some huge research project for disassembling casks to actually physically measure them. And I'm having difficulty reaching out into the future to try to figure out how it is you're going to do that. And it seems to me like what you're planning is let the licensees figure it out and convince us that they're okay.

MR. EINZIGER: No, not quite. I tend to agree with everything you've said except for the huge research project. We make our judgements based on what we call separate effects testing. We test for various mechanisms and how they are in there and then we make a guess of what we think is a reasonable lifetime. Now, one of the parts of this program, and

I don't know whether we're going to touch on it, is what is called a demonstration program.

DR. RUBENSTONE: I think that will come up probably in the second half of the meeting, because John was going to do that.

MR. EINZIGER: And basically that demonstration program is to stay ahead of the curve. To see if what we think is happening is really what's happening. And also it recognizes the fact that there might be something out there that we might have missed and it could turn up during this monitor demonstration.

MEMBER SIEBER: Okay. I'll wait and let you go through that, but right now I'm not convinced.

DR. RUBENSTONE: No, that's fine. I think, I'm not going to get into the demo, what's been talked about. I think John will pick that up. But just to make sure we understand that we're not saying that over the next few years we will solve the 300-year storage problem and then we'll just forget about it until 300 years are up. The idea is we will look at what we have identified now. Try to get our best estimates on when these phenomenon become important, and some of them may never become important.

And that's one of the challenges we're

trying to wrestle with. But this is part of an active NRC licensing, oversight, inspection, the whole package of regulation. So if you look at it from can I make this safe now for 300 years that's a different question than what do I need to do now.

MEMBER SIEBER: No, I didn't ask that question.

DR. RUBENSTONE: Right, so I just wanted to make sure we're on the right line on that. So we picked up some of this already. Our most number one need is to look at what potential changes to regulations and guidance might be needed to accommodate long-term storage, and transportation then of fuel that has been stored for some longer periods.

And we're starting out by looking at the technical issues, which I think most people from engineering point of views would say is the place to begin. Those will then form any potential regulatory changes. Now there are potential regulatory changes that aren't directly derived from technical issues and we'll talk about those a bit later on.

But once we identify what these issues are and we've taken our first attempt at this and report this out for comment now, then we can move into performing the focused research on those areas. In order, as Bob said, to determine what NRC needs to know. And what NRC needs to know, reinforcing what Bob said, is not exactly the same thing as what we expect the licensees to

We need to know, first off, is this an issue that we should be worried about? And if it is what sorts of information will we need to know in order to evaluate an application coming in. So in my mind the dual purpose of this report is both to help define NRC's research program going forward but also to inform the industry of what NRC sees are the information needs going forward.

We do not have either the staff, the resources, the time to do the full-blown program that one would need to resolved every potential question. So we are focusing our efforts on those areas that, one, we think have the biggest impact in regulatory space. And two, it will accomplish what I said NRC needs to know.

And I think there's been good response so far from the industry, and you'll hear that in the second half today, that they're recognizing very much the same issues in their own work and beginning their work on those issues, including things that would give one the bigger picture rather than just focusing on individual tests. So hopefully we'll capture all of that as we go forward in this section.

MEMBER SKILLMAN: Jim, please let me ask a brief question. When we began the campaign to ship the waste from TMI 2, we had some ready-to-go casks that various vendors had but had to build a couple custom casks. And as we went through the process we found ourselves dealing with 10 CFR 20 for shielding. 10 CFR 50 Parts 71 and 72.

We also found ourselves connected to 49 CFR, the transportation regulations. And that was a surprise for us because most of us were fairly comfortable over in Part 10, but none of us had ever spend any time in Part 49.

So as you talk about transportation my question is, have you ventured over into the DOT transportation regulations to understand how they can impact the decisions that you make be making under Title 10?

MR. EINZIGER: Not really. But we are aware of some of the regulations. We have people who have worked over in DOT that inform us of some of those regulations. But in terms of the influence it might have on the cask itself we have not looked at that.

And I can see where there's an interaction. If the DOT had a regulation on what the maximum vibration spectra a truck could see. Or a road they could go over that would effect what kind of impact limiters we might have on a transportation cask or what shock the fuel might see during normal transportation. But we haven't spent a lot of time in that, no.

DR. RUBENSTONE: Yes, I don't think we've been explicitly working in that. But as Bob said, because we have experience in licensing transportation packages those reviewers are aware of some of those constraints. Now, the U.S. has not engaged in a large-scale spent nuclear fuel shipping campaign. There have been shipment of spent nuclear fuel, but not on a large scale. The U.S. was gearing up for that at one point, which is now on hold.

So there was some preliminary work. And that involved coordination between NRC staff, DOT, DOE, which would have had a role in that campaign. So there has been some groundwork done. We have some awareness. But we haven't, as Bob said, gone to the explicit rule-by-rule thing. So that's a good thing to look at going forward as we look at the transportation.

MEMBER SKILLMAN: I just wonder if it may have an impact on your conclusions?

DR. RUBENSTONE: Yes, I think it might. Most of our transportation conclusions we have, and we'll get to this as we get into more details, we didn't come up with specific degradation mechanisms that we only worry about in the transportations phase. They may become more significant in the kinds of analysis one has to do there as opposed to storage. But I think we could expand our circle a little bit and look into if there's anything specifically in the DOT Regulations that may impact this.

MEMBER SKILLMAN: Thank you.

DR. RUBENSTONE: So this is the report and, like I said, I think you've all seen if not a hard copy and electronic copy of it. It's out for public comment now. As our first cut we focused just on the dry storage systems because we see that as the major way of storing fuel for extended periods. And we looked at what degradation phenomena can do to the system, structures and components and their performance.

We were considering the impact on the safety functions as defined within the regulations and, again as we've said, what level of understanding does NRC staff need in order to do its regulatory review. So we built on some previous work that had been done, including a study that we sponsored at Savannah River National Lab to update some earlier work they had done to look at potential degradation over extended periods.

We looked at a report that had come out from the Department of Energy from the Nuclear Waste Technical Review Board. I think this one you referred to earlier. And the Electric Power Research Institute also put out their Gap Assessment of technical needs. And this was where Darrell's team and research stepped in for the report. That analysis is contained in the first appendix of this report where we go through and look at what is the level of knowledge for each of these degradation process as we know.

And we're really looking at three specific instances. When will this degradation begin and under what conditions? How fast does it progress once it begins? And then, what is the end state? Is the end state complete failure of the component? Or is it a rest before you get to complete failure?

And then laid on top of that is also questions about the level of knowledge about how could one monitor this, how could one inspect for these things as they're moving along. And what mitigation might be available to stop some of these things in process if you pick them up.

So we were try to do a, sort of as broad a sweep as we could of all the phenomena that were recognized by these other reports that we had come up with, answer these questions. And then once we had that level of knowledge report we overlaid on top of that, okay, for these phenomenon, if they progress, how would they impact our review.

How do they match up with the regulatory requirements that are looked at when staff has an application or a renewal application for a certificate or for an ISFSI. So we really took the two approaches and overlaid them and then see what issues came up to the top.

For the regulatory criteria there are five basic design criteria that are included in Part 72 that map precisely to safety functions for the systems to perform. Confinement, control of criticality, shielding from regulation, structural integrity and thermal control, the ability to remove heat from the system.

And additional considerations from the regulatory point of view is the ability to retrieve the fuel from storage, by normal means. And then the impacts on the transportation. If these phenomenon happen they may be fine while it's in storage, you put it in transportation you're subjecting it to different conditions, different sorts of analysis. How might that affect your review at that stage?

So perhaps not surprisingly, the ones that came as high priority technical information needs had an overall low level of knowledge about one of these phenomenon. We went through a number of them where we felt very comfortable with what was known about them. And an overall high impact on one or more of the regulatory criteria. And those became our highly ranked ones, which are summarized in the report here.

We have tables that go through some of the lower ranked ones. That's not saying that those are completely irrelevant, but we wanted to focus our attention on the things that had the highest impact on the regulation, on the review and the overall low level of knowledge where more knowledge could really help us determine if this was in fact an issue.

We identified three, what we call crosscutting issues, that affected either multiple components of the system or came into multiple processes, degradation processes, that need to be evaluated. There's several of these processes that if we knew more about one process that would tell us whether some other subsidiary process was important or not and we'll get to one good example of that.

And the other thing we detected, and this became clear pretty early on and I think was known to most people who are informed in the field, is that these are not, for the most part, unique to extended storage. They overlap many areas where we have current discussions going on about how to approach it.

And particularly that question about when a phenomenon initiates and how fast it progresses, because we discovered that there is uncertainty on a number of things that people said, oh this doesn't start until much later. But when you look at it in detail there may be conditions where it could be happening sooner.

And we wanted to clear that up, because we're not just drawing a bright line between extended storage and current storage because the cask doesn't know the difference. And it's seeing things as it evolves and work that we could do in this area could inform everything. And we're trying to keep an active dialogue going with the people who are doing the current reviews and are monitoring the current issues with industry and the work we're doing under extended storage.

This is I think, the next two slides are the meat of our discussion where we call out some of the specific degradation areas that we think are important for first priority work. And what I have here are sort of the top three ones we came up with. And then the top three crosscutting issues. And we can spend some time on these if you're interested, or pick them up as we go forward.

Stress corrosion cracking of stainless steel canisters. And especially high stress areas like welds on the canisters in a marine atmosphere. Stress corrosion cracking is a relatively well known phenomenon that effects often stainless steel. The questions we're trying to address is is that something that needs to be considered for these particular systems. And when does it become important.

And there's two ways to look at this and we're doing work. NRC is sponsoring work on one angle, the industry is coming at it from the other angle. I think they're nicely complimentary. And those are what exactly are the conditions were stress corrosion cracking becomes a problem and then do those conditions exist on canisters, or when will those exist on canisters.

And the details of that, what you need for stress corrosion cracking are you need stresses in the material. You need the right material. You need chloride, salts, present and you need moisture present. For relatively hot fuel, relatively early in the storage stage, you may have the stresses, you may have the material that's too hot for water to be there.

As fuel cools down over extended periods the outside of the canister could drop into the temperature range where moisture could be present. Especially in an environment where you get salt deposited. Sea salt will deliquescence and pull moisture from the air under certain humidity conditions.

We're trying, as I said, we have some lab experiments going now to try to clearly define what those conditions are. And the industry, and I think John will talk to this later on, has an active program going looking at what are the conditions that current casks are experiencing.

MEMBER BLEY: What kind of temperatures do you see at the canister early on?

DR. RUBENSTONE: Early on it's well over

100 C. But if you get fuel with relatively low burn-up, some canisters were loaded relatively light, you can get to lower temperatures over time. The region of deliquescence that you're worried about certainly below 50/40 C, in the presence of salt you can get moisture deliquescing. What that upper temperature limit is, that's something we're looking at now.

MR. EINZIGER: You also have to remember that these canisters have a fairly severe temperature gradient on them so that both the upper part of the canister, where the closure weld is, and the lower part of the canister where the bottom is welded on and there's high stresses, will also be lower temperature earlier in the life cycle.

MEMBER SIEBER: Now, those temperatures that you just quoted, those are canister temperatures --

DR. RUBENSTONE: Right.

MEMBER SIEBER: -- as opposed to fuel temperatures which could be in the order of magnitude or more higher?

DR. RUBENSTONE: Oh, maybe not an order of magnitude, but considerably high. There's a limit for initial loading of keeping the cladding temperature below 400 C. But that's, and we'll get into this when

I talk about one of the crosscutting issues, that's analyze to find what's the hottest spot within the load. Because you're looking at keeping things below that maximum temperature.

MEMBER BLEY: And this is assuming fuels loaded as early as they can be?

MR. EINZIGER: No. We have about a five-year limit before most fuel loadings will actually meet the criteria.

DR. RUBENSTONE: So these are analysis that are done by the applicant for conditions they want. And we use those analysis for when we grant a certificate that says this is your loading curve limit for what you can put in this canister.

MEMBER ARMIJO: I'm puzzled by this particular issue. First of all, as you said, chloride stressed corrosion cracking is a very well-known phenomenon and anybody who used welded stainless steels in a marine environment should know that and should have fabricated their welds in a way to immunize them. If it's shot peening them after welding, periodically washing the cask down in case there's, you know, marine environment. Seems to me that there's a lot of practical ways to deal with this without going into a big research program. A periodic inspection.

MR. EINZIGER: Well, you're right, Sam, in that there's an awful lot of work that's been done on marine stress corrosion cracking. And as my colleague Jeff Hornsetts (phonetic) liked to say, we could fill this whole room with reports on it and most of it wouldn't be applicable to this situation, because the large preponderance of the information is an actual aqueous solutions. There also are ways to do stress relieving of it. And those are being looking into.

Right now the NRC doesn't mandate that the way these canisters are manufactured, we just mandate that they behave suitably to meet the safety criteria. So the Japanese are taking a big role in looking at mitigation techniques. In hindsight maybe the vendor should have looked at steps to prevent this problem before it occurred.

MEMBER ARMIJO: Would the staff consider periodic inspection and washing down --

MR. EINZIGER: Yes --

MEMBER ARMIJO: -- as an effective way of dealing with something like that?

DR. RUBENSTONE: -- some challenges because of the radiation fields. These things are still relatively hot.

MEMBER ARMIJO: I'm not talking of going up there and scrubbing them. I'm talking about getting a water hose and just --

MR. EINZIGER: Well let's just talk for a moment about that, Sam. I mean, if the critical density for the salt depositing on the canister takes 100 years to occur, or 50 years, maybe washing them down is going to do the job. If the critical density of salt on the canister takes a couple years to occur maybe that isn't a method that will work. In fact I've seen calculations done based on the outliers on the database that says it may only be a few hours before the actual critical density occurs. And then we have a whole new employment method of having people hosing down these things continuously.

MEMBER ARMIJO: I think that's sort of Yucca Mountain kind of thinking where these phenomenon are given these super capabilities and without any data.

MR. EINZIGER: Yes, that's exactly true and we don't have --

MEMBER ARMIJO: Without any data, without any testing.

MR. EINZIGER: We don't have the data.

MR. DUNN: There actually is data. And

there's industry experience with this. There have been reactors that have had problems with chloride stress corrosion cracking from a marine deposition. It happened at St. Lucie, it happened at Turkey Point, it happened at the Koeburg Plant in South Africa.

MEMBER ARMIJO: I'm not disagreeing that chloride stress corrosion cracking. What I'm disagreeing with is that you need a big research program as opposed, and this is not a criticism of the staff, it's more of a criticism of the industry of not addressing ways in which to mitigate to prevent this from becoming a big issue.

DR. RUBENSTONE: Well I think we all agree there are ways to mitigate it, but those have not been taken so far, the 1,800 casks that are out there have not been stress relieved. And we can discuss whether we could justify putting that in as a condition going forward. What we're trying to get to is, again, the specific conditions so we know when this occurs. And then what the industry is doing is saying, is this occurring, you know, what are the conditions look like out there.

And you might have a great appreciation after John's talk about some of the challenges trying to make these measurements. There is some data from

Japan, the Japanese are taking this very seriously because all of their sites are marine environments.

MEMBER ARMIJO: Hey, their casks were flooded at Fukushima.

DR. RUBENSTONE: And they are worried about salt that was deposited during the flooding.

MR. EINZIGER: Sam, we're looking at doing the minimum amount of work to determining whether an actual problem exists. We're not looking at doing a big research project. Once we determine that there is an actual problem, either for now or later or very far, then it's up to the industry to do what they need to do to make sure that it doesn't happen during the licensed storage period. They could decide to have a big research project to do it. They could decide to wash them off. They could decide to fabricate them in a different way. But that is, as you mentioned, in the realm of what the industry has to do.

MEMBER ARMIJO: Right.

MR. EINZIGER: The NRC is trying to minimize the amount of research they need to do to determine whether there's a question we have to ask the industry.

MEMBER ARMIJO: One other question. I notice in all these pictures a lot of these things look like they're painted. Are they?

MR. EINZIGER: Some are.

MEMBER ARMIJO: Like these white ones. Are they anything unique about them to corrosion resistance or anything?

MR. EINZIGER: Coatings have been considered.

DR. RUBENSTONE: Yes, what you're seeing in most of these pictures is the outer over pack, not the inner --

MEMBER ARMIJO: Not the inner container itself? It's not painted over then?

DR. RUBENSTONE: Yes, I think in general, and I can't say 100 percent but there hasn't been coatings used on these canister systems that would --

MEMBER ARMIJO: There hasn't been any kind of treatment that would minimize --

MR. EINZIGER: Only on the ones that are using, as what Jim called, integral systems. And those aren't the austenitic stainless steels.

MEMBER ARMIJO: Okay.

MEMBER BLEY: I don't remember how long we've been moving fuel into dry storage, what the oldest ones are, but have there been inspections inside the over pack looking at the canisters? Have we seen any problems?

MR. EINZIGER: I think that EPRI is going to talk a little bit more about that later on.

MEMBER BLEY: Okay, that'll be fine.

MR. EINZIGER: So I'll defer that question.

MEMBER BLEY: That's fine.

DR. RUBENSTONE: The oldest ones are 20 plus years. The late 80s were the first deployed commercial dry storage.

MEMBER ARMIJO: Do you have any carbon steel casks?

MR. DUNN: They're painted ones. In Missouri in 1986.

MEMBER ARMIJO: Are they kind of old technology? And then now a modern way you're going all stainless or what?

MR. EINZIGER: Well, we're not going any way but --

MEMBER ARMIJO: I mean the industry not you. When I say that I mean the people who work in this area.

MR. EINZIGER: If you were in Europe most of them are going towards bolted integral dual purpose casks. In the United States most of the industry is going towards cansiterized systems, welded systems inside and overpack.

MEMBER ARMIJO: But mostly stainless steel or carbon steel or an equal amount?

MR. EINZIGER: Mostly stainless.

MEMBER ARMIJO: Okay.

DR. RUBENSTONE: The second issue in this first group is not a big issue, but it maybe is an easily resolved issue. And it's questions about degradation of the bolts. As Darrell said earlier, that's not a big part of the U.S. inventory but it's a question that has regulatory impact. It's probably easily solved, probably through some combination of inspection and monitoring. The bolted system is usually a dual concentric seal and they monitor the pressure between the two seals as a way of looking for seal failure so conceivably both failures would turn up on that monitoring as well.

And then the third one is I've rolled up a couple of topics into this one. And it's the effects of the swelling of the fuel pellets over time and pressurization of the rods and how that can drive stresses on the cladding. And this is an example of how we have interrelated phenomenon.

On the next slide we talk about some

cladding failure mechanisms that mostly depend on this applied stresses from either fracturing the pellets and swelling and pressurization. So if we can resolve the swelling and pressurization question that dictates how we would worry about some of the cladding degradation issues.

MEMBER ARMIJO: And you're going to get into the mechanism that drives the fuel swelling?

DR. RUBENSTONE: Bob can talk about that right now.

MEMBER ARMIJO: Time, temperatures.

MR. EINZIGER: Want to talk about that now?

DR. RUBENSTONE: Why not.

MEMBER ARMIJO: Yes.

MR. EINZIGER: Basically we're worried about the decay causing a helium buildup in the pellet and how much of it's staying in the pellet and swelling the pellet. How much of it's being released and increasing the fission gas pressure. When is this going to occur, how it's dependant on the temperature.

There's some work out there that seems to indicate that this may not be an effect that's occurring until well past 100 years. But so far it's been calculation. It's been ion implantation work which is forcing the issue. It drives issues such as low temperature creep, delayed hydride cracking. A couple of other mechanisms I'm not yet willing to work on those mechanisms until I really can get some evidence that there's a driving force.

MEMBER ARMIJO: But the driver there is helium production?

MR. EINZIGER: Yes.

MEMBER ARMIJO: And you've got data on how much would be built up?

MR. EINZIGER: Yes.

MEMBER ARMIJO: Okay, at some point there I want to get into that.

DR. RUBENSTONE: Okay. The crosscutting issues, we've touched on the first one which is the thermal model calculations. As we talked about the previous way of approaching this was to calculate what the maximum fuel temperature would be early on and during the loading and early on in the stages because that was seen as an important parameter, and still is, to preserve the cladding lining.

But as we look at some of these other issues it's more than just the maximum temperature within the fuel assembly that may make a difference. It may be some minimal temperatures and when you start reaching lower temperature steps. If you design your thermal models to be conservative to calculate a maximum temperature you probably will not adequately capture what the lower temperatures are over time.

And the models also don't look specifically at what the thermal evolution of the outside of the canister is. Only to the extent that there's a sufficient heat transfer to remove heat. So we've suggested that a good area for work is to develop more realistic thermal models that try to look at both the interior and exterior temperatures, because a large number of the phenomena are temperature dependent on both ends.

Residual moisture, there's been some interest in this. There are standard drying procedures that the industry follows. There hasn't been a lot of benchmarking work following that to see how effective they are. Some of the residual moisture questions we've done some preliminary work in this area.

Our preliminary conclusions is that we're getting down to what we think are the residual amounts of moisture, that everything's fine. There's some reactions that take place but there are no real serious impacts.

If we are dramatically off on how much moisture is left in these canisters and if other kinetic processes happen at different rates, these could pose problems down the line.

MEMBER ARMIJO: If the quantities are really small they're consumed, by whatever reaction takes place.

DR. RUBENSTONE: Well even if the quantities are large they're consumed but then you have different effects.

MEMBER ARMIJO: It's how fast it reacts.

DR. RUBENSTONE: I mean one thing to remember, and we would appreciate it more when we did a little work is there's a large amount of surface area inside a dry storage canister to react out relatively small amounts of whatever is left. But again, if you have some mechanism by which you could trap more moisture in there than you think, by a large amount, then you could have some issues down the line.

MEMBER ARMIJO: How dry is dry? What criteria do you use as far as DPM of water in --

DR. RUBENSTONE: The standard drying procedure is basically they empty the water. They force it out, pump on it for 30 minutes and pump on it and --

MR. EINZIGER: They pump on it until they get down to three torr, they valve it off and it can't rise in pressure more than three torr during the next 30 minutes. Supposedly when you look at the vapor pressure of everything that says you're down to about a quarter of a mole of water in the canister. And our analysis has shown if you're actually down there the mechanisms aren't going to, there's not going to be enough degradation due to that remaining water.

Now, are we actually down there? That's the question. Because nothing's ever been benchmarked and you have water that could be sitting below the fuel assemblies so it's rather cool when the drying is taking place. You could have water that's trapped in the crud and in the oxidation level. And we get new information about that, just recently I heard that the radiolysis that they're seeing in the water that's trapped in the oxide could have a g-factor that's 100 times higher than they thought, which affects things.

So one of the things we're looking at is how dry do we have to get that. And we're in a the process of having an evaluation done now and then doing some benchmarking on the technique.

MEMBER ARMIJO: So there isn't any real spec that says after you finished your drying process the water content shall be no great than X ppm or nothing like that?

MR. EINZIGER: No.

DR. RUBENSTONE: It's the operational procedure with what's the rise in pressure.

MEMBER ARMIJO: Okay.

DR. RUBENSTONE: And as Bob said for the most part that probably works, but we would like to have some benchmark data if we could.

MR. EINZIGER: And that's only guidance to the applicant on where they should be. It doesn't mandate that they have to use that procedure. Fundamentally the licensee gets back to the applicant showing that the five criteria of criticality, containment, et cetera are met.

And the last crosscutting area is a very broad one and it's monitoring and inspection methods. Generally inspections have been visual inspections and you can see what's on the outside pretty easily. And that's about as far as you can go. There are some requirements for inspections during renewals, but they're not particularly detailed.

We think that this is an area that could be sort of a growth industry. There's a lot of new technologies that may be available to monitor different components with different techniques or to have specific inspections for specific degradation phenomena. So we think some further research in this area could be warranted.

There's possibilities that you could begin sort of building in monitoring techniques into new cask technologies as you go forward.

MEMBER BLEY: What kind of renewals are you talking about?

DR. RUBENSTONE: Again, the initial terms were generally 20 years, you can get a 40-year term now. So the application --

MEMBER BLEY: So it's the license renewal?

DR. RUBENSTONE: Right. But, you know, if new technologies come up, you know, if we become aware of some phenomena we don't wait until the next renewal period. We certainly bring it to the industry's attention. But I think this is a good time to start developing these techniques. And especially as sensors have gotten better, smaller, more easily in place. I think there's things that are available now that certainly weren't available when dry casks were first developed in the 1980s.

MEMBER BLEY: Visuals they do with remote?

DR. RUBENSTONE: Generally if there's some visual on the outside, there have been some inspection with cameras put in, you know, within the concrete structures. In general these structures were not designed to promote inspection or monitoring.

MEMBER BLEY: Because that wasn't a requirement.

DR. RUBENSTONE: It wasn't a requirement.

MEMBER BLEY: So maybe all they're looking at is the overpack?

DR. RUBENSTONE: I think that's the most obvious, but you can get into some parts of it. And I think John will talk about this in some detail too.

MR. EINZIGER: There's a few monitoring requirements. If it's a welded system they have to monitor that they're not leaking. They have to monitor that no birds are nesting in the outlets to change the temperature. They have to monitor that they're not getting a dose at the site boundary. But really they're relatively small monitoring criteria.

We're interested in can we monitor what's happening inside a sealed canister in terms of fuel degradation, in terms of other mechanisms. Can we determine what's happening on the surface of the canister, which is inside the overpack. And as John's going to tell you that's no easy task. We're interested in how good is visual examinations. We're interested in how do you monitor the state of the rebar in the concrete to make sure that it's not having degradation. Or in the concrete that's incased in stainless steel.

NRC is not intending to do research to develop monitoring techniques. Our research is going to be into what's the ability of monitoring techniques to detect, what criteria should be put on them, what monitoring would be desirable? How do we know what the monitoring is doing in order to tell the inspector see if they're doing this monitoring correct. Or are they doing that monitoring correct or how often should monitoring be done.

DR. RUBENSTONE: So those are the three which we think, if we do work in those areas it could help inform any number of things.

So this is the next set and we broke them up just so you could read them on the slide, but they're not really that much lower in what we considered priority. And again I've grouped some of these. They're broken out in more detail in the report itself.

This first group is what we've talked about as being driven primarily by the stress on the cladding. So there are a number of cladding degradation phenomenon. Propagation of preexisting flaws, fatigue and low temperature creep. But I think --

MEMBER ARMIJO: How can you get fatigue in a static environment?

DR. RUBENSTONE: I think this covers transportation also.

MEMBER ARMIJO: Oh, this is only during transportation where there could be some cyclic loading on the components?

MR. EINZIGER: There's two types of fatigue. One is the fatigue during cycling, loading and transportation. The other one that I think we analyzed was the thermal fatigue due to cycling from the change in the ambient temperature.

DR. RUBENSTONE: You have an initial thermal heating of the material.

MEMBER ARMIJO: That's really pretty tiny.

MR. EINZIGER: Sam, this is an awful long time period. And as you're well aware things that don't occur, don't appear very active in the short-term, if you go for a long-term they can build up.

MEMBER ARMIJO: Well when somebody does some calculations I think you'll, that's really tiny stresses that you could get from ambient temperature gradient.

DR. RUBENSTONE: But they all depend on the stress question. So that's where the stress questions --

MEMBER ARMIJO: Yes, so somebody's got to come up with a good stress story.

DR. RUBENSTONE: You get with the stress first and then you can see how important some of these are.

MR. EINZIGER: Sam, because the things are on this list does not mean that the NRC is going to start with a large experimental program. Some of these items could be handled with modeling. Some could be handled with analysis. Some will require more data. Some of them are only suitable for a particular type of material, for instance the neutron absorber one. Really the main concern there is those neutron absorbers that are also being used for structural components.

DR. RUBENSTONE: Yes. So these other ones address some of the other materials that are inside the canisters, especially over long-term. Neutron absorbers are also of interest in some wet storage issues. Keep in mind dry storage is generally higher temperatures so we have different sorts of phenomenon that could be going on.

Microbial influenced corrosion is another one we were just trying to define under what conditions is this something we need to worry about. That's clearly a lower temperature issue, I think. Darrell's done some work in this area.

MEMBER ARMIJO: Are you looking at spacer damage or degradation, do you know --

DR. RUBENSTONE: If you're talking about the grids?

MEMBER ARMIJO: A lot of these spacers -- Yes.

DR. RUBENSTONE: Yes we are looking at it as part of the fuel assembly hardware corrosion and fatigue embrittlement. There are a number of projects underway, especially overseas, we're trying to get into those programs at least to get that data. And we are actively, I think we're still pursuing with the industry to try to get a radiated grid for testing purposes.

MEMBER ARMIJO: Well there's all sorts of designs that have grids using Inconels using zirconium alloys, it's a huge number of variables there.

DR. RUBENSTONE: Understand.

MEMBER ARMIJO: And they are thin components. So if there's a degradation problem. And they're supporting these things, that's why I asked the question about the horizontal loading.

DR. RUBENSTONE: Yes, I mean that's where those small components can make a difference when you're talking about changes in geometry and adding different stresses to other components.

MR. EINZIGER: Well there's not only the supporting geometry, there's also the relaxation of the springs and grids that will affect how they hold things even in a vertical drop.

DR. RUBENSTONE: And then the concrete degradation. Concrete seems like a straightforward issues, but as Bob said, there are a lot of places in the concrete where you cannot easily inspect it. The rebar question over long periods of time, there have been some observed degradation issues in concrete related to freeze/thaw.

Again, if you can see it easily it's pretty easy to detect and mitigate but what you don't want to do is get to a state where you try to pull a canister out of something and see that the concrete is sagging. Or it breaks when you try to move it. So this gets back to the monitoring question, if there's ways of detecting concrete issues that come up early on, you know, see them before they've gotten to the point where they're actually challenging the structure.

So that's really the essence as far as we've gotten in this report. As we've laid out these technical issues. We're awaiting comments from the public, from industry, about whether we've missed things. If we've mischaracterized it. And we'll finalize this report.

There's another class of areas that we are just starting to examine which are not purely technically driven but they certainly have technical components to them that we're calling regulatory areas. And one of the next projects we'll be starting on is sort of an equivalent regulatory analysis if there are additional areas that need to be looked at systematically and what changes might be needed.

Some of these issues have been around for some time and they're even being looked at in a current framework. Decommissioned sites was a big focus of the Blue Ribbon Commission discussion. The requirements for possibly being able to handle canisters or move canisters in a site where the only thing that exists now is a dry storage facility.

Questions of whether physical security regulations would need to be changed as one moves out for very long periods of time. There's a current rulemaking going on for physical security requirements, upgrading those at dry storage facilities. When that is completed the answer will be looking at any issues that might come up for extended storage.

Risk informing is always a big issues when everyone looks at, you know, when we look at our regulations. As I said these regulations are very much performance based. They're not strongly risk informed at that time. WE have not been directed by the Commission to go full-bore on risk informing but we're certainly using risk information as we go through this.

MEMBER BLEY: Jim?

DR. RUBENSTONE: Yes.

MEMBER BLEY: Back to that NWTRP report. They had a couple recommendations that I kind of like, but I just wonder if it's even possible because of the way the regulations are organized to do it. And the first was that it could be helpful in managing extended dry storage if the regulations were revised as an integrated set. And that's integrating transportation and storage, which seems to be the trouble. At least to me administratively troublesome, part of that. And risk informing them as you're saying now. Any comments about that?

MR. EINZIGER: There's a number of activities going along in that area. Internationally the IAEA had a group looking at integrating storage and transportation regulations. For dual casks that's a major issue over there because they have a lot of those types of casks. Here in the United States we have a number of groups within NMSS and especially in the SFST Division that are looking at integration.

And integration does not mean necessarily making them all in one regulation. It may mean a separate regulation for spent fuel. Because remember now the regulations are covering the movement of radioactive material. They're not isolated to spent fuel. It may mean leaving the regulations the way they are and just changing the guidance. It may mean just fine tuning the regulation so they're a little clear on what's meant in the words.

There's a variety of ways of attacking this issue. And the best I think we could say at this point is all of them are being considered to see if there's any advantage in taking any action on any of them.

MEMBER BLEY: Let me ask one other one, because again it was triggered by some of their recommendations at the discussion, and this is an open meeting so I know you can't peruse this much. But they also, in the same breath, talk about security and a risk informed approach there. There must be some interplay between the safety and security and these areas of uncertainty that you have. And are they being looked at completely separated or is that being looked at as in the way the exist in the real world and maybe a coordinated?

DR. RUBENSTONE: I think we're trying to keep them together as much as possible. There's not really an active work right now on the physical security aspects. That will come probably, like I said, when they finish the current rulemaking, which could be two years. But we'll still have time to look at that. There's certain assumptions that are made about the fuel and the properties of the fuel. And the security analysis --

MEMBER BLEY: So that would be a place these would come together?

DR. RUBENSTONE: And then we have to say are those still valid assumptions if you're out 50 years from now.

MR. EINZIGER: Having worked on the security aspects prior to coming to the NRC I can tell you some of the things that we have identified as degradation mechanisms, will have implications for the analysis that were done for security. We have not yet sat down with the security people to discuss those implications. And any discussions in that line would be of a classified nature.

MEMBER BLEY: I understand that. But the idea that they'll take advantage of the same information as --

DR. RUBENSTONE: Right. Right. That's what I meant, that these are regulatory areas but they have to be informed by what we learn on the technical side.

So what are our next steps? Certainly the first step is finalizing this report when we get the comments in. Two things we're developing right now in parallel are the research plan for what NRC is going to do. And some of these investigations are already begun. The best example is the stress corrosion cracking, trying to define the actual conditions from some lab experiments. But there are a couple of other things that we've started on.

And we're going to lay out a research plan that shows what NRC sees as its main areas over the next several years. And that will, I think, help inform this bigger picture of well, who's going to do the other components, because there are certainly other players with a strong interest in this and most of them will be represented in the second half of the meeting.

And we certainly are going to monitor what's going on by all other groups because we're not claiming that only the things we do are the ones we believe. So we want to build and keep the dialogue going.

MEMBER BLEY: You haven't talked about burnup since your original opening remarks. Is there an issue with respect to burnup and some of the phenomenon that --

DR. RUBENSTONE: Well there's sort of a whole family of burnup questions that have come up even in the current context and they don't go away over time. And Bob can give you the short synopsis.

MEMBER BLEY: They weren't on your final list of big things to look at, that's why I'm asking.

MR. EINZIGER: Well, burnup per se is not a degradation phenomenon.

MEMBER BLEY: Exactly.

DR. RUBENSTONE: But when you're looking at how fuel behaves and all aspects, you need to consider what's being stored. And if it's more and more high burnup fuel then that will color how you look at the phenomenon.

MR. EINZIGER: As you increase the burnup of the fuel you change the properties. We know that some of the degradation mechanisms will change with higher burnup if the stresses for those changes are available. That's why we didn't identify burnup per se as an issue, but rather it's sort of incorporated in these particular, some of the mechanisms that we did look at.

For instance, we're interested in fuel swelling but it's really a high burnup issue, not a low burnup issue just because you don't generate as much product decay into the helium. So it's buried in there. It's definitely an issue. Things that some of these mechanisms that we don't consider for low burnup are high burnup issues.

MEMBER BLEY: Is this a scenario where there's sufficient experimentation and existing research? Or is this a place we need actual experiments to get a better feel for what might be happening?

MR. EINZIGER: I think that in some cases we have a feel for what's happening. For instance, with respect to hydride reorientation. I think we have enough feel t know what the questions are for the NRC. That doesn't mean that there's enough research out there to answer the questions. But once we, as I said before, once we know that we have a question then the responsibility for answering that question shifts.

For other questions like delayed hydride cracking, is there an issue? Does more work have to be done? We don't think there's a current issue. We think there may be a further issue down the line, but that issue is going to be dependant on whether there is a suitable stress to drive it.

And so our question to start with is not do we have delayed hydride cracking and should we have an experimental program to look at it, but rather do we have a stress that's going to drive it in the first place? So there are areas that need further aspects done.

MEMBER BLEY: I'll ask again when the others are up. But I'll ask you in case you have an idea on it. Does DOE have a role in this research or does it belong to the industry? You don't really care, I mean, when an application comes in it's whatever's there to back it up. But if you can just give us some information on that I'd appreciate it.

MR. EINZIGER: There's two parties in this whole game. There is the person that holds the CFC for the cask, and has to defend the cask. And there's the person who's going to use the cask. As far as I know DOE has not held a CFC and built any casks for commercial fuels. That may be wrong, but I think that's the case. And the other part of it, so far DOE doesn't hold the fuel, other than a little bit of fuel I think that was part of test programs.

DR. RUBENSTONE: Well we've got the Idaho.

MR. EINZIGER: Well that's what I'm saying, that's the test programs. And I don't know that they are a shipper of record. If the utilities are the shipper of records they're the one that's going to have to produce the data. If DOE is the shipper of record they're the one that's going to have to make the case. I really don't care.

MEMBER BLEY: We'll look forward to hearing from them. But before we break I wanted to get that out.

DR. RUBENSTONE: Yes, at NRC the position is that we need the information to make these decisions. And where it comes from, but I think DOE probably feels it has some role in this.

MEMBER RAY: What we're talking about is identification and prioritization of the technical information for potential regulation. How do you see, so we're just involved in the very early stages here, but what's the next step from a regulatory standpoint? Are you going to produce a final report or how does it proceed from this phase that you're involved in now?

DR. RUBENSTONE: What we have laid out to the Commission, and we recently sent up a annual status paper on this issue. So we're on record now of saying what our plans are. We are shooting to, by 2018, to know what changes need to be made in regulations. And if they're small changes to have started that and starting on changes in guidance.

So our step wise is first identify the needs, lay out the research plan, gather that information that we think NRC needs specifically. Assess any regulatory issues that fall out of that and then make the decision. So the finalization of this report is the immediate first step that says we've identified these are the needs.

We will be putting out then, subsequently, our research plan saying these are the issues we're addressing, this is when we expect to get results. And then the somewhat parallel but not exactly the same, prioritization of potential regulatory issues. Now the regulatory issues are evolving in parallel with some of this current licensing process improvement activities that are going on.

So we're not going off and saying we're going to make these changes just for extended if there's something that could help in the current framework as well. So like I said, the next step is the final of this report, the research plan and then as the results come out we'll probably be issuing individual results as we get enough and then maybe a roll up at the end saying here's a summary of everything we learned with a bibliography of all the reports that have come out along the line.

MR. EINZIGER: Over the next five years we expect to be doing separate effects testing on various mechanisms, or modeling, as it may require. And based on that and other information we get, make a decision whether there's any technical change to technical guidance. But ultimately we're going to be asking the licensee to back up these prognostications with some hard fact that what we think is happening really is happening.

And that gets back to John's question of somebody along the line is going to have to produce some data to show us that we know what's really happening on a cumulative basis by some actual, looking at some fuel under actual conditions. Looking at some casks under actual conditions. Looking at some canisters.

MEMBER RAY: Yes, well it sounded like maybe this research plan you referred to implied, well it was up to the Government to answer all these questions.

DR. RUBENSTONE: No.

MR. EINZIGER: No, we want to answer as few of them as we have to answer. We want to depend on other people as much as possible.

DR. RUBENSTONE: Yes, what I meant by the research plan would be, from the large set of questions we've posed in the report how is NRC going to pick a subset that we think we need to do the work on. And that's clearly a subset of everything that's laid how.

MEMBER ARMIJO: How do you pick the subset that are important? That, you know, that's really to me the first thing is say these are important. These are a zillion other phenomenon that people can get.

MR. EINZIGER: Well that's why we have the first six laid out there.

DR. RUBENSTONE: I mean that's our first pass. And I think what we're going to refine is --

MEMBER ARMIJO: Then having said that, what data needs to be made available so that you can resolve it.

DR. RUBENSTONE: Right. I mean it's not that different than addressing any technical issue in that you first define what the issue is. That alone doesn't tell you what the specific data needs and the data needs don't alone tell you can this experiment be done or can this analysis be done. So that's the sharpening of the pencil that we're getting into now.

MEMBER RAY: Okay, but I felt better after what Bob said. I mean, you can say this is the extent of our knowledge and therefore if you guys want to extend the license it's up to you to show that it's okay, speaking to the licensee or to whoever has the stuff. But because of the way this is all viewed ultimately, I suppose as a Government problem, I was wondering if you were thinking well no it's up to the Government not only to figure out what the answers are that we need but also to go find them.

MR. EINZIGER: I guess the simple way to

put it is what I tell industry all the time. We're both seeing different sides of the same cup. We look at the cup and say what are the questions. You have to look at the cup and say what are the answers.

MEMBER RAY: Well that's fine. I can buy that.

DR. RUBENSTONE: And keep in mind that we are doing this now so we're ready for problems that may crop up over the next number of decades. This isn't the end of the story but we didn't want to just sit around and let it sit. Because some of these projects may involve sort of long-term experiments or monitoring of existing systems or future deployed systems over decades to make sure that we are in fact capturing the right phenomenon.

MEMBER ARMIJO: What about the people that are trying to get a 20-year extension to their current license right now? What do they have to, you know, given all these questions and the potential need for new data, are they out of luck? Or is there resolution? Is there some way to --

DR. RUBENSTONE: I wouldn't say they're out of luck. There have been extensions already granted and there are current actions moving forward. This is helping define the kinds of questions that are being asked and kind of information we're getting back. I don't think any particular one is at an impasse.

There are, certainly I won't diminish the fact that there are certain current issues being addressed and they involve things like high burnup fuel. They involve some of these stress corrosion cracking issues. But I don't think anyone is at a sort of out of luck position out there.

MEMBER ARMIJO: Well in some cases the research would confirm judgement that you've already made that there was or was not a problem.

DR. RUBENSTONE: Right.

MEMBER ARMIJO: And that's valuable. But I'm just saying that if someone comes in and says, here's my cask, it's really old fuel, it's been sitting there for 20 years, it's not in a marine environment, you know, just the stuff inside, and I really don't have any more information than I had for you than what I had 20 --

MR. EINZIGER: We look at their overall case. We have had a number of applicants come in for low burnup fuel. We allow them to use the examination of the fuel that was out in Idaho, after 15 years on the low burnup fuel, as evidence that yes we thought we knew what we were doing and yes this confirms it. And so we don't question it very much.

If they're in a non-marine environment we may ask them a question if they're in an industrial environment. I don't know what would happen to casks if they were sitting in Akron. Nothing against Akron.

MEMBER ARMIJO: There is very little industry --

MR. EINZIGER: What's that?

MEMBER ARMIJO: I don't think there's too much industry in Akron.

DR. RUBENSTONE: Maybe not the best example.

MR. EINZIGER: We take a realistic point of view. Now if they come in and there's issues that they don't have answer to we look at their arguments. We discuss what their points are. We try to tell them what we need. We try to give them some hint of ways to go about getting this data. We try to give them a number of alternatives, those alternatives might be take a different approach to it.

It may be we're going to put some restrictions in your CFC. But ultimately they've got to convince us that they can meet the Part 72, or if it's a transportation Part 71, license for the fuel that's been in that storage for some period of time, recognizing that what you put in may not be what you put out.

There's different ways of doing it. The Japanese have taken an approach that at 400 degrees C we have a change in the fuel condition, we get hydride reorientation that changes the mechanical properties and we don't want to deal with that. So they took the step and says we're not going to go up to 400 degrees C. We're going to limit our temperatures to 275 C., where very limited hydrogen goes into solution. We don't have a hydrogen reorientation effect. And we're going to make the assumption that since we don't have this effect if we know what we put in storage that's going to be the same thing 50 years later.

Now we could take that approach too. Or we don't even have to take that approach. If a vendor decided that from now on they wanted to limit the storage temperature to 275 and try to make the argument that the Japanese made, they're free to do that.

MEMBER ARMIJO: If they recalculate. You know, the 400 was a bounding temperature, right? That's a maximum temperature they could go to. So they calculated the cladding temperatures, using whatever model. Probably worse, not worst case but a lot of margin probably. And a lot of this fuel that's out there is really old fuel, doesn't have much decay heat. So you probably have a lot of fuel out there that's already at pretty low temperatures that started out at low temperatures.

MR. EINZIGER: It may well be and they might do those recalculations. It also may be that the points in the fuel that are going to see the higher temperatures and possibly have a defect like hydride reorientation, that's not the part of the fuel that's going to be at the low temperature when you go to transport it or you go to do extended storage. It may be that that part of the fuel is still high enough so it hasn't had any change in ductility.

So that's one of the drivers for us looking at modeling of the more realistic temperatures with more realistic properties. Not so much to give the industry a tool, we're expecting the industry to actively try to hone their models better. We're looking at it as a tool for our reviewers to use to check on the calculations of temperature that they're getting from the industry.

MEMBER ARMIJO: Thanks.

DR. RUBENSTONE: The next couple slides

are just about what came out in the Blue Ribbon Commission Report. And I think we can go through those relatively quickly.

There were eight key elements and their recommendations in their January final report. I've picked out three that are relevant, I think, for these issues. The first overarching one was this new consent based approach to siting. And that included a variety of facilities including potentially what's in the next point, one or more consolidated storage facilities. And they also stressed prompt efforts to prepare for eventual large scale transportation.

The second one I think we had brought up earlier and some of the implications. Staff has prepared for the Commission our, sort of, what are the implications for NRC from the BRC recommendations if they are in fact implemented. That was a briefing back in April. And there's a report that's in ADAMS there. There is expected a report back from DOE to Congress. And maybe Jeff may mention that as he talks about DOE.

But the implication that come up is the question of consolidated facilities could lead you to multiple transportation stages. Sort of overarching belief over the years has been generate the fuel, put it in storage, move it once, it's disposed. That may not be an accurate capturing. So you may have things that have been in storage for some time, they are then moved, they go in storage again and then will be moved a second time.

And then how long those different time periods depends on where you are in the stage and that then has implications for the state of fuel, you know, when it enters into the first transportation stage you've got one set of issues. If it's been stored for decades and then is transported you may have some additional different issues.

And certainly moving things from a static facility, taking them on the road, putting them back in storage, what's the state of the fuel. That's a question that needs to be addressed. You may also end up with multiple stages of handling, either just handling canisters, moving them between different overpacks or potentially if things are in storage long enough, having to remediate and change the actual storage capability.

CHAIRMAN RYAN: Jim, could you describe the database that exists to kind of get at or answer or maybe even address some of the questions you've just raised? I mean how many examinations of long standing storage fuel or fuel that's been moved and reloaded or, you know, what's the database --

DR. RUBENSTONE: Pretty limited, Mike. The example Bob gave earlier about the low burnup demonstration experiment that was done at Idaho, and it's still ongoing, there's still fuel in that storage, was some moderate transportation of relatively young fuel, leaving it for 15 years, opening it up, pulling some materials out to look at. You know, that's valuable data.

CHAIRMAN RYAN: Oh absolutely, yes.

DR. RUBENSTONE: But there are some limitations of it. The Japanese did periodic examinations of reopening canisters in storage. That has some relevance but it's not directly mappable because of the offset --

MR. EINZIGER: Low temperature. It's very low temperature. Low burnup.

DR. RUBENSTONE: They have low burnup and they also have this lower temperature constraint and --

CHAIRMAN RYAN: Well it's a start though.

DR. RUBENSTONE: So it is some data. There's some discussion of other things. There is some information from the French who do transport things relatively early on in the cycle but on a relatively larger scale, going from the power plants to the reprocessing facility. So there is some information of what the fuel looks like when it arrives there.

Again, it's not perfect analog for this but it can be used. There are discussions, and I think this will come up in the second group of talks, about another demonstration project that could give some information after a storage period could have some sort of realtime monitoring information available.

CHAIRMAN RYAN: Yes.

MR. EINZIGER: There's lots of data out there on various topics that applicants like to quote. Usually where they get into trouble is when you say, is this data really applicable to the system. For instance, the French have transported a lot of fuel, as Jim has said, from the utilities to Le Havre. Most of that transportation occurs in the 350 to 450 degree C range. So is that data applicable to fuel that's going to be transported in the 100 degree range? Probably not.

DR. RUBENSTONE: And then there are all these separate effects tests. And there has been a fair amount of work on specific questions that have been addressed. And some of that data is more applicable than others. You really have to look at it case by case. So there's a fair amount out there. There are some holes, and that's something we came up with that it would be nice to get something that's had this history, looked at at this level of detail.

CHAIRMAN RYAN: Thank you.

DR. RUBENSTONE: And then the last bullet there, I think we'll all agree, is there probably will be statutory changes. There have been a number of discussions of things being introduced. There's not a lot of action yet from Congress but we're keeping our ear to the ground. Well certainly many of the recommendations of the Blue Ribbon Commission would require statutory changes up front.

So NRC's regulations, they match the law, so that may drive some changes in our regulations as well. And I think, yes, just to wrap up. This is where we stand. We hope we've met your current needs and we are certainly open as we progress and move through these various steps to come back and tell you what we've found.

I have some backup slides, they're mostly just diagrams and pictures of different systems if we wanted to get into the details of them.

CHAIRMAN RYAN: And I guess what I would, thinking ahead a little bit, you know, the Full Committee meeting, you're really reporting on work in progress. This is not a final product by any means. You know, these bullets to me kind of summarize here we are at this point. We've done these things and here's where we are going forward a little bit.

If you could just summarize and say what are the top three or four things you want next time you come and see us. What do you want to have finished at that point? What are your high priorities for the NRC staff? I know, I heard from industry reps on some other activities, but what are you looking at?

DR. RUBENSTONE: I think my highest priorities, I think in finalizing this report we can do that. But getting this research plan in place so we really have defined, over several years, what are we expecting. And what can we realistically do. And then opens it up and I think it further informs the industry of what's on their plates. So getting that research plan together.

Getting a systematic regulatory analysis. I gave you some bullets of areas we're looking at, that's certainly not the final word. And those are the two things that I see us getting done. I don't want to give you dates on when we're going to have those.

CHAIRMAN RYAN: No, no. I'm not looking for dates. I'm looking for comments.

DR. RUBENSTONE: I think those are the next two things. And then certainly as we move through the research that we're doing and we see what other groups are doing there may be opportunities that come in and say well, now we know what the pressure is going to be and the stresses are going to be on the cladding. So we're doing this or we're not doing that. That may be a point that we could come back --

CHAIRMAN RYAN: So you might be able to fine tune your research program based on what you learn from others as we go forward?

DR. RUBENSTONE: Absolutely. And we've mostly looked at U.S. activities, there is a lot going on in the rest of the world. We're involved with a number of activities with IAEA. NEA is starting up an activity on this area. A number of individual countries have it. It's hard to find a country that has nuclear power generation that isn't seeing extended storage as a challenge.

CHAIRMAN RYAN: Would you say that the NRC is well engages in all those process with others or should that be enhanced?

DR. RUBENSTONE: I think we are well engaged. I think you can always do more, but where we are now we seem to have our involvement with the NEA activities, the IAEA activity and some bilaterals. And you know some countries are further along that others.

CHAIRMAN RYAN: Yes.

DR. RUBENSTONE: Like Japan and Korea particularly are doing a lot of work. The Spanish are getting very much engaged in this. The Germans, although they have very much a narrower set of cask designs, they're all bolted systems, they've done a lot of work in that area. The UK is just realizing that they have a problem I think and they are trying to catch up. So we're trying to stay in good with the right players.

MEMBER SCHULTZ: Jim, are those timeframes, the international activities, are the timeframes that they're viewing similar to what we've discussed today or are they really looking at extensions, 20 years, 40 years?

DR. RUBENSTONE: I think it differs in some of them. Some of them are looking at shorter periods.

MR. EINZIGER: We're one of the few countries that licenses storage without mandating that transportation be licensed at the same time.

MEMBER SCHULTZ: Correct.

MR. EINZIGER: If you looked at the international spectrum the timeframes that are considered vary over the map. The short is 50 years. The official IAEA declaration of long-term storage is more than 100 years. So it varies over the map. And that somewhat defines the issues that they're dealing with.

Also what their path forward somewhat defines their issues. For instance, as you heard, one of our top priorities is marine stress corrosion cracking of the canister. Now if you look at the priorities that the Spanish have, they don't even list that because they're building a centralized storage facility essentially in the middle of the country. Nowhere near a marine site, so they don't care.

On the other hand if you look at the British program it's very much an issue with the British program. And even some of the fuel issues are higher with the British program than our because the Brits count on the cladding as a barrier. For us the cladding is only a defense-in-depth. The canister in storage and the overpack in transportation are the primary barriers.

So depending upon the individual country's priorities, there's different timeframes, there's different research they're doing. What we're trying to do is to make we're on top of it to make sure when they get results we use those results in our program. Let them guide what research we're doing, what research we don't have to do.

If they're having programs that are looking in effect for some other reasons, let's say for the reactor purposes, and we can piggyback on that for some reasons. We're trying to get involved with piggybacking on them so that we could either use the same materials or the use the same people or the same facilities to minimize the effort that we need to do.

MEMBER SCHULTZ: Thank you.

CHAIRMAN RYAN: Thank you. Any other questions? Or we're kind of right on time for our break so we'll go ahead unless there are any other questions? Comments? Going once, going twice. Okay. We'll break until 2:45. I'm sorry until 3 o'clock.

(Whereupon, the above-entitled matter went off the record at 2:42 p.m. and resumed at 2:58 p.m.)

CHAIRMAN RYAN: Okay. We'll continue with the agenda. I believe, let's see, Jeff Williams is up from DOE.

(Off the record comments.)

CHAIRMAN RYAN: Jeff, welcome.

MR. WILLIAMS: Yes, I'm Jeff Williams, I'm at DOE's Office of Nuclear Energy. I actually came from the Office of Civilian Radioactive Waste Management, where I was there for about 25 years or so.

So anyway, as I was sitting there listening to this I thought of a whole bunch of other things to mention. I'm really focused on our R&D activities is what I was going to talk about today.

So the way we're organized is we have nine laboratories that are working for us and we're providing them funding. And in this area primarily PNNL, Sandia and Idaho are the biggest players in this area. And so this is a new program that was developed after the withdrawal of the Yucca Mountain license application and the stopping of doing that program.

And so a report called the R&D Roadmap was developed by NE that laid out sort of the mission of all of the Office of Nuclear Energy and this used fuel disposition program was part of it. And it lays out all the research that's being done related to alternative geologies for repositories as well as extended storage. And then more recently we've added transportation.

So this is an area where basically where we're just getting started. And so this talk here is going to focus on the storage and transportation part of our program. And this is, I'm going to talk about the major activities and the collaborations that are going on. And this is just showing that we're looking at all the way from spent fuel assemblies up to canisters to casks.

The recent focus has really been trying to determine, well what do we do. And so our overall objectives is to develop the technical basis to demonstrate the used fuel integrity lasts for extended storage periods. And develop a technical basis for retrievability and transportation after the extended storage. And also to develop the technical basis for transportation of high burnup fuel.

The pictures here are sort of the same way. Showing that we're looking at the nano scale, small scale, all the way up to large scale and casks and so forth. And that we're doing this through a science-based engineering driven program. And how do we know we're doing the right things? Basically we started off by doing a functional requirements assessment. Then we conducted a technical data gap analysis. And then we compared that gap analysis with other gap analysis that were trying to identify data that's needed in this area.

The Nuclear Waste Technical Review Board did one. Bob and Jim just talked to you about the NRC one. We've conducted external reviews of this work. We worked closed through a program that John, I imagine will tell you about, called the Extended Storage Collaboration, or Cooperation one of them.

CHAIRMAN RYAN: Either one sounds correct.

MR. WILLIAMS: So anyway, I think we're all trying to identify the same thing, where the focus of the limited amount of money that does exist. And DOE does have some, I think there was a question about well what's DOE's role here. And we do have some funding and Rod always tells me that it's my fault because I stopped working on Yucca Mountain.

So anyway, we do have some funding. We do have special capability with the labs. We have some capability to do some fuel examination and so forth. And we would like to replace some of the missing fuel capability examination that used to exist. So based on all this we think that we're doing the right kinds of research right now.

And as a matter of fact we identified the gaps -- Well I'll go into that in a minute. This right here is just a listing of the major areas that we're working in. We have a couple other smaller areas but it's just the way we sort of organize our work into R&D investigations, engineered materials which is experimental, engineered analysis which is computational, field testing and then transportation.

So these are the major activities that I'm going to just go through. The first one called R&D Investigations, this is a real complicated table here, but it's just a picture out of a recent report that we've put up. I'm not going to go into the details of it but what we did is we did this initial gap analysis. Where are the gaps, what data needs to be gathered, which is what we shared with industry, NRC and so forth.

And then this year, just in the last month or so, completed what we called a prioritization of these gaps. And what this table does is it goes down through each one of the gaps on the left and then it talks about the likelihood of occurrence. There's two numbers there. The number on the left is near term and the number on te right is farther term. And then it shows what the consequence of something going wrong. And then talks about whether it's easy or hard to remediate.

For example, you can look down at concrete and it's got a one. So concrete's easier to remediate than if you had neutron poisons falling apart or cladding annealing. And then we added all these up and we got the importance for licensing. And we identified whether they're high, medium or very high. And this is a report that's, like I said, it's out in draft right now. We have circulated it through the escape committee that we're part of hoping to get comments soon on it.

And I think we're identifying the same type of gaps that everybody else is. And the next step will be start to gather data, to get funding in place to address these gaps. We're also doing things such as developing aging management plans for storage systems. Some of that work I think is due later on this year. And we --

CHAIRMAN RYAN: In the report is there a key that tells me what difficulty for remediation one, two and three mean?

MR. WILLIAMS: Yes, one is easy. There's, we put a key.

CHAIRMAN RYAN: What's easy mean? That's $60 million, $5 million, $20, what?

MR. WILLIAMS: Well relatively.

MALE PARTICIPANT: It's not a matter of money.

CHAIRMAN RYAN: Well whatever the criteria it's really vague what these mean. It's hard to understand what's going on here without some detail, but that's okay.

MR. WILLIAMS: Yes, well John's probably read the report better than I have.

CHAIRMAN RYAN: Okay. Actually if you could just give us a reference to where we can get the report, that would be helpful. If we could give that to Chris or to Rod -

(Simultaneous speaking)

MR. WILLIAMS: Well it's not publicly out yet but we can sure get it to you. It's a draft report that is undergoing a review, we're waiting to comments back.

CHAIRMAN RYAN: Right, well whenever we can have a public report we need to have it.

DR. KESSLER: Okay. We can do that.

CHAIRMAN RYAN: But you have distributed

it outside the --

MR. WILLIAMS: Yes, we've distributed it. I mean, it's not up on a website somewhere where I can point it for you.

CHAIRMAN RYAN: That's all right, if it's a public report we'd like to have it.

MR. WILLIAMS: Okay. We'll get that to you.

MEMBER ARMIJO: I'm sorry, I came in late. I'm just trying to catch up. Just define consequences difficulty for remediation.

MR. WILLIAMS: Yes, basically these are relative. And it's just based on subjective judgement where a group of people got together and said relatively is this one harder than that one? And, you know, as far as any more quantitative criteria --

CHAIRMAN RYAN: So these are opinions? These are not based on any --

MR. WILLIAMS: Yes. Yes, these are opinions of the people who work on this report.

MEMBER ARMIJO: How many worked on this?

MR. WILLIAMS: It's probably, I don't know how many people, five or six people or so.

CHAIRMAN RYAN: Well not to cast dispersions at your colleague, but how do we interpret somebody's opinion? What's, I mean it's a pretty soft sort of measure.

MR. WILLIAMS: Yes. Yes, except that the good part is I think the things that we're identifying as important for licensing are the same sort of things that everybody else is identifying as important to licensing. Like aqueous corrosion, okay? And so now we're going to start up a collaboration to do some testing. We're providing funding through EPRI. We're hoping to get more funding to work on that further. In addition --

MEMBER SKILLMAN: Isn't this somewhat biased from the perspective that what is deemed as very high likelihood of occurrence is really focused around the canister or the cask and so the original orientation here is the cask or the canister have to carry today as opposed to some other characteristic of the fuel. So this begins with the idea of good, strong, robust steel encapsulation. That's where you began, or that's where it appears that the team began this.

??: There isn't too much you can do with fuel.

MR. WILLIAMS: Yes, well the fuel is important from a transportation standpoint and a retrievability standpoint I think, Bob or somebody mentioned that.

MEMBER ARMIJO: But, Jeff, you can retrieve anything. It's just how much work does it take and how much cost does it take.

MR. WILLIAMS: Right, I think you got it right.

MEMBER ARMIJO: And we can't assume, or maybe we can as regulators, and require that something remain in its pristine condition unchanged over 20 years on the basis of retrievability. Let's say it embrittle, I'll make that an assumption. And that it cracks a little bit during transportation. It's still retrievable, it's just going to cost time, money and effort to do it right.

So I'm still trying to catch up with how we get to something that's worth funding that it's really an issue that effects safety. And maybe I better read the report again to really understand.

CHAIRMAN RYAN: I was going to say. I'm stuck on the fact that this is a qualitative opinion survey rather than anything else.

MR. WILLIAMS: Yes, that's right.

CHAIRMAN RYAN: And without understanding the details of the report it's going to be real hard to divine what these mean at this stage. So we get this is a lead in to the report. Hopefully we'll get the report and then we can go from there. Fair enough?

MR. WILLIAMS: Yes.

CHAIRMAN RYAN: And in the interest of time I suggest we move on.

MR. WILLIAMS: Okay. So the next one here is engineer materials, experimental. And that's just some work that we're doing in this area and the two pictures show focus on cladding and the canister.

MEMBER ARMIJO: But this picture is, I've got to object to that. You know, this is a picture of cladding that's gone through a LOCA, simulated LOCA transient --

MR. WILLIAMS: Right.

MEMBER ARMIJO: -- and it's been squeezed and then it's not your normal.

MR. WILLIAMS: Right, and I was going to say that.

MEMBER ARMIJO: It's not your normal, normal fuel doesn't look like this at all.

MR. WILLIAMS: That's exactly what I was just going to say, okay. Is that yes, this isn't fuel but we do test this up to failure. And as a matter of fact this is tests that were initiated by NRC and then we picked up the funding on it, I believe, last year. On these ring compression tests.

CHAIRMAN RYAN: But not to put to fine a point on it it's hard to make any, how does this help inform our assessments of what we're doing?

MR. WILLIAMS: Well my understanding it has to do with the hydride reorientation and trying to determine how strong the fuel is. I don't know whether -- And then the next bullet on the HFIR cladding testing, that's not real fuel. That's gilped fuel and they're trying to correlate between the ring compression tests that are being done at Argonne with real fuel to doped fuel and putting stresses on --

CHAIRMAN RYAN: Well, I guess what I'm taking away is these are phenomenological studies that were done in a laboratory situation, they're really not designed to be in vivo real reactor fuel. They're looking at parameters and features and events and processes but not the behavior of a fuel element or fuel elements in a storage cask for extended periods of time.

MR. WILLIAMS: That's right.

CHAIRMAN RYAN: Okay, fair enough.

MR. WILLIAMS: And then the third bullet

down there talks about conducting also research on the stainless steel corrosion test, which is being done out of Sandia and in baths and so forth. And this is another area that we're hoping next year to continue work on this and provide additional funding to continue this sort of work at this scale.

Let's see. Well you guys talked about the real fuel and the real casks and I'm sure Rod and John are going to talk about that some more. But we haven't started a program on that yet, other than the fuel that's up at Idaho that Bob talked about. The low burnup fuel that's been up there forever that we opened the casks back in the late '90s.

This is the next work account is called engineering analysis and it's a computational thing. In most cases we have several different what we call work packages. One of the areas of work in this area has to do with taking canisters, but there's been emphasis on this for 20 years. It comes from the Nuclear Waste Technical Review Board, BRC mentioned about the compatibility or the standardization of the canisters with disposal.

It was an issue that we thought we could get our hands around when we knew what the repository was. However, now that we don't know what the repository is there's still be efforts, or interest in pursuing this. And as a matter of fact our budget this year we got a line item that told us we need to continue to work on this. So we have a low-level bit of work on looking at the compatibility of storage casks.

As a matter of fact we even have started up a program to look at what does it actually take to dispose of existing dual purpose canister casks. If you went to the Yucca Mountain program, everybody that did the analysis out there would just say, oh they're way too big you can't do it because of thermal criticality reasons.

??: Not everybody.

MR. WILLIAMS: Well --

DR. KESSLER: We're on record saying the opposite.

MR. WILLIAMS: Well I mean, yes, okay. I always --

CHAIRMAN RYAN: But others didn't.

MR. WILLIAMS: Yes. I always believed it was primarily because they had an analysis for 21 assembly waste package and they, in order to meet our schedules, they didn't have the ability to redo everything. So anyway, we've started that. We started that fresh. We're also looking at small canisters for fuel that's not yet loaded. If you go to any repository around the world none of them are planning to do dispose of things this large. It doesn't mean it can't be done.

So that's one item we're doing. We're participating in this Calvert Cliffs inspection that's going on by doing the thermal analysis on that. We're trying to calculate the hydride reorientation and basically how it, from a calculational standpoint, how would you expect it to occur.

MEMBER ARMIJO: You have to have some starting assumptions of what the stresses are on the cladding from the pellet swelling or existing pressure in the rod. Do you have a model for that?

MR. WILLIAMS: Yes, I'm sure they do. I really don't know the details of it.

MEMBER ARMIJO: Is this Calvert Cliffs canister inspection, is that somebody's actually going to open up a canister?

MR. WILLIAMS: No, no.

DR. KESSLER: I'll talk about it.

MR. WILLIAMS: Yes.

MEMBER ARMIJO: All right.

MR. WILLIAMS: Okay. And then another

program we have is we want to look at what are the stresses that are actually involved in transportation. And so this is the work that's being done in engineering analysis and we plant to continue that into FY13. This next one, again is field testing, which is just getting underway. We're writing a storage/transportation R&D plan that defines the near-term separate effects testing that's needed. So we've laid out a plan that talks about actual tests on small bits of fuel and so forth, because there isn't the capability like there had been in the past at Idaho to examine large spent fuel assemblies. And out team thinks that we can gather a lot of data on separate effects testing.

But specifically with EPRI we're starting to gather atmospheric data close to the canister. We're looking at actual surface temperatures. And we want to develop remote optical capability to look inside like a NUHOMS cask. And I think John or somebody will talk more about the Calvert Cliffs work that we're providing funding to work on as well.

In the transportation area we've started some criticality analysis to look at for extreme accidents conditions for used fuel and looking at K effective to identify margins under criticality requirements. This was something that was also originally started by NRC and we started to fund it this year. Moderator exclusion is something else we're looking into. So it would provide additional allowance and criticality analysis for damaged fuel.

And then the last one, I guess I mentioned it previously, is the transportation testing which is actually obtaining data on realistic loadings that's transmitted to the fuel during transport And this bottom test, picture over here, shows a shaker test that is being designed at Sandia. And we plan to continue this work into FY '13.

And someone brought up the Blue Ribbon Commission report and our program had been focused on R&D ever since it just started in 2010, until we're into the third year of it. The Blue Ribbon Commission report came out and, well the draft was last summer and the final. And basically it supported the work that we're doing in R&D, but it had a whole lot of other near-term actions not really related to R&D. And if you follow our budget we actually got a plus up in our budget this past year, in FY '12, the president request $36 or $37 million and we ended up getting $60 million.

However, the direction wasn't to expand

the R&D it was to look into the activities that the BRC has recommended DOE pursue prior to any legislation, or prior to any new, what they call the Fed Corp, or any new organization that would actually take this over. Things like funding regional transportation groups. Developing design concepts for consolidated storage facilities. So these are outside of the R&D area.

So anyway, in conclusion. DOE is supporting this research to the extent that we can. We do have funding, to some extent, nothing like what Yucca Mountain program had. Very small bits of it. We're supported by a lab team and we've started to conduct experiments. We're working collaboratively through the ESCP Program with NRC to make sure that our experimental program is really looking at the right things.

And we're also working closely with international people. One of our lab members is the chairman of the International Subcommittee under the ESCP Program. So that's what I have to say about our Storage and Transportation R&D Program.

CHAIRMAN RYAN: Thank's Jeff, that's a great overview, we appreciate it very much. Any questions for Jeff? Comments? All right, without further ado, John Kessler, you're up.

(Off the record comments.)

DR. KESSLER: I do have a lot slides, but fear now. Both Chris' of ACRS have admonished me to move along through the slides, so I shall.

CHAIRMAN RYAN: You got a little over a minute a slide. They're good.

DR. KESSLER: Yes, well, a minute a slide, but you're a chatty bunch. So we're not going to do any better than that.

CHAIRMAN RYAN: Well, you still got a minute a slide.

DR. KESSLER: Okay. I'll just hit on a couple things based on the questions which you've asked both Jeff and Jim and Bob earlier. I think that just the background, Jim's already talked about, which is that extended storage isn't just a U.S. issue, it's an international issue, and that most nuclear countries now face extended storage, no reprocessing, and now U.S. joins the throngs with no disposal either.

And centralized storage, while it may exist, is still storage, and so there's a lot of countries that are out looking for it. There are, and Jim mentioned it again, several countries that there's already work on extended storage under way.

Jim mentioned stainless steel dry storage canister degradation, we're going to do some more. NRC has done some nice initial work at the lab scale on dry storage canister degradation to kind of focus in, you know, the wealth of stainless steel degradation knowledge into something that's more relevant, or at least we think might be more relevant, to what's actually out there.

There's efforts to continue to take data from that CASTOR V/21 that was in 15 years of storage prior to reopening in about 2000. Japan, Germany, U.S., others -- excuse me, the U.S. and Japan have collected data on that. Bolted casks, Jim mentioned about that, and then the periodic visual inspection of some cask internals, Japan is taking one or two casks, reopening them, I think, every five years, and just doing a visual of them, which provides some information.

MEMBER SIEBER: Does that disturb all the conditions?

DR. KESSLER: It could. We need to find out about it. I don't know the details about how hot the fuel was or things like that. Nevertheless, even if it disturbs it, it's always good to see what's going on rather than leave it.

MEMBER SIEBER: Yes. I would worry about moisture intrusion, all kinds of things --

DR. KESSLER: Exactly. I don't know the details of how they do that, so it's a good question to ask and keep in mind; absolutely.

MEMBER SIEBER: Okay.

DR. KESSLER: So with, primarily, the demise of Yucca Mountain, we recognize that there was a need for international collaboration. A lot of people were doing, more or less, the same thing. The idea is simply to share information as much as we can inside and outside the U.S.

Are there common technical issues for future technical work? In a large number of cases, yes there are, and the idea was to identify specific industry needs and regulatory needs for R&D. So two and a half years ago, or so, we launched what we call the extended storage collaboration program, and I think it was Bob Einziger who first dubbed it ESCP. So we now we finally just refer to it as the ESCP program.

It's comprised of the people you see there on the view graph. We have quite a few people in the U.S.; vendors, NRC, DOE, utilities, that are all part of it. And you can see the various kinds of organizations across the world that are involved. Our membership keeps growing because of the commonalities of the issues that everybody faces.

Here's our mission statement for ESCP. Provide technical bases to ensure continued safe long-term use fuel storage and future transportability. That's what we all agreed to. You know, extended storage is the first part and then, is the fuel transportable after some period of extended storage?

It is modeled after that initial work that was done at Idaho.

CHAIRMAN RYAN: Sorry, John, just for clarity's sake. This transportable layer, there's two components to that and I'm going to, just for the record --

DR. KESSLER: Sure.

CHAIRMAN RYAN: -- make sure we're understanding what you mean.

DR. KESSLER: Okay.

CHAIRMAN RYAN: And I think one is, what shape is the fuel in.

DR. KESSLER: That's right.

CHAIRMAN RYAN: So clouding, degradation, all those kinds of things come into play, gas, rupturing, whatnot.

DR. KESSLER: Right.

CHAIRMAN RYAN: And then the transport unit is, you know, kind of the more standard put it on the road and crash it into stuff or have stuff crash into it.

DR. KESSLER: Exactly. Right. The mechanical integrity of the whole system and then there's the mechanical integrity of the fuel.

CHAIRMAN RYAN: I just want to make it crystal clear that you're looking at both components, the package and the contents, as a system.

DR. KESSLER: Absolutely.

CHAIRMAN RYAN: Okay. Thank you.

DR. KESSLER: There is a lot of focus on the fuel, but there is increasing focus on the rest of the system and you heard a bit from Jim and Bob on that.

CHAIRMAN RYAN: Yes. Okay.

DR. KESSLER: Yes. Good clarification. Thank you.

DR. KESSLER: Thank you.

MEMBER SKILLMAN: For this program, what are the rules for admission and how often do you meet? And who runs it?

DR. KESSLER: The rules for admission is, you have to be actively working on, or planning to work on, extended storage issues. If you've got funding, that's something that we want to have you do to be included. In terms of who runs it, EPRI is kind of the coordinator, but in a sense, it's self-run.

We provide meeting space and if there is a need to publish something jointly, EPRI volunteers to publish it for people, but it's really self-run in the sense that we have subcommittees. Jeff mentioned we have an international subcommittee that's run by some volunteers. I'll talk about some subcommittees here in a second.

But it's basically people who have an interest in a particular area that run, we just try to, you know, facilitate it all happening.

MEMBER SKILLMAN: Thank you.

DR. KESSLER: Okay. So three phases for the program. Phase one, we're pretty much done, are these gap analyses. What data do we think we need to establish extended storage followed by transportation? Phase two is where we're getting ourselves into, which is conducting the experiments, field studies, and additional analysis to address the gaps. You've heard some from Jim and Bob, as well as Jeff, what's going on.

And then phase three is getting into what I'd say are more the field trial stages and the field inspections that we're starting to think about now. I mentioned the subcommittees, here are the six subcommittees we have now. So you can see, we focus on various parts of these storage systems in terms of specific degradation mechanisms, or in one case, the confirmatory demonstration that I'll talk about a bit more.

Highest priority items, this is me summarizing from a couple different reports that you heard about earlier. Welded stainless steel canisters, stress corrosion cracking is at the top of, essentially everybody's list. For high burnup cladding, it's the hydride effects, the reorientation and embrittlement.

And I would argue that one view graph that Jeff showed isn't atypical of what high burnup fuel may look like; decent amount of hydrides, but still circumferential. The issue is, when you heat it up and apply stress on it, do those circumferential hydrides turn into radial hydrides that really would start decreasing the ductility?

So that example was fairly high burnup,

but not atypical. Okay. So we're interested in those issues. Bolted casks, you heard, corrosion of bolts, embrittlement, and degradation of the bolts, and then fuel pellet swelling that Jim talked about.

MEMBER ARMIJO: Do you have any papers that describe and provide something quantitative on the fuel pellet swelling at those kinds of temperatures as a function of time?

DR. KESSLER: EPRI doesn't. There's a lot literature out there that I think even NRC is kind of pulling together. You know, the amount of --

MEMBER ARMIJO: Are there any papers, key papers, that you cite in your -- to justify this is a significant issue?

DR. KESSLER: That one's an NRC one, so you should ask NRC.

MEMBER ARMIJO: I will.

DR. KESSLER: I know some of the work that they've cited is a guy named Vincenzo Rondinella at ITU in Germany, who's done a lot of work on how many, you know, alphas you'd expect that would turn into helium gas that causes this internal pressurization. That's just one example of R&D that's been out there.

MEMBER ARMIJO: Right. But, you know, as far as a, kind of, systems analysis of --

DR. KESSLER: No.

MEMBER ARMIJO: -- the pellet and how much helium is there compared to how much helium is in the gap anyway, plus other fission gases. All these other things --

DR. KESSLER: We haven't done it, but I think NRC probably has as well as these other organizations, so you'll have to ask them.

MEMBER ARMIJO: I'll just ask the staff to get me that because I think we need to understand that because that's what's driving everything. That's where the stress is coming from, unless there's some other source. And if that's a strong case, that's okay, but if it's a weak case, we'd like to understand it.

DR. KESSLER: Right. That's, essentially, a different mechanism than, of course, the irradiation hardening ones that effect all kinds of different materials. But, yes, this one where you actually cause, you know, the amount of helium being generated from alpha decay. That's the primary one that NRC and some others are interested in as a potential mechanism that needs more data; that could be important.

MR. EINZIGER: Sam, I'll get you some references.

MEMBER ARMIJO: Yes. I'd like to read --

MR. EINZIGER: It's all unpublished at this time and it's all very weak. It's enough to wet your appetite, but not to feed you.

MEMBER ARMIJO: Okay. Thanks, Bob.

DR. KESSLER: Well, thank you, Bob.

MEMBER ARMIJO: I'll read it. But, you know, that's, to me, a key thing. If you can show that you do have sufficient swelling to drive the stresses and cause hydride reorientation, that's one case, but if you don't have swelling and somebody's really creating a mechanism that might occur at a higher temperature, but just isn't going to do anything at this temperatures, then you ought to take a critical look at that before you launch --

DR. KESSLER: Absolutely. And then there's also the question of when the swelling occurs. For example, in this mechanism, the swelling occurs over, Jim mentioned, I think, a 100 years or more, and by that time, temperatures are pretty low, whether that actually causes hydride reorientation or it's just the, you know, increased stresses --

MEMBER ARMIJO: Yes. Nothing's mobile. You know, everything is --

DR. KESSLER: Well, that may not be the

issue in terms of what could fail the cladding then, but again, you'll have to ask NRC later. Cross-cutting needs, again, I've summarized the ones that we've seen --

MEMBER ARMIJO: John, since you represent the industry to some extent, the issue of welded stainless steel canister chloride stress corrosion cracking --

DR. KESSLER: Right.

MEMBER ARMIJO: -- is such an old issue and our canisters are not just one weld, we have a double weld, right?

DR. KESSLER: Just for the closure lid.

MEMBER ARMIJO: The closure lids, there's a weld underneath the closure lid --

DR. KESSLER: Right.

MEMBER ARMIJO: -- that'll protect it from the --

DR. KESSLER: The body of the canister, though, is a single weld that's not stress relieving.

MEMBER ARMIJO: The body, which you're talking about, the axial welds?

DR. KESSLER: There is longitudinal welds when you create the cask cylinder. They're rolled from flat plates; 5/8-inch thick 304 or 316.

MEMBER ARMIJO: Okay.

DR. KESSLER: So there are longitudinal seam welds, and there are usually four plates so that you have one circumferential weld. Those are --

MEMBER ARMIJO: Okay. Those are the welds you're most worried about?

DR. KESSLER: Those are the welds we want to look at -- I'll talk about it now. The reason is, it's the outer closure weld, but there's an inner one also that's protected by helium, so it's a fairly inert atmosphere. The out closure weld and the seam welds are the ones that are exposed to the atmosphere and may have some amount of salt deposition from, you know, salt air being drawn in through the air inlets.

And that's the part where I hear you. We know a lot about stress corrosion cracking. What we don't know is, do we have the temperatures we think we need? Do we actually have sufficient deposition to drive the reactions the way we need to initiate and go with this?

So it's not so much what are the mechanisms, but do the conditions occur? And that's the part that we're trying to get some --

MEMBER ARMIJO: You're always going to have uncertainty in a situation like that.

DR. KESSLER: Well, given that we have very little data now, we're going to, but the idea is to reduce that uncertainty by going out to the field and getting some.

MEMBER ARMIJO: And these canisters were made for Marine Environment Service without any attempt to reduce the residual stresses on the welds exposed to the marine environment; no annealing, no stress relief, no --

DR. KESSLER: No annealing, no stress relieving. Those are things that we're about now. I think the idea was is that when these systems were designed originally, the thinking was, these were not canisters that were going to be in service for decades and decades like we're thinking about now. And in addition, it was some mechanisms that I think industry hadn't thought about back when they were being designed; or NRC for that matter.

And so now that things are cooling down and we're recognizing what environments they're under, it's becoming more recognized as an issue that we need to address and look into, at least to begin with. So I think that's the history behind, you know, why is it that industry didn't do something regarding, you know, potential stress relieving of the welds?

MEMBER SIEBER: Is there suspicion at this point time that some old canisters will have to be discarded and fuel moved to newer packaging?

DR. KESSLER: Suspicion? There's a concern that we may have the right set of conditions to support stress corrosion cracking.

MEMBER SIEBER: At some locations.

DR. KESSLER: Right, at some locations, and hence, the inspection of Calvert Cliffs, followed by a couple more that I'll try to go through here, in terms of what we'd like to do just to put it all together. Do we think we've got the right temperature, and salt, and stress conditions to cause stress corrosion cracking based on the separate effects testing in the lab? What do we actually see out in the field? Do they match up?

And then start to get information about what are the temperature distributions? You know, how much salt do we have? To start putting together an industry-wide picture that would feed in, ultimately, to an aging management plan, which is where we want to head with this eventually.

MEMBER ARMIJO: Well, how are you going to know what the stress is on these seam welds?

DR. KESSLER: Separate tests. One of the

things that we're trying to do is get some prototypic welds and go and measure the residual stresses; or calculate them.

MEMBER ARMIJO: No, I'm talking about the casks that are actually out in the field.

DR. KESSLER: Right. We want to --

MEMBER ARMIJO: How are you going to measure the residual --

DR. KESSLER: In the field, we're probably not. What we need to do is figure out -- get some samples that were welded under the same conditions. We know what the specs were, we know how many passes were required, you know, what kind of inspections occurred during each pass, so we have some idea of what kind of residual stresses we've got.

Okay. Then we can go --

MEMBER ARMIJO: Do you know if they were solution heat-treated after the axial welds?

DR. KESSLER: I'm not a welding guy. I'm sorry. I can't answer that question. Bob Einziger is back there shaking his head no.

MEMBER ARMIJO: The answer is they were not or you don't know?

MR. EINZIGER: No, they were not.

MEMBER SCHULTZ: And you don't have any

archived samples from welds that are --

DR. KESSLER: I think there are some, and that's one of the things that we're actually trying to look up now. In fact, Jeff Williams has got some funding; some universities that are looking into this too. So there's a couple of us that are trying to go after just this issue. You know, what are those welds? How are they made? What are the residual stresses?

And then we'd like to tie that back to what we're seeing in situ, and then what kind of experiments have been done to say, you know, these are the conditions to support it or not. So we're trying to paint that whole picture.

MEMBER SKILLMAN: What will your path forward be if you do this work and determine there really isn't any degradation and there really isn't any stress corrosion cracking of significance? What will you do?

DR. KESSLER: I think the idea is, what's an appropriate aging management plan as these systems sit there near the ocean, or wherever they're sitting, for, you know, each additional potential licensing period that the utilities might go into NRC with?

So the idea is, okay, can we say that we would expect stress corrosion cracking to be supported when we achieve this set of conditions, okay? That some combination of temperature, residual stress in the welds, salt content on the surface, et cetera.

And so then if we can do all the appropriate measurements to say, we know, roughly, when those conditions will all come together we can say, we'll measure all those things externally, and now as we get close to when we think those conditions will support stress corrosion cracking, now we've got to do something more. We've got to go do some kinds of inspections.

So the initial work will help us define what's an appropriate aging management plan in terms of what it is we have to go monitor and then when we may have to get more aggressive about inspections. You know, so essentially, we're at step zero or a half in terms of trying to collect the data now; field data I'm talking about. Lots and lots of experimental data and aqueous data, less on atmospheric corrosion and almost none in situ.

Okay. I'm going to skip this because I need to get on to the two main field trials. Jeff and Jim both mentioned this. We are grateful for this PNNL that DOE funded to do some thermal modeling of that particular Calvert Cliffs canister. We're going to go measure surface temperatures on the canister, and we'll see if the PNNL models are right, and at least it will provide some benchmarking data.

It also helps us determine where we want to take samples, so thanks PNNL, already, for providing that thermal analysis.

MEMBER ARMIJO: Is that a best estimate analysis?

DR. KESSLER: The PNNL one is. That gets back to one of your questions earlier about -- the industry models tend to overestimate temperatures, which was great for making sure your peak temperatures didn't exceed 400 during drying. But is it the wrong direction for when do these potential conditions supporting stress corrosion cracking, when would those occur?

You tend to over-predict. You know, you predict it would happen farther out in time than it might really happen if you had a better estimate model. So best estimate models help on both ends in the sense of getting us a better idea of when things, or to what extent will things, happen.

My opinion, the better estimate heat transfer model helps during drying, because it may be that only a small fraction of the cladding, even for high burnup, gets anywhere near 400 C during the drying process if we actually did best estimate calculations. And that'll tie back into this demo program that we're thinking about that I'll try to get to here.

Okay. Yes. Various examples of the kinds of testing that's already underway. I'm going to skip this, other than just to point out, there's a lot of work that's already underway, both in the U.S., and especially outside the U.S., on some of these particular mechanisms and components of the system that you've heard about earlier.

MEMBER SCHULTZ: John, general question there. Where do the schedules of these separate components converge? In other words, when we look at the modeling in the laboratory testing program that is underway, are we looking at a horizon of two years; one year, two years, three years?

DR. KESSLER: Again, it's a question you have to ask each organization. This is what's the benefit of sharing these gap analyses, you know, what data do we need and what are the priorities on getting the data? We have reasonable good consensus on both the gaps and the priorities. I'm kind of dancing around answering your question because it depends on who's funding it.

I know that, for example, BAM in Germany, CRIEPI in Japan, are doing some really nice ongoing work on seals in bolts that I would guess is going to be done in three years or less. There is other work, what are the conditions that support stress corrosion cracking? That's been going on. I expect more data to be done in the lab over the next two or three years.

The field inspections, we're planning to do a total of four, maybe, over the next two years and then we'll see what we get, you know? Depending on what we see, maybe four will be nearly enough or maybe we're going to have to inspect a whole lot more. That'll take us quite a few years.

The high burnup demo, I'll talk about the schedule for that one, but anywhere from two years to, maybe, five to ten years in terms of time frames when we get some information. And for the full-scale demo, we got to load it, let it cook for about ten years, and then reopen it. To get all those data, you're talking 15 years or more before those data are available.

CHAIRMAN RYAN: John, you were doing good, but you're falling behind.

DR. KESSLER: Yes, okay. All right. Thank you. Okay. Let's get into field inspections. We talked about stress corrosion cracking. I'm going to skip that. All right. On to what we're doing. Right now, June 28th is the magic date that Calvert Cliffs will be the first one to go in and visually look at the surface of the canisters, specifically for signs of corrosion and stress corrosion cracking.

Why did we pick Calvert Cliffs? Well, first and foremost, their license was coming up for renewal and they had to do some inspections to support NRC's requirements for license renewal. They were kind enough to volunteer up a second canister that may be one that's more in the right conditions for stress corrosion cracking, which is, it's old enough, so it's had some time to accumulate salt, if it is accumulating salt.

That means it's going to be colder conditions, and again, something that may support stress corrosion cracking. So they're going to do visuals on both and then we're going to do a bit more on the lower temperature canister.

MEMBER BLEY: Do you know how they're doing the visuals?

DR. KESSLER: A boroscope camera and I'll show you a cartoon or two of, roughly, where they're going to shoot things through. So I mentioned visual, we're also going to take some surface temperature measurements of the canister, and then we're going to try to get some samples of surface contaminants just to see what we've got; dust, salt, whatever.

MEMBER ARMIJO: By visual, what kind of magnifications are you going to use?

DR. KESSLER: Oh, goodness. I don't know that number, but I can tell you --

MEMBER ARMIJO: If you can see it with the naked eye, you've got big problems.

DR. KESSLER: I can tell you that from three feet away, they could see the eyeballs of a black widow spider that was done at one corner of --

MEMBER ARMIJO: So they have a magnification capability.

DR. KESSLER: They have a pretty good magnification capability. We're hoping, but not promising, they can see pretty far into the crevice. This is a horizontal system that sits on stainless rails. It'd be nice to see into the crevice as much as we can, but primary thing is to take a look at those circumferential and longitudinal welds.

MEMBER ARMIJO: Do you have good fabrication history information on those canisters?

DR. KESSLER: Yes.

MEMBER ARMIJO: So you know that they weren't made with a pristine press procedures that I would --

DR. KESSLER: Exactly. In fact, we have this one, the cold one, we have visuals of what it looked like, because they did some demo work with it initially. So we have photos of what it looked like when it came out of the shop, essentially, and you can't see yourself, like, in a mirror, like some of the other manufacturers.

MEMBER ARMIJO: But you know it wasn't post-weld annealed? There was no attempt to polish the welds or anything like that?

DR. KESSLER: Not sure, but we do have that information.

MEMBER ARMIJO: Okay.

DR. KESSLER: I just don't know it, but I know that those data exist. So we know how it was made; we know what the criteria were.

MEMBER ARMIJO: The reason I'm pressing on this is that the state of residual stress at the surface of that canister is entirely dependent on the way it was fabricated.

DR. KESSLER: We know that.

MEMBER ARMIJO: And if you don't have that information --

DR. KESSLER: We know that.

MEMBER ARMIJO: -- I don't know how far you can take the findings, good or bad --

DR. KESSLER: I hear you. It's one of those things that if we can't correlate up the residual stresses, the amount of salt, the humidity, the temperature, all of those things together, then it's going to be hard to develop an aging management plan we can rely on. So absolutely, we need to know what the residual stress distribution are of those welds and that is part of both industry's testing program, and you heard from Jeff, part of what DOE's going to be looking at too.

So, yes, that's, you know, in the books to do some work.

MEMBER SKILLMAN: It could be that your crumbiest looking cask is the one that has no stress because it hasn't been polished and the welds have not been affected. In fact, the thing may have been crimped in position, the welds nothing more than a cosmetic seal, and there is no stress.

DR. KESSLER: We don't know. We'll find out, at least on some of them. And then we are thinking about, in the longer run, can we measure, in situ, residual stresses, but that's down the road, because that's a little harder to develop.

Okay. Back to this picture that's similar to the one that Jeff showed. I actually like Jeff's better because he showed one of the analyses of that PNNL work. So this is kind of a see-through view of this Calvert Cliffs new homes, the new tech horizontal module system. You can see the canister laying in there sideways. You get kind of a cartoon of the longitudinal welds and the seam welds.

The closure weld is, I think, at the far end. What's important, this is natural convection, so you see the air inlet in the bottom left coming in underneath, and the two air outlets at the top. For visuals, the plan is to put this boroscope, essentially, on a glorified stick, bring it in through the air outlets, and see what they can see.

Apparently they can see a good chunk of the canister's surface just by going through the air outlets. I mean, the surface dose rates on the canister surface are in the 1000 to 10,000 R an hour. So that means you got to do things pretty remotely and that limits what we can do.

Then I think I may have it in the next one. Yes. Good. That's for the visuals. For the surface temperatures and the salt samples, we're actually going to go through a 3/4-inch gap between the entrance to the module and the outside of the canister, and slide a tool, and place those Salt Smarts that Jeff had in one of his pictures, along with a thermal couples at various angular locations and locations along the length of the canister.

And start getting the information on the distribution of how much salt we see and the temperatures to start putting some of these pictures together in terms of everything that we need to assess whether we should or shouldn't have stress corrosion cracking, and that, of course, goes with the visuals.

There's a picture of the Salt Smart again. We have a backup system we may use where, essentially, we're taking a scratch pad with a vacuum cleaner to try to pull up the dust too as a backup for the Salt Smart system, and we'll see how much of it we get to because the rad protection folks at the site are being real sticklers on how much dose we're allowed to get for this research activity on top of the other things that are going on.

CHAIRMAN RYAN: How much are we allowed to get?

DR. KESSLER: 75 to 100 person millirem.

CHAIRMAN RYAN: For?

DR. KESSLER: For the whole inspection. So we're having to make sure we get our guys in there, put it on there, and get out of the way. We've gone through dry runs two weeks ago to try to get the technique down to minimize their exposure.

CHAIRMAN RYAN: Okay.

DR. KESSLER: But that will limit, you know, how many data points we can collect when we hit that limit. Okay. On top of all of that, if we'd like to do a correlation to how much salt we see on the canister versus how much salt is in the atmosphere and how long it's been sitting there, we need to figure out how much salt there is in the atmosphere.

MEMBER BLEY: You going to do this over some extended period of time?

DR. KESSLER: Oh, yes. At least a year.

MEMBER BLEY: Okay.

DR. KESSLER: To get some sort of annual average salt concentration that we can then correlate back to the canister surface.

CHAIRMAN RYAN: Are you happy with a year being enough data?

DR. KESSLER: I'll take what I can get. We have some data that's already archived at Calvert. Some sites do it; some sites don't. We'll do what we can.

CHAIRMAN RYAN: Are you going to try to pool data or do the best you can --

DR. KESSLER: Right. We've already put some data out that's been collected, like, by NOAA and other folks. It's not right at the site, but we'll cobble stuff together and run, you know, these kinds of in situ devices for as long as we can with the money we've got.

MEMBER BLEY: I guess, with Mike's question, you know, when a hurricane comes close to one of these guys, you get a lot of salting up of lots of equipment, which means you must get a lot of salt deposition around these. And without a major storm like that, that's a big gap, I think, in the information.

DR. KESSLER: It's a good point. Clearly, if it's the once every ten years storm that provides the majority of the salt, we're going to miss it if that's the case. I think we probably have enough idea -- we have to bear that in mind.

MEMBER BLEY: Yes. I suspect you can get information on that kind of storm from some other place.

DR. KESSLER: Well, and then we can also go and see how people calculated averages, temporal averages, anyway and how much these affect things. That's literature mining we have yet to do, but it's a very good point.

Okay. I mentioned the inspection schedule. They're going to do the visuals on June 27th, weather permitting, and then the temperature and salt measurements on the 28th, and then the environmental monitoring will get going at a later time.

I mentioned we're going to try to find some more volunteer to do some of these inspections. There's the criteria. Right now, we have seven utilities that have expressed interest, I think five of them have sites on or near the cost, so I think we've got some people to talk to lined up to do the additional inspections.

We have some inland sites if we need them. So in terms of volunteers, they're getting lined up for additional inspections. And as Jeff mentioned, for the ones past the Calvert one, DOE will be providing co-funding to do some of these inspections, so that's great.

Okay. Next subject, on from inspections on to this confirmatory demo. The idea of, can we open something up and look at what's going on inside?

And the idea is, take some sort of full-scale cask, load it with higher burnup fuel, instrument, a lid that you're going to put on this thing for, say, temperature and gas analyses, take those temperature, and take gas samples from time to time during the drying process and during this, say, ten-ish years after that, and then move the cask somewhere, take the lid off, pull some rods out, maybe some assemblies out, and see how much they've changed.

And then take a look at, maybe, not just the cladding, but the spacer grids, as was talked about earlier, take a look at, you know, has there been degradation of any other cask internals. So that's the idea of what's going on in terms of what we'd like to do.

All of that is to confirm, in a sense, the separate effects testing there that you heard Jeff and Jim both talk about. They'll have the laboratory scale or the sub-full-scale kind of testing that you use to generate the majority of you data, we need to have a couple of these confirmatory demos to say that those test conditions are the right ones, like Bob was talking about earlier.

And so in our view, a full-scale confirmatory test is going to be needed over some time period. So we're looking for, you know, higher burnup systems, things like that. We're looking for volunteers. So here's the objectives. One of the big issues is right here, avoid re-wetting the fuel after initial loading.

This is that issue about if you open and close it, is that going to mess up the properties of the cladding? That is a concern and DOE is proposing to do some work to assess what impact of, say, instead of being able to open the lid in dry conditions so that there's not the thermal shock, maybe you have to bring it back into a pool.

All right, how is that going to affect what you see for cladding properties, and then, if you have to re-dry it and put it out there for another ten years, how much loss of information based on true prototypic conditions do you get? That's a thing we have to work through.

Right now, the goal would be, with everything dry, but we don't have a facility in the

U.S. that can handle a full-scale cask in dry conditions to take the lid off. That's going to be something that will have to be constructed either at a national lab or who knows, maybe at some consolidated storage facility some time down the road. It will be part of the facilities there.

Okay. For this demo, there's quite a few steps. Before we get this thing going, we need to have initial data, which is, what's the condition of the cladding at T=0, before you get things going? And I show the T=0 data for the rods.

Profilometry, the cladding properties, which I have listed there, then we've got to modify that existing cask to put a special lid that includes the thermal couples and the gas samplings, load the cask, and then place the lid.

And even before we've let it cook for ten years, we're going to get good temperature data that we don't have now and we're going to get gas sample data for krypton-85 to see if we've got leaks that are occurring during storage. Oxygen, do we have oxygen in there? Water, it's that question earlier about how adequately are the casks dried?

We can measure how much humidity there is in the air and get an idea of how much water there is.

So all those data will be coming during that storage period. And then after so many years, we'll open, remove some rods, we'll visually inspect them, and then compare them to the T=0 data, and we may look at some of the other cask internals.

MEMBER ARMIJO: John, could you go back to that chart?

DR. KESSLER: Ooh, geez. Can I go previous? Ooh, look at me.

MEMBER ARMIJO: Yes.

DR. KESSLER: Okay.

MEMBER ARMIJO: To get the hydrogen content initial hydride orientation --

DR. KESSLER: Yes.

MEMBER ARMIJO: -- you actually will take out some fuel and do some destructive examination?

DR. KESSLER: Yes.

MEMBER ARMIJO: Okay.

DR. KESSLER: Yes, from sister rods or maybe even from the same assembly. We may pull a rod or two out of the actual assembly that will go into the demonstration cask. And then perform destructive exams on those claddings, yes. So, yes, that's the idea, or we'll find some other assemblies that have the same irradiation history, you know, from some other, you know --

MEMBER ARMIJO: And you will purposely select high burnup fuel that probably has a high gas release or, you know, we have this variable of the cladding material --

DR. KESSLER: Exactly.

MEMBER ARMIJO: -- and how much hydrogen pick up there is, whether it's Zirc-4; insert that.

DR. KESSLER: Yes. And one of the reasons why we like a particular demo, which is one that Transnuclear and Dominion are proposing, is that it would happen at North Anna, where Dominion is volunteering to start this demo at North Anna. They have M5, Zircaloy, and Zirc-4 all in the 50-plus gigawatt day per metric ton burnups.

So they've got three different kinds of fuel, admittedly, it's all PwR fuel, but three different kinds is probably about as good as we're going to get at any individual site. So we've got TN who's willing, probably, to reduce costs to provide two casks as part of this.

And what's nice about it, given that it can be started at North Anna rather than waiting for one of these dry handling facilities, it can probably be started in, maybe, three to five years. And where we're at now is, EPRI is just about to initiate funding for TN with Dominion's help to start designing what this lid should be.

We're going to work with DOE and others in terms of what kind of testing should go on? We'll certainly involve NRC in terms of what kind of tests should we do? Where are these thermocouples going to be located; et cetera?

And then we're going to be looking for co-funding, and right now we're talking to DOE, but, you know, between EPRI, and D-TN, and Dominion, and maybe DOE, we're hoping to pull together the funding to get this demonstration going, say, in the next three to five years.

Ooh, only a couple minutes over. Sorry.

CHAIRMAN RYAN: You're going good, John. Any questions for John; additional questions?

MEMBER SIEBER: Is there an opportunity for you to discover that as a cask deteriorates, that fuel inside is deteriorating at even a faster rate, so repackaging becomes a very difficult situation?

DR. KESSLER: It would happen through the demo program where we would see what happens with the cladding. Some of the separate effects testing, we would get an idea of how rapidly the assemblies might degrade in the presence of, say, water, or oxygen, or something like that, so there are opportunities.

MEMBER SIEBER: I think it's important to keep in mind that the packaging may deteriorate at a rate slower than the fuel inside, depending on the conditions that it's in. And from a safety and economic standpoint, it'd be good to know that.

DR. KESSLER: Yes. Good point.

CHAIRMAN RYAN: Any other questions for John? Stephen? Anybody else? John, thanks very much. It was a great briefing.

DR. KESSLER: Okay.

CHAIRMAN RYAN: All right. Next up, Rod, your turn. Fire away.

MR. MCCULLUM: Yes, I want to thank the committee for the opportunity to speak here today and I will try to address some of the regulatory perspectives from the industry viewpoint that on this issue, much has already been said about the R&D.

I do want to say, in addition to thanking the committee for the opportunity for me to speak, I thank the committee for looking at this subject. Extended storage is a reality. I know Jeff says I tend to blame him for, you know, the conditions, but the fact of the matter is is that, the Department of

Energy has made policy decisions which mean that we will be storing used fuel for an extended period of time, whether it's at consolidated sites or existing reactor sites.

You know, as we address this challenge and try to figure out what it means for the regulator and the regulated, we need to do so in a stable, disciplined, and risk informed manner. This subcommittee, and its expertise, and its independent views will be, I think, very valuable towards helping shape that going forward.

And certainly, from what I've heard this afternoon, you have not disappointed me in that regard. You are all asking the right questions and I would encourage continued focus on this. To start out here, this is a slide that kind of gives some more data behind something I think that Jim already mentioned earlier this afternoon, that we have 1500 casks out there; anticipated to double that number by 2020.

This is really -- and it's in a lot of different locations, obviously. The point of showing this here, and it's useful to keep in mind as I go through the regulatory perspective, it talks about the scope of the challenge before us and I think it says two things.

First of all, obviously, it says that dry cask storage is probably the most recession-proof business in the country. And the second thing is, we have a lot of experience with dry cask storage. Some of these casks have been out there for more than 20 years. There's a couple places where we've been through our first renewal already.

They are successfully performing their safety function. You know, as we look at some of these degradation mechanisms that we've been talking about here and trying to prioritize where the needs are, it's not that we expect things to be going wrong on some time period, but it's that we need to conduct a focused research so that we can further confirm the confidence that our experience has given us, as well as extend that confidence out over greater periods of time.

To put a slightly finer point on that graph, I've broken some of these numbers down. I apologize for the grey area on the right-hand side of the chart. That simply means that NEI wasn't gathering data at that level of granularity over those years. But the point of this slide is, as you can see, we only had two ISFSIs for a while, for the first three years, back in the 1980s, and very gradually added ISFSIs.

And you can kind of extrapolate to the number of casks. It somewhat follows the number of ISFSIs. So that we have the opportunity to learn from our experience at a very few sites before we have to address the challenge, you know, on a very large industry-wide basis.

And I think some of the things that we've talked about already from the cask that was opened at Idaho, to the demo project we're setting up now at one of those first two ISFSIs that was licensed, will help us do that. And I think Bob Einziger said it best, we want to stay ahead of the curve. This is the curve we need to stay ahead of.

Again, we've got a strong basis and confidence in safety, it's about confirming that. You know, and I really appreciate some of the questions I heard to day, you know, do you really expect this to happen? Well, no, we don't, but we're going to go chase these degradation mechanisms anyway so that we can run it all to the ground and further verify that.

In summary, on the basis for safety, there's a lot of things out there. Again, these are very robust systems with no moving parts. You know, stepping out, you know, it's been mentioned in the marine environment, there's a lot of things in marine environment. We have a lot of, you know, experience outside just dry casks.

We have all kinds of structures and systems that exist under all kinds of conditions. Maybe not the exact same conditions that we are looking at here, which is why we're doing the demo and the other inspection work, but we have a lot of confidence that systems way less robust that this, in challenging environments, can last for extremely long periods of time.

So given the very nature of what these things are, the confidence starts there. That and, you know, I won't try to go backwards here, but when we were renewing those first two licenses, we did get a lot of information and those licensees had to make the case to the NRC, and did successfully make the case that an extension of the license to go from 20 years to now 60 years, because originally, it was, you know, you had 20-year terms, you get a 20-year license with 20-year renewals.

Now, NRC has amended the regulation, based on what it learned from those first renewals, to allow 40-year terms. And the question was asked earlier, I want to come back to, you know, what is extended storage? You know, and I think Jim put a really good point on it, he says, we're talking about the second renewal here.

You know, we have a strong basis for the first renewal, so some casks got a 20-year term and are going to get a 40, some will start with a 40 and get another 40, so basically, extended storage begins somewhere between 60 to 80 years, depending on what cask you're in.

So again, you look at that curve of the rate at which extended storage is coming on to us --

CHAIRMAN RYAN: I take from that kind of numerical example, I think that, beyond 80, 40 and 40, is there something going to be new out there, or do you feel if you get 40 plus 40 we're really kind of closing off the need to get further research, or see how things behave over longer periods of time than that?

MR. MCCULLUM: I personally don't expect much or anything new at all. I think what is is, we want to have data, again, staying ahead of the curve. We want to have leading data, so that when we get to that point, you know, the regulatory process is, it should be very rigorous and it's not based on, you know, elicitations of opinions, it's based on data. It's based on what we know.

And so while we have time to contemplate extended storage, industry is moving with a great sense of urgency on some of these programs. And we're moving, as I'll talk about in a minute, some great expectation for DOE to help us fund those programs.

The waste confidence rulemaking examined, again, the large population of information that is already known, concluded that studies perform to date have not identified any major issues with the long-term use of dry storage. Probably one of the most important data points I have is, the EPRI and NRC dry cask storage PRAs from 2007.

Those showed an annual cancer risk of between 1.8 times 10 to the minus 12th and 3.2 times 10 to the minus 14th, that's against a standard in NRC's risk informed decision making criteria of 10 to the minus 5, 10 to the minus 6 worker's public. That tells me there's a lot of safety margin here.

So we're starting with very robust systems. We've got a lot of safety margin. We have a basis of experience. We have other things out there we can compare them to and now we're doing focused research on those very systems. The mantra for the demo project, real data on real fuel in real casks.

Certainly believe DOE should, within the next 10 to 15 years, develop the capability to open casks in a dry environment, whether it be at a consolidated storage facility or at one of its existing labs, and that almost becomes a political question, not a technical question.

So within these parameters we have the opportunity, and as I say, industry is very aggressively pursuing these opportunities.

CHAIRMAN RYAN: Just a little extra point there for the members benefit. The cancer rate in the United States right now is between 0.2 and 0.3.

MEMBER SCHULTZ: But admittedly, the studies done in 2007 weren't focused on extended storage. They were focused --

MR. MCCULLUM: No, they weren't on storage.

CHAIRMAN RYAN: No, I'm just pointing out there's 14 orders of magnitude between actual cancer rates and what they calculated.

MR. MCCULLUM: But it tells us that we can tolerate a certain amount of degradation before -- you know, there's some safety margin out there and we haven't seen degradation, you know, the doses at the site boundary due to dry cask storage in 1500 cases are zero, you know, over quite a few years.

So I'm not trying to take credit for that same level of risk 80 years in the future. I'm just saying we've got a long way to go from that level of risk to a level of risk that is something we really need to be frightened of.

And so, again, that's why I encourage, let's look at this in a risk-informed and disciplined manner. And focus on what we know as well as what we are trying to confirm. This, basically, has been talked about, and I went back a few weeks ago and actually looked at the report from the INL project. We got a lot of data out of that.

And we didn't plan that data in advance. It was kind of done on the, okay, well, let's open up an old cask that had been out there 15 years. And we did a lot of examination of the fuel that was in there. Yes, it was low burnup fuel. Now we have the opportunity to do that on a preplanned basis.

So the demo project that we're doing, hopefully, at Dominion and TN with DOE's funding help, although industry is putting some money into this, you know, we're going to choose a challenging population of high burnup fuel, we're going to be able to get data real time and not have to wait 15 years for the data because we're going to have an instrumented lid, as John said, so this is going to be, I would say, orders of magnitude, a better demo than the one we had.

And the one we had has gone a long way to informing license renewals up to this point in time. And I think we'll certainly have that data and this is why we're treating it urgently. I mean, this is something that's been discussed at very high levels of industry; the need to stay ahead of the curve here before we get to those second renewals.

And also, to give confidence behind the licenses that are in place and give us opportunities, you know, to adjust aging management plans and put in place the contingency planning. One of the things that John did not talk about is EPRI is also working on a communications plan for, what do you do if some of these canister inspections actually find something, you know?

Going back to all the reasons why we know these things are safe, we have the opportunity, you know, if you identify some stress corrosion cracking on a canister, that doesn't mean the canister fails tomorrow, but that does mean, tomorrow, you start identifying what you're going to do about it.

And so we fully intend to take advantage of that opportunity. And one think I will also mention with respect to DOE's role in this, and I don't want to blame it all on Jeff, but we believe that the Blue Ribbon Commission report did specifically identify this area. It did talk about the need for research on extended storage in a couple different places in the report.

And the $60 million that DOE has to look at Blue Ribbon Commission stuff, some of it, very well in accordance with that report, should go there and I'm happy to report it looks like some of it is going to go there. We've had some very positive dialog with DOE, they are going to be participating in this demo, they understand why it's important to industry, and, you know, we look forward to more strong participation.

DOE has made decisions to redesign the Federal/Civilian Radioactive Waste Management Program in ways that will cause extended storage to be a much bigger part of that. With that comes the obligation for DOE to fund the work, which will continue to support the licensing of those extended storage systems over those periods of time.

And so far, the early returns are, they are beginning to warm to that task. I want to change gears just a little bit here, although it is something that has been raised in the context of extended storage.

You know, an effective regulatory process, above all, it must assure safety. It needs to focus on the more significant risk and not get distracted by the least significant risk; be risk informed. We need to recognize dry cask storage as a mature industry, benefit from all that we've done with 1500 casks, be consistent with good principles of regulation, and those include things like efficiency, and clarity, and reliability, and be implemented in a stable manner.

So as we're looking at extended storage, the challenge of what the regulations have to consider grows, it is necessary for the regulations to become more efficient. And in all honestly, I'll point out, industry's desire to make dry cask storage more efficient doesn't stem directly from extended storage. It stems from a desire that, as the industry becomes busier and we're loading more and more casks, doubling the population casks, we've got to get more efficient in the process.

We believe that the level of detail at

which licenses exist today needs to be improved. But this was recognized by COMSECY-10-07 in the context of extended storage, which also tasks the NRC staff to look at improvements in the near-term efficiency in the same vein that the commission was approving going forward looking at extended storage.

And more recently, NRC's risk management task force recommended selected guidance and rule changes to make the regulatory framework more risk informed. We heartedly endorse that report and those recommendations.

And while our motives for trying to make the regulatory framework more efficient don't directly stem from extended storage, the presence and reality of extended storage makes the need for the regulatory framework to be more efficient, much more pressing so that it can deal with the challenges that are being raised. Yes.

MEMBER RAY: You speak of the industry, rightly, as if it were an ongoing vigorous enterprise, but there are a number of parts of the industry, of course, that are legacy nuclear plant operators that no longer are as engaged as others are in the regulatory process or anything else.

Now, they still have to be licensed and so on, are they involved in this process?

MR. MCCULLUM: Absolutely.

MEMBER RAY: Portland General Electric, SMUD, people like that?

MR. MCCULLUM: Yes, the Yankees, you know, each year we host our annual used fuel management conference where we bring together the whole industry. We have, as a whole special session, half a day almost, where the decommissioned plants come together.

We have a number of task forces on extended storage and other issues. The decommissioned plants are very frequent participants in those task forces. They are as concerned about the issue of extended storage as anybody right now because it has a dual-meaning for them. There's the obvious regulatory implications, there's also the public perception aspect.

They do not want the consideration of extended storage to be viewed in their communities as a commitment to extended storage. In other words, if NRC is considering 300 years of storage, they don't want that to be viewed as the government has decided that there will be 300 years of storage.

And that's why I think the Blue Ribbon Commission recommended prioritizing moving used fuel off those shutdown sites. That's why consolidated storage is such a -- I mean, of all the things that aren't happening with respect to the Blue Ribbon Commission, consolidated storage is happening.

There's a lot of interest in that, you've seen the language in the Senate appropriations bill that's been talked about earlier, the interest in communities in places like New Mexico, although I will say New Mexico is not the only one, is extremely strong.

I know Jeff is doing some work on planning for consolidated storage facilities, but all of that means is that, we will have to deal with transportation and a fuel that's been in storage for a while. At the shutdown sites, it's been in storage for a while, and then storing it again at another site.

So that continues to support the need for focus programs in this area because the extended storage will continue to occur, it just won't occur at the same sites.

MEMBER RAY: Well, the issue of legacy liability for these kinds of operations is a real problem and nothing we can solve easily.

MR. MCCULLUM: Right.

MEMBER RAY: But if you're imagining yourself out 50 years with a liability that requires you to transfer casks that somebody filled 50 years ago into new casks, you know, you're talking about humongous impacts on --

MR. MCCULLUM: Yes, and the goal is --

MEMBER RAY: -- companies that don't have any revenue stream to match up with it, but that's a small issue.

MR. MCCULLUM: No, the goal is to avoid that. Obviously, the companies that I say are very engaged with our industry-wide efforts and one of those efforts that's at the head of the class is focusing on making sure that consolidated storage happens because DOE takes title when they move it, and these efforts do support consolidated storage.

MEMBER RAY: Well, we tried with NFS for a while. Got one in Utah, but just can't get access to it.

MR. MCCULLUM: Yes, well, it's the same political problems and, you know, I'm often reminded at NEI how I don't understand politics because it's always so much simpler to me than it seems to play out.

MEMBER RAY: And such a mess.

MR. MCCULLUM: But anyway, so right now, industry is in the process and we're in the final stages of developing what we hope to be submitting this year, which, as we go through our various industry consensus building processes, will be a petition for rulemaking to improve the efficiency.

And if the subject weren't extended storage I'd talk a lot more about why we want to make the regulation more efficient, but we want to standardize the format and content of COCs and tech specs, provide backfit protection. Basically, we want to do to dry cask storage regulation what happened in Part 50 with the standardization of tech specs there.

That gained a lot of efficiency, we want to gain the same efficiency. We think the efficiency will benefit the incorporation of extended storage. We've decided not to pursue changes to the amendment process itself. We think by standardizing, getting the level of detail right in the license, there'll be less license amendments going forward.

That's the efficiency we're looking for rather than try to make the process of reviewing too many license amendments more efficient. Again, that's kind of off-topic, but I bring it up here because it does help in our extended storage efforts.

Some things more specific to extended storage that, while they won't be part of what industry will be seeking to do this year with the staff in terms of that potential petition for rulemaking, things that we think warrant consideration, and they've already been mentioned here.

Retrievability, we talked about, you know, the extent to which you care about the condition of the cladding 80, 100, 200 years down the road, depends on the extent to which the fuel is required to be retrievable.

And currently, we have requirements for retrievability in the regulation, and I'll have some slides a little bit later talking about a developing view in industry that perhaps the canisters should be the waste form for ultimate disposal, which would lessen the need for retrievability.

Obviously, some canisters would want to go to a reprocessing facility, perhaps, and there might be a different standard for if you're loading something you think you're going to reprocess versus loading something that you think you're going to direct dispose of, but that's a long way in the future.

The point here is that, and this is where the DOE role is very big, because as DOE designs the next repository system thinking about, what is the role of retrievability and how does that play into the regulatory requirements for extended storage?

Moderator exclusion is another one. You know, if you had additional ability to assume water did not get in the package in the analysis. Perhaps, again, then, you know, the condition of the fuel inside the package might be less important and also, in the vein of the good questions that I've heard asked all afternoon here, the harmony between regulations has been raised, and that's something we're looking at is, the system has to work, and I'll talk about systems.

You know, you've got Part 71, Part 72, Part 50, you've got the transportation rules that aren't even in 10-CFR, so on down the road, industry may be looking to drive improvements in this area. As I alluded to, taking a systems view of this, and I think that's also been discussed here this afternoon.

As a minimum, you have to connect the following elements and the reason I say at a minimum and have an asterisk is, recycling is something that may also happen, but again, you know, I don't think you're going to go back and recycle all 65,000 metric tons that have been stored to date. You know, a robust recycling system might eventually get to the point where it can keep up with the new arisings.

So at a minimum, you're going to have to look at storage reactor sites, transportation, storage at consolidated sites, transportation again, perhaps, unless you, you know, if you store in New Mexico and dispose of at WIPP, I don't know if that's a second round of transportation or not, and then, of course, disposal.

And the most important thing is that you have to build this integrated system on the system we have not the one we wish we had. You know, we could unload and reload 1500 casks, because as we mentioned, you know, that's just a question of, you know, what you have to go through to do it.

Is that really a smart thing to do? Is that, you know, when you look at, I think, the next slide, well, the answer is no, and I'll get to that in a second. We do want to facilitate direct disposal if possible. That would simplify some of the challenges of extended storage.

It's been looked at before. In the 1990s there was the multi-purpose canister system. They got pretty far down the line of designing something that could be disposed of in Yucca Mountain. And because there was a lot of uncertainty at that time as to what Yucca Mountain was going to be designed as itself, that ran aground in about 1997.

With Jeff's help, well, he was involved in both efforts, but we picked that charge up again in 2005 when we had a Yucca Mountain design that was pretty much locked down at that point. We developed a performance specification and actually had license applications for a disposable canister to be loaded when Yucca Mountain was terminated and the staff no longer had resources to review those applications.

Of course, none of the 1500 casks are TADs or MPCs. Realizing that, and this is where the discussion earlier when Jeff mentioned the disposability of existing casks and I said we were on record differing with that, we filed three contentions in the Yucca Mountain licensing proceeding that were built on work that EPRI had done, documenting our belief that the existing dual-purpose systems could be direct disposed of in Yucca Mountain.

Now, if the repository isn't Yucca Mountain, will this be challenging? Absolutely it will be challenging. Jeff alluded to some of that, but this is, I think, a challenge worth considering, again, when you think about, do I really want to analyze how cladding looks 300 years from now, or do I want to design a system based on the system I have where it's not as much of a concern?

Obviously, you have to know something because there is defense-in-depth to think about, but to the extent that you can place the fate of extended storage on the canister and reduce the importance of retrievability, you do get a benefit. And here's the slide I started to jump into earlier.

You know, these are the benefits of directly disposing. You know, radiation exposure ALARA. When you look at the low risks of, you know, a canister degrading and releasing radiation versus the certain exposures you get unloading them all and reloading them all, that's not a very fair risk tradeoff.

Obviously, unnecessary costs, we do care about that in industry. One of the things that doesn't get a lot of consideration now, but is very important, because the purpose of these nuclear plants is to generate electricity and a plentiful supply of electricity is, itself, a very important, you know, public health and safety benefit.

We all depend on electricity to live our lives. You start interfering with plant operations if you're bringing casks into pools. The refueling floor, the time is pretty much booked up and we're lucky to get the loading campaigns we now do blocked off on those refueling floors, to have to then start having casks going both ways, that would start to disrupt plant operations.

And if you had to reload, now you have a whole other population of low-level waste in those canisters you just unloaded, some you might reuse, but you would have some low-level waste burden there just from the reloading operations.

Overall risk reduction, you know, the risks are low, but, you know, you are handling fuel, you are doing things that have industrial safety implications when you move these big casks around. And as I already mentioned, you alleviate the need to assure retrievability for 80, 100, 200, 300 years.

So in conclusion, we believe there is a strong basis to support the safe storage of used fuel. The 1500 casks are successfully performing their safety function. We are not resting on that, as I think John has described, and working with DOE as well. We are working on an urgent basis to address the future challenges to stay ahead of that curve.

We think that as we do that, improving the regulatory framework, bringing it up to the modern era as we did with reactors, because reactors, we're able standardize, because now they had so much experience. Well, dry casks are now standardized because we have so much experience.

And looking at the system, based on 1500 casks we loaded and figuring out what's the smartest thing to do with those 1500 casks is probably the best place to start when considering extended storage. So thank you for your time and I encourage the committee to continue to place its focus and expertise in this area.

CHAIRMAN RYAN: Thanks, Rod. Appreciate your presentation. Any questions for Rod? Hearing none --

MEMBER ARMIJO: I have a question.

CHAIRMAN RYAN: Whoops, Sam?

MEMBER ARMIJO: Yes. Let's say you do your inspection and you find stress corrosion cracks on your seaside containers. And you have a little bit of information on the fabrication history so you can guess, but not really solid information, what the residual stresses are.

What is the industry going to do then? Are you going to argue that the cracks are just surface cracks and they are not growing? Are you going to do some sort of a periodic inspection for other sites that you haven't examined? Are you going to do something to mitigate that problem?

You know, there's a high likelihood that you're going to see some cracks. That's my opinion, because eventually, you'll have enough salt. If you haven't been cleaning it off, you have axial welds where there's residual stresses, they weren't solution heat-treated, no actions taken to protect them, eventually you'll have enough of a chloride concentration built up and enough stress that, somewhere along the line, there will be some cracks.

Personally, I think they'll be very shallow and they are not going to grow, but now you've got a dilemma. You're going to have to start explaining that, and measuring that, broadening your inspection, so why aren't you working right now to look at that issue and what you would do to mitigate it, or explain it, or deal with it, because I think you guys are painting yourself into a corner.

MR. MCCULLUM: Well, the answer is, you're absolutely right, we'd have to assess the extent of condition and you're now putting us in a different context from a regulatory standpoint and we have to take action. We have to define that action and be ahead of, you know, the potential consequences of that.

MEMBER ARMIJO: Yes.

MR. MCCULLUM: And John's chomping at the bit here because that's really the essence of the communication plan that EPRI is working on and this has been called for by, you know, very high level of industry. At the Chief Nuclear Officer level they have this commitment. So, John, if you want to talk about your communication plan.

DR. KESSLER: Yes, you pretty much talked about it. We are looking into NDE techniques such that, if we see some indication, you know, some visual we are not really sure what it is we're looking at, how is it we can determine whether it is or isn't a crack, and then, yes, is it through going or not, is something that we're starting to look at.

We know that there is NDE techniques out there, but NDE techniques that maybe you have to do in situ because moving it something that you may not want to do, is something that we're looking into. How can we adapt existing NDE tools that can get in there, that can survive under these conditions? We're looking at that.

We're also starting to think about, okay, if it's limited cracking and we are not relying on the canister for a huge amount of structural integrity, can we put some sort of patch over the crack if it's limited cracking?

And we're starting to think about, okay, how would we do that and what, again, tools would we have available to get inside these systems to do it in situ? And if not in situ, then we have to think about, you know, what analyses that we have to do to move it. So we're looking through and thinking through those issues now of, what is it that we need to do?

Certainly, if we see something, we will be looking at more systems, again, to get the industry-wide extent of condition as well as the, you know, individual canister extended condition.

MEMBER ARMIJO: Well, from what I heard in these presentations, you know, you got this issue of, how do you assure a benign environment for this fuel? So a better drying process procedure to really know that there is no residual moisture or an acceptable level of residual moisture, you know, is the industry working on that?

On putting some special requirements on stainless steel canisters that are destined for seaside exposure requiring solution heat-treatment of axial welds, if that's your only -- careful control of post-weld grinding. All of these kinds of things are well-known --

DR. KESSLER: Looking at 316, something, yes.

MEMBER ARMIJO: -- good best practices. Is the industry going to do something to truncate the problem so you've got a heritage group of casks that may be susceptible, are going to give you headaches for a long time, but the stuff that's coming out the door now is built to better standards, just like we pick better materials for steam generators, or piping.

You know, it seems to me that the first time you find some stress corrosion cracks on these canisters, it's going to open up a huge mess and you're going to have to deal with it. And I think you can, but it's going to be very expensive and you probably want to see if you could use well-known good practices to cut this problem off at the pass before you just keep making more casks of the same design with the same inherent --

DR. KESSLER: Well, you've named the things that could be done, I mean, right there.

MEMBER ARMIJO: Yes. And the other thing is, I think, Einziger just told us, you're better off to start with a low temperature. If you're going to put this stuff in there, the amount of cladding degradation, all these phenomena, are better if you start at a low temperature than if you start at a high temperature.

DR. KESSLER: Yes.

MEMBER ARMIJO: There's proposals to expedite the unloading of fuel from spent fuel pools which will push you in the direction of more hotter fuel going into these casks, which is the wrong direction from an ISFSI standpoint. All of these things have to be thought of --

DR. KESSLER: And that's where risk-informed thinking is essential, because you could say, all right, you know, it's just so obvious we need to lower peak temperatures during drying, but what does that mean? Maybe we have to go to smaller canisters.

Maybe, you know, there's more, you know, other kinds of operational stipulations that, in the end, may, you know, somewhat negate, or at least have to be factored into, an overall assessment as to what you want to be doing.

MEMBER ARMIJO: Or prove that high temperature is okay.

DR. KESSLER: Yes.

MEMBER ARMIJO: Either way, but somewhere along the line, near term --

DR. KESSLER: We've been working hard at what temperatures and stress combinations are okay versus not okay. Yes.

MR. MCCULLUM: I think one thing that's important to point out here, and I really, that was a good point about what we do to truncate the problem going forward, is the competitive nature of the dry cask storage industry. It is the most competitive aspect of the nuclear business.

There's three major vendors out there. They are all intensely competitive. Once one of these cooperative programs finds anything to be worried about, every single one of them is going to be wanting to sell its customers on why their design is resistant to that problem, which means --

MEMBER ARMIJO: Shame on them for not being able to do that right now.

MR. MCCULLUM: Well, I'm not so sure they're not. Yes, I'm not so sure they're not.

DR. KESSLER: There's been a few changes of design in some cases.

MR. MCCULLUM: Yes. The designs, you know, it is truly, you know, the competitive aspect of this is what drives rapid design improvement and we anticipate that the more we learn about this, the better that'll work.

MEMBER ARMIJO: Yes. I don't disagree.

DR. KESSLER: And that's one of the reasons why, when we do additional inspections, we'd like to get at least one inspection from all three vendors.

CHAIRMAN RYAN: I think they would like that too.

DR. KESSLER: Yes.

MEMBER SKILLMAN: The constraints that will be on your inspection team at Dominion, 75 millirem is a very --

DR. KESSLER: Yes, Calvert, right.

MEMBER SKILLMAN: Or excuse me, Calvert, is a very meager budget for what you need to accomplish what you need to accomplish. So you would be well-advised to make sure that you've got the right inspection tool, that you have tested, and that you are prepared to utilize, because the question's going to be, did you use a thick enough magnifying glass? Did you encounter problems that you could have anticipated, but you didn't? And therefore, have you lost your opportunity?

DR. KESSLER: Well, let me address, and specifically, for the Calvert case. Let us treat Calvert as a first attempt in the sense that we're going to learn better how to do the next ones from this one. We're going to make mistakes so things aren't going to go as well as we'd like to have. We're not going to take as many data points before all --

MR. MCCULLUM: John, if I could interrupt. I should point out that the Calvert inspections have already been before the ALARA challenge board and, you know --

DR. KESSLER: Thank you.

MR. MCCULLUM: -- they are asking those questions. How are we going to make best use? And I'm sure that --

DR. KESSLER: Putting in temporary shielding and things like that.

MR. MCCULLUM: Yes. The feedback from that is going to help make sure that we've got to think things through in advance there.

DR. KESSLER: Right. Like, for example, this dry run they went through to make sure that you get the tools in and out efficiently. They're sitting there with stopwatches. You know, they're estimating where the dose streaming will be around the edges there and they're figuring out, you know, how many of these samples can we do? And if we're limited to how many samples, well then, which ones do we do and in what positions?

We're thinking through all of that right now just for the Calvert. And then for the next ones, yes, we may have improved tooling, more remote tooling, something like that. We know that Idaho is developing a robotic arm for, you know, one of these new home-type systems. Maybe that's something we could begin --

CHAIRMAN RYAN: Well, I'm thinking about what you just said, and I'd like to interrupt you if I may. I think too that, while the ALARA goal of 75 millirem is certainly challenging, I think if it has to be 95 in order to get the right data, that can't be closed off.

You know, 75, there's nothing magic about 75 in terms of the risk to the workers.

DR. KESSLER: You're talking to the wrong guy, Mike.

CHAIRMAN RYAN: Okay.

(Simultaneous speaking)

DR. KESSLER: Yes, but the point is, I have no idea where they're at.

CHAIRMAN RYAN: All right.

DR. KESSLER: You know, Calvert is the site, so I can't --

CHAIRMAN RYAN: Well, maybe if there's a compelling argument, that could be revisited, but some small increment that might help get the job done with an additional inspection. You know, but I would hate to see, you know, that ALARA becomes a negative of, you know, not allowing the collection of all the data you need as opposed to 80 percent of it, which is not all that great, maybe, or maybe it's okay. I don't know.

But, you know, I think you just have to balance the research plan, and the ALARA plan, and some balance to say, what's the right mixture, and it can't be because we've decided up-front the number is 75.

MEMBER SKILLMAN: Let me finish my first point and make my second point. There's going to be a high anticipation of success and that requires that there be enough practice and rehearsal under real conditions, or simulated conditions, that you've got the greatest chance of being highly successful.

DR. KESSLER: I'll say.

MEMBER SKILLMAN: The flipside is, and respecting Dr. Armijo's point, on the one hand, you may find some, or a lot, of cracking. You need to be prepared for the message that comes with that, but the flipside is also true. For some reason you should discover there isn't any, there will need to be an explanation and the explanation can't be, we didn't use a thick enough magnifying glass.

There has to be an explanation that says, you know what? It's possible that there wasn't going to be any and we've confirmed that there's not any.

DR. KESSLER: You're right. What is nice is that, we have some experimental data, which we're trying to add to, that says, these are the combination of conditions we need to support stress corrosion cracking. So if we don't see any, and the experimental data suggests we shouldn't have seen any, then maybe that's helpful, but we're not going to stop at one inspection.

We need to do more just to see whether it was just a fluke, or we didn't happen to see it, or something.

MEMBER ARMIJO: The other difficult thing when you do visual inspections, you see something, is it a crack, or isn't it a crack?

DR. KESSLER: Exactly.

MEMBER ARMIJO: Is it, you know, a weld crevice? And so you have all this problem so would you have some sort of a supplementary technique to assure yourself, this indication is really a crack, whether it's a penetrant inspection, or some other way, but, you know, in real life, that's what happens when you do these inspections.

You get information that isn't quite clear and so --

DR. KESSLER: Right.

MEMBER ARMIJO: Going back to the point of the ALARA budget, you don't have a chance to resolve it, because if you've met this hard constraint and --

DR. KESSLER: Well, my guess is --

MEMBER ARMIJO: -- go down the tubes.

DR. KESSLER: -- if we saw something, they'd revisit the ALARA budget. But also, one of the things that's already been done for the initial license granting was that, Constellation did a consequence analysis in the sense of, what if there is a crack? What kind of offsite doses would we get?

And my understanding is, the doses are pretty small. We're going to go back and look at that too, if for no other reason than to say, are we in a big hurry to address this issue and fix it, or do we have some time to make sure we can really inspect it, et cetera?

So we're kind of thinking through that too in terms of, you know, do we have to, like, throw sandbags at the thing or something else? I don't think so, but --

MEMBER ARMIJO: I don't think so either.

DR. KESSLER: -- you know, you have to think through all those things, and we're doing that.

CHAIRMAN RYAN: Fair enough. Okay. We're kind of running into time. We got Jim, who's wanting to wrap up over there. So, Jim, come on up.

MEMBER RAY: Okay. While he's coming up, just so not to extend the time, you know, as far as I know on any of the technical things we talked about here, there's a high likelihood of a benign resolution. But I guess the last comment that was made, I'm a little concerned with the idea that, well, maybe, something different ought to be done now. Sam mentioned wanting --

MEMBER ARMIJO: I just want to make sure that it's conclusive.

MEMBER RAY: Well, but there are others, such as, supposing for just a moment somebody said, okay, high burnup fuel cannot go, period, into dry cask storage, or at least not any that we know of today, what would that do? It'd be better to know that sooner than later, wouldn't it?

MEMBER ARMIJO: Sure.

MEMBER RAY: Or if you're going to do it, you're going to have to change something every 50 years, so we've got to establish a trust fund to do that down the road. I mean, it's just better to push this along, it seems to me like, and reach these conclusions because they affect things that are going on today.

MEMBER ARMIJO: Sure.

MEMBER RAY: And the assumption thought that, oh, well, whatever the problems are, we'll manage them in the future, I'm not sure is the right outcome. Anyway, that's the end of my speech.

CHAIRMAN RYAN: Well, that's an important point, Harold. I think there is a wall that you can run into that you can't climb over it because it costs too much, or it takes too much time, or resources, or whatever it is, so it's a good caution, actually, that we might ought to think about having in the letter.

MEMBER RAY: It's the one thing that concerns me out of all of this because, just the mere idea that something that you designed for one purpose can suit a quite different purpose, extended long-term storage, without any changes at all, is almost, you'd say, a miracle that that happened.

And so, you know, it's that kind of concern that I'm articulating here. And with that, I'll shut up.

CHAIRMAN RYAN: Thanks, Harold.

DR. RUBENSTONE: I will make this brief because I don't want anyone to miss the transit of Venus. That last comment, I think, is important and that's, to me, the motivation of why we're addressing this issue now, why we're getting started on this when we're talking about time frames that are long from now, but decisions you make now, especially if you don't want to have to re-handle things, are important for long time periods.

So I appreciate the committee's interest in this and I think this has been a good discussion. I want to thank the outside, the non-NRC participants who came in to give us the industry perspective, because I think that was a valuable counterbalance so you can see how they're addressing the problem compared to the staff's approach.

Just a quick recap, there's a limited number of things we owe you. A reference or two on the, kind of, state of understanding of fuel swelling and how that can affect --

MEMBER ARMIJO: Particularly low temperature alpha decay.

DR. RUBENSTONE: Yes. And Bob has taken that as his action. We ready to come before your full committee on July 11th. Any guidance you can give us about what areas to stress, what things not to talk about, would help us --

CHAIRMAN RYAN: Okay. Maybe what we'll do is, Chris and I can get with you at a little bit later time and talk that over in a little bit more detail than we can do here.

DR. RUBENSTONE: Yes.

CHAIRMAN RYAN: But, yes, we'd love to do that.

DR. RUBENSTONE: Right. And then the one other action is, you'd like to know when we have something more to tell you and when is the best time to come back to you.

CHAIRMAN RYAN: Sure.

DR. RUBENSTONE: And that's all I've got as actions out of this. So I think, from my point of view, this was quite successful, and Jeff's waving his hand.

MR. WILLIAMS: I was just going to say, we owed him one reference. And by the way, I think Bob has that reference because he's been part of the ESCP committee.

DR. RUBENSTONE: Oh, the --

MR. WILLIAMS: The gap analysis priority report.

DR. RUBENSTONE: If you're comfortable with us providing that, or John providing it, maybe that's a better path. Why don't you talk to Christopher Brown and you guys can work that out.

CHAIRMAN RYAN: Thank you. That's great. Anything else for the presenters or the topic? Jim, thank you very much and -- I'm sorry, one last time around. Sam?

MEMBER ARMIJO: I have no more.

CHAIRMAN RYAN: Dennis?

MEMBER BLEY: Yes. I'm not an expert on this, but I thought I'd toss it in because we talked about a lot of things about this coming examination.

We talked about magnification and some research we reviewed a couple of years ago, you know, it's not just the magnification, it's the lighting and the experience of the guys trying to do the readings.

And they range from really good at picking up cracks to very bad, so I'm hoping all that's in consideration before they start marching through this thing.

CHAIRMAN RYAN: Okay. Steve.

MEMBER SCHULTZ: Yes. I'd like to just put in the comment that this is caused, for me, a sense of urgency associated with the technical work that is ongoing related to these issues that come from the Blue Ribbon Committee and the mission going forward. And where the staff, of course, comes in is this risk-informed approach associated with this decision making.

And as Dr. Armijo has indicated, we're following, very closely, some very important decision making associated with spent fuel pool movement to canisters, dry storage, and that decision making could come upon us very rapidly. And it'd be a real shame if we didn't make the right decisions. And, of course, this has a clear nexus to it.

So I think what we didn't hear today, and that is, firmer schedules about how this is going to play out, we're going to have to identify that as we move forward to make these broader policy decisions about what we should do on reactor sites going forward.

CHAIRMAN RYAN: Thank you. Jack.

MEMBER SIEBER: No.

CHAIRMAN RYAN: I share Steve's comment. You know, I think I didn't have any sense of urgency this morning, but I feel a little bit more that there's a lot of moving parts here and some are moving, perhaps, in ways that are clear and some maybe not so clear.

And that there's a lot of work to get how the whole machinery is going to work together in a time-efficient way so that we have fuel out of the pools where it should be out of the pools, in casks where it should be, and, you know, we could really, kind of, choke up the system if we're not correct in all the moving parts decisions that have to be made in this process.

So I kind of join that comment that, you know, my sense of urgency has been heightened a little bit and it's clear that you've got the moving parts, you know, well in hand in terms of understanding what these parts are and the plans forward to address them well and, kind of, put some clarity in this.

So I think I applaud your efforts to take the clouds away and, you know, make it a clearer path forward.

MEMBER SCHULTZ: Okay. I would certainly agree with that too.

CHAIRMAN RYAN: All right. Well, thank you very much. I think with that, unless there are any other public comments. We had somebody on the bridge line earlier. Are there any comments from the bridge line? Are there any comments from the bridge line? Hearing none from the bridge line, are there any comments in the room?

With that, we'll adjourn the subcommittee meeting and thank you all very much.

(Whereupon, the above-entitled matter was concluded at 4:53 p.m.)

Regulation of Future Extended Storage and Transportation Technical Information Needs

James Rubenstone
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission

Advisory Committee on Reactor Safeguards
Subcommittee on Radiation Protection and Nuclear Materials
June 5, 2012

Overview

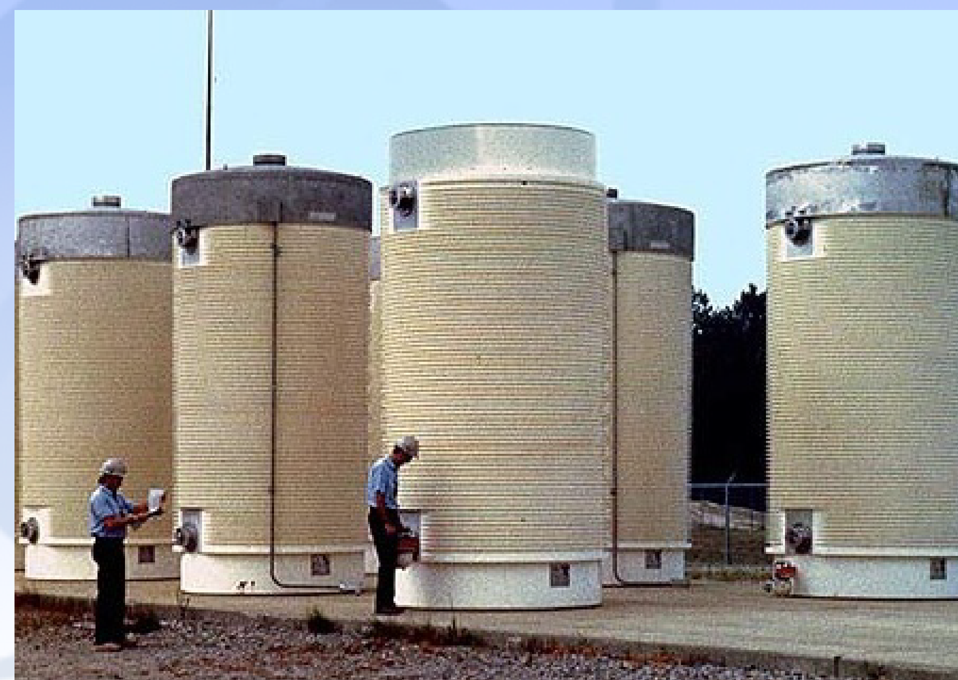
- Changing policy environment
- Regulatory framework—current and future
- Extended storage and transportation—technical information needs
- Next steps

Current Policy Environment

- U.S. national policy for disposition of spent nuclear fuel is in transition
  - Extended (dry) storage of spent fuel may be necessary
  - Alternative disposal options may emerge
- NRC's mission remains the same – ensure the safe and secure use of radioactive materials while protecting people and the environment
- Consistent with Commission direction, NRC staff is preparing for potential changes in policy
- BRC recommendations may provide some insight

Spent Fuel Storage: Dry Storage Systems

- Canister and integrated systems
- Horizontal and vertical orientations



- About 18,000 MTU commercial SNF currently in dry storage
- About 1,500 casks currently loaded

Spent Fuel Storage and Transportation: Framework

- Storage
  - 10 CFR Part 72
  - Term certificates and licenses
  - Aging management plans for renewal
  - Multiple renewals allowed
- Transportation
  - 10 CFR Part 71
  - Term certificates with renewal
  - Certification generally separate from storage

Extended Spent Fuel Storage and Transportation: Needs

- Potential changes to regulations and guidance to accommodate extended storage and transportation of long-stored spent fuel
- Technical information to inform potential regulatory changes and support future licensing reviews
  - Identify technical issues associated with long-term storage
  - Perform focused research on technical issues of regulatory significance

Extended Spent Fuel Storage and Transportation: Technical Needs

- Focus on potential degradation phenomena for dry storage systems, structures, and components
- Consider impact on performance of safety functions for storage and transportation
- Consider understanding necessary for regulatory review

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Draft Report for Comment

Identification and Prioritization of the Technical Information Needs Affecting Potential Regulation of Extended Storage and Transportation of Spent Nuclear Fuel

May 2012

Extended Spent Fuel Storage and Transportation: Methodology

- Used previous studies of technical gaps
  - NRC – Savannah River National Laboratory
  - Department of Energy
  - Nuclear Waste Technical Review Board
  - Electric Power Research Institute
- Level of knowledge for degradation processes
  - Time and conditions of initiation
  - Rate of progression
  - End state
- Impact on meeting regulatory criteria

Extended Spent Fuel Storage and Transportation: Criteria

- Design criteria – Safety functions
  - Confinement
  - Criticality control
  - Radiation shielding
  - Structural integrity
  - Thermal control
- Ability to retrieve stored fuel by normal means
- Possible impacts for transportation of long-stored spent fuel

Extended Spent Fuel Storage and Transportation: Results

- High priority technical information needs have
  - Overall low level of knowledge for one or more degradation questions
  - Overall high impact on regulatory criteria
- Crosscutting issues affect multiple aspects
- Several degradation processes interrelated
- Some information needs overlap with current licensing topics

Extended Spent Fuel Storage and Transportation: Technical Needs

- High priority degradation areas:
  - Stress corrosion cracking of stainless steel canister body and welds in marine atmosphere
  - Degradation of cask bolts
  - Effects of fuel pellet swelling and fuel rod pressurization on cladding stress

- High-priority cross-cutting areas:
  - More realistic thermal model calculations
  - Effects of residual moisture after canister drying
  - In-service monitoring methods for dry storage systems

Extended Spent Fuel Storage and Transportation: Technical Needs

- Other (nearly as) high priority degradation areas:
  - Propagation of cladding flaws, cladding fatigue, and low temperature creep (stress dependent)
  - Fuel assembly hardware corrosion and fatigue embrittlement
  - Neutron absorber degradation
  - Microbially influenced corrosion
  - Concrete degradation in unexposed areas

Extended Spent Fuel Storage and Transportation: Regulatory Areas

- Long term cladding integrity and retrievability
- Long-term financial assurance
- Decommissioned sites
- Physical security
- Risk informed regulations
- Integration of storage, transportation, and disposal regulations
- Coordination with current licensing process improvements

Extended Spent Fuel Storage and Transportation: Next Steps

- Finalize report on *Technical Information Needs Affecting Potential Regulation of Extended Storage and Transportation* after public comments
- Complete research plan for technical investigations
- Assess potential regulatory issues
- Continue technical investigations in selected high-priority areas
- Engage industry and other stakeholders
- Monitor outside technical work

Spent Fuel Storage and Transportation: BRC

Blue Ribbon Commission proposed a national nuclear waste management strategy with eight key elements, including:

- A new, consent-based approach to siting future nuclear waste management facilities
- Prompt efforts to develop one or more consolidated storage facilities
- Prompt efforts to prepare for the eventual large-scale transport of spent nuclear fuel and high-level waste to consolidated storage and disposal facilities when such facilities become available

Spent Fuel Storage and Transportation: BRC

- NRC staff reported to Commission on implications for NRC (SECY-12-0037; in ADAMS at accession number ML120410684)
- DOE is expected to respond to the BRC report this summer

Potential Implications

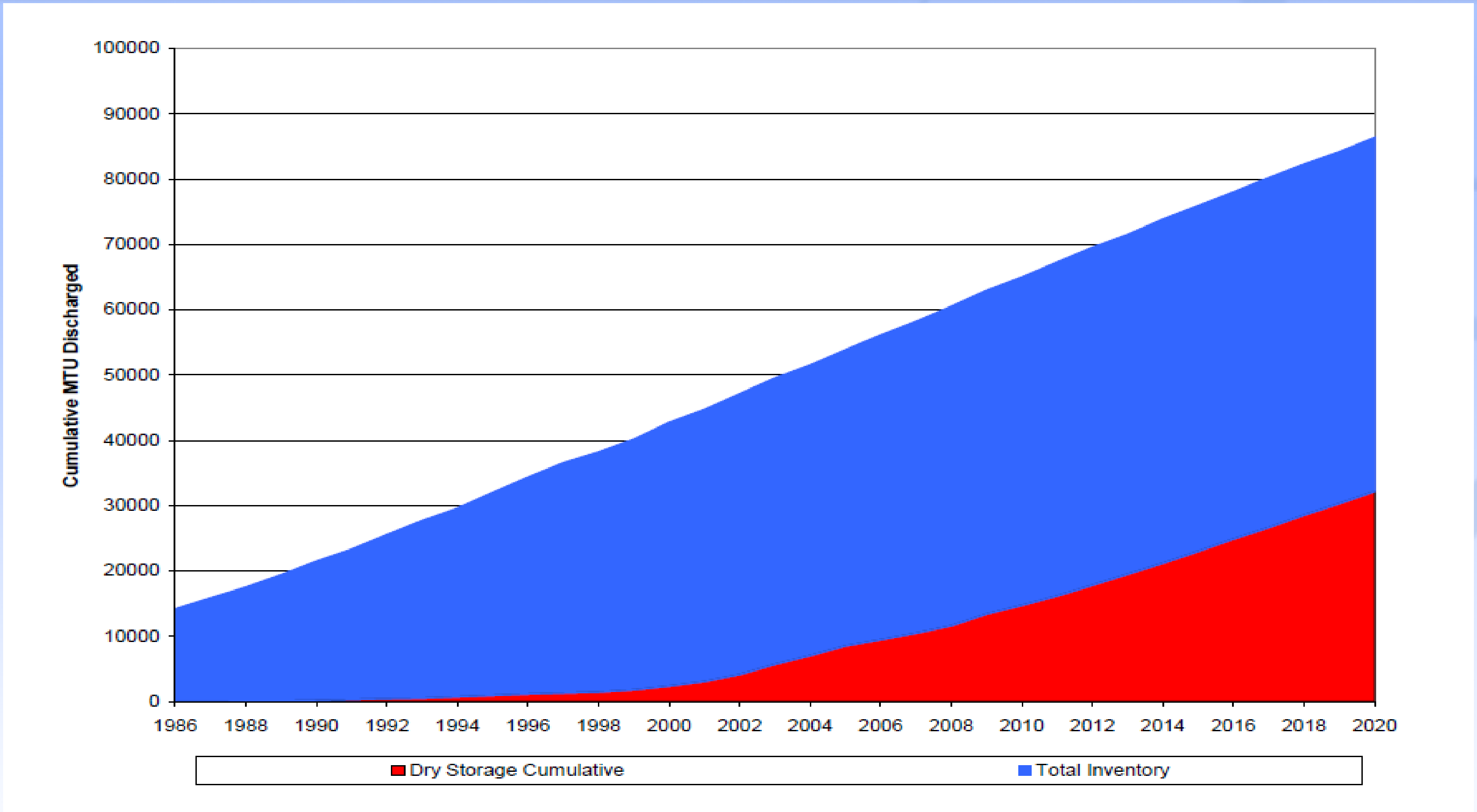
- Consolidated facilities?
- Multiple transportation stages?
- Multiple handling stages?
- Statutory changes?

Conclusions

- NRC is continuing to perform its mission while preparing for potential policy changes
- Initial NRC staff efforts have defined tasks and developed plans and schedules
- Draft report for technical needs been issued for public comment
- Staff is completing technical work plans, examining regulatory areas, and has begun some technical work
- Staff is continuing interaction with public, industry, and other stakeholders

Backup Slides

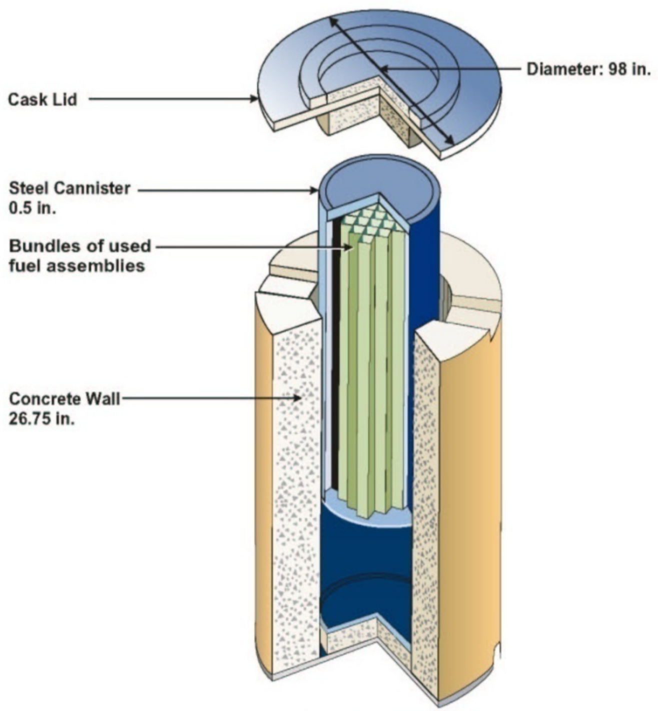
Spent Fuel Storage: Historical and Projected Spent Fuel Discharges



Source: *Impacts Associated with Transfer of Spent Nuclear Fuel from Spent Fuel Storage Pools to Dry Storage After Five Years of Cooling*, Electric Power Research Institute, 2010

Spent Fuel Storage: Dual Purpose Systems

Dual Purpose Storage Cask*

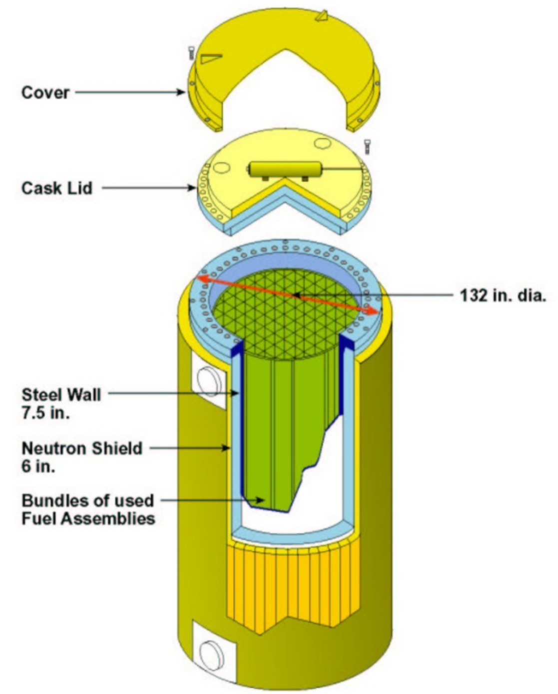


(Holtec International HI-STORM 100)

Overall Length: 197 to 225 in.
Loaded Weight: 360,000 lbs.
Typical Payload: 24 PWR Bundles

** Storage and Transportation*

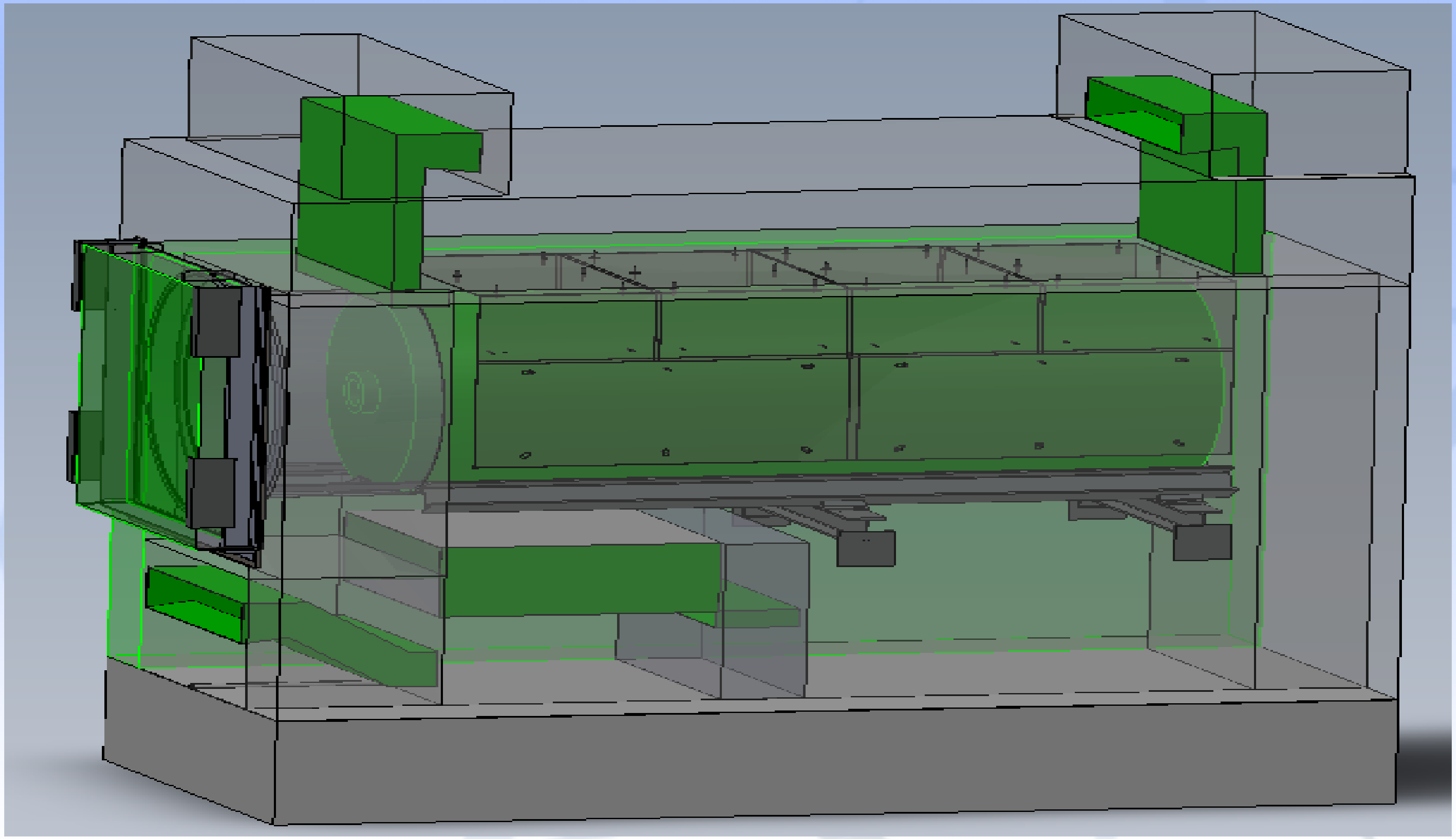
Dual Purpose Cask*



(Transnuclear TN-68)

Overall Length: 178 in
Loaded Weight: 240,000 lbs.
Typical Payload: 68 BWR Bundles

Spent Fuel Storage: NUHOMS Canister System



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Extended Storage Technical Issues

John Kessler
Manager, Used Fuel and HLW Management Program

ACRS Subcommittee on Radiation Protection & Nuclear Materials
5 June 2012

Extended Storage – an International Issue

- Most “nuclear” countries face extended storage
  - No reprocessing
  - No disposal
  - Centralized (consolidated) storage is still storage

R&D in Several Countries Already Well Underway – a *Few* Examples:

- SS dry storage canister degradation (e.g., Japan, NRC (SwRI))
- Continued data collection from the CASTOR V/21 at INL (US, Japan)
- Bolted casks: seals and bolts degradation (Japan, Germany, US, others)
- Periodic visual inspection of cask internals (Japan)

EPRI Initiates Extended Storage-specific Work in 2009

- Recognized need for international collaboration
- Share existing information
- Are there common technical issues for future technical work?

- Identify specific industry needs for R&D

"Extended Storage Collaboration Program" (ESCP) Launched in 2009

Bring together US and international organizations engaged with active or planned R&D

- Storage and transportation system vendors
- Regulators and their R&D contractors
  - (e.g., US NRC/ SwRI, CSN, UK DfT and NIL, BAM)
- National waste management organizations
  - (e.g., US DOE, ENRESA, PURAM, NWMO)
- R&D organizations
  - (e.g., US national labs, EPRI, CRIEPI, KAERI)
- Industry (utilities/cask vendors)
  - (e.g., France, Germany, Japan, Netherlands, Spain, S. Korea, Switzerland, Taiwan, UK, Ukraine, USA)

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EPRI Extended Storage Collaboration Program (ESCP)

- Purpose: “Provide the technical bases to ensure continued safe, long-term used fuel storage and future transportability”

- Modeled on prior dry storage license extension research

- Phased approach
  - ✓ Phase 1: Review current technical bases and conduct gap analysis for storage systems
  - ➢ Phase 2: Conduct experiments, field studies, and additional analyses to address gaps (already underway)
  - – Phase 3: Coordinate research that results in a program documenting the performance of a dry storage system loaded with high burnup fuel (>45 GWd/MTU)

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ESCP Subcommittees

- Fuel/Internals
- “Marine environments”
- Non-destructive evaluation (NDE)
- Concrete Systems
- High burnup confirmatory demonstration
- “International”

Gap Analyses: Highest Priority Items

- Welded SS canisters SCC
- High burnup cladding: hydride effects (reorientation, embrittlement)
- Bolted casks:
  - Corrosion of bolts
  - Embrittlement and mechanical degradation of bolts
- Fuel pellet swelling

Cross-Cutting Needs

- Improved thermal modeling
- Stress profiles
- Degradation monitoring systems
- Adequacy of drying
- Sub-criticality: burnup credit
- Examine casks at INL (DOE)
- Retrievability: fuel transfer options

Modeling and Laboratory Testing are Underway

- Modeling
  - Improved heat transfer models (PNNL, vendors)
- Laboratory testing *examples*
  - SS SCC
    - Identify conditions supporting SS SCC (CRIEPI, NRC/SwRI)
    - Correlate marine atmosphere to salt deposition (CRIEPI)
  - Bolted systems
    - Bolt degradation (BAM)
    - Seals degradation (BAM, CRIEPI)
  - Adequacy of drying (NRC/SwRI, DOE)

Next Step: Field Inspections and Large-scale Testing

- In situ inspections of SS canisters
- Full-scale, high burnup confirmatory data collection (the “demo” program)

EPRI Plans for In Situ Inspection of SS Canisters

SCC of Welded Canisters – What Do We Know?

For stress corrosion cracking you need:

- Susceptible material (austenitic stainless steels; e.g. 304, 316)
- Tensile stress (residual weld stress)
- Corrosive environment

Environment parameters affecting susceptibility of SCC

  – Salts in the air
  – Deliquescence
    - Surface temperature
    - Humidity

Studies have shown SCC can occur on canister materials under lab conditions

What we don't know …

What are the conditions on actual canisters?

Inspection #1: Calvert Cliffs (late June 2012)

- ISFSI ~ ½ mile from Chesapeake Bay
- Canisters in service for > 15 years
- Low decay heat canisters
- Two canisters to be inspected
  - Aging management inspection for license renewal
  - Marine environment effects

General Inspection Plans

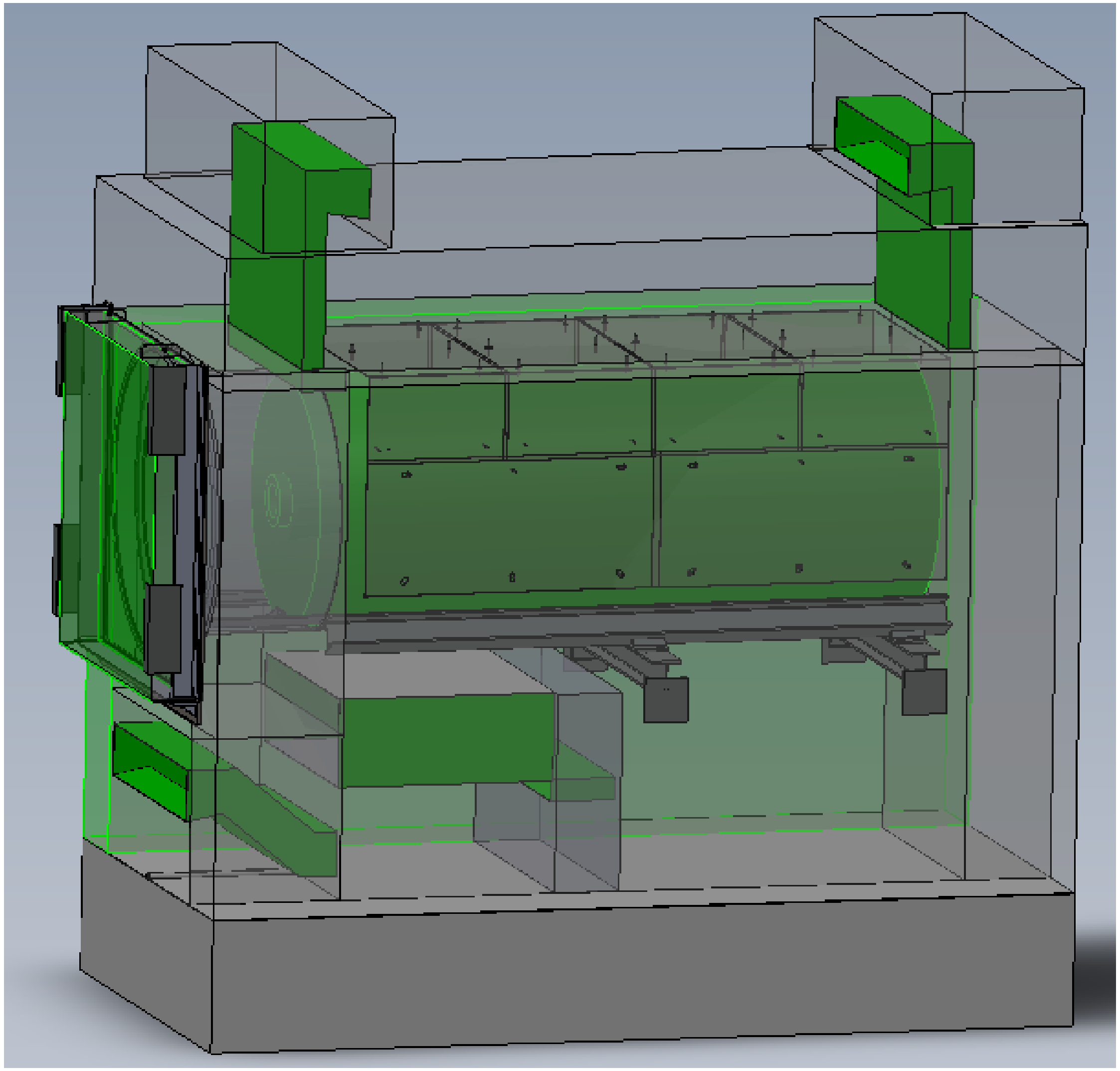
Scope of inspections:

- Visual
- Temperature
- Surface contaminants

Additional data collection on environment

- Air temperature & humidity
- Salt content in air

Calvert Cliffs Visual Inspection through NUHOMS Air Outlets

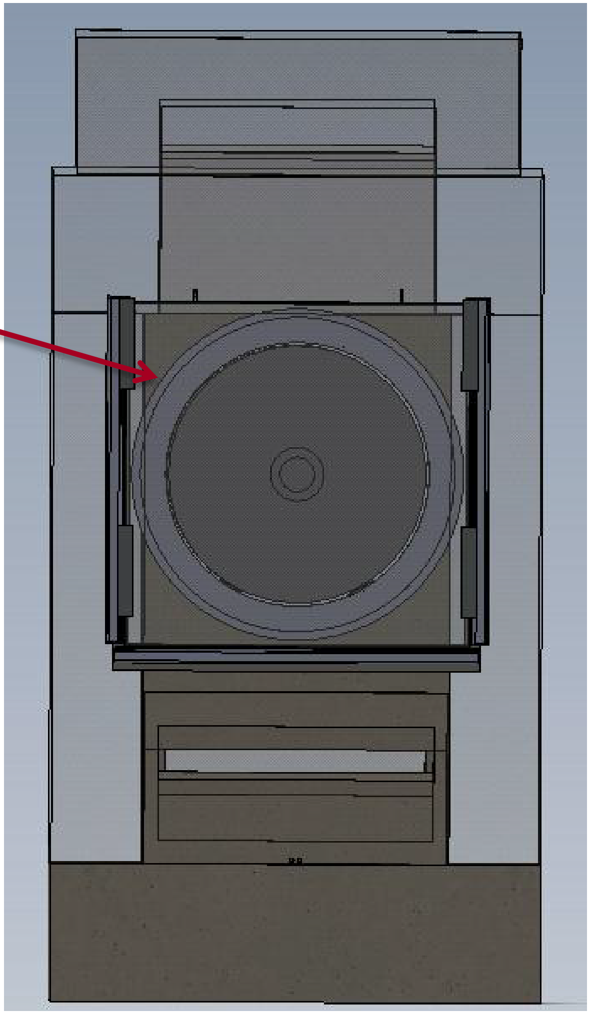


Calvert Cliffs

NUHOMS Design

Calvert Cliffs Surface Contaminant and Temperature Measurements through Front (remove door)

- Tool to access canister side through ¾-inch gap
- Temporary shielding



Canister surface temperature

- Altered air flow may affect canister temperature
  - Thermography immediately after door raised
- Thermocouple at several radial and axial locations

TN Surface Contaminant Inspection Plans for Calvert Cliffs

- Wet (e.g. “Salt Smart®”)
  - Qualification testing for temperature and range of concentrations expected
  - May not work on upper surfaces that have a layer of “dust”
- Dry (scraping, brushing, vacuum)
  - More complicated tool design and construction
  - Space and weight constraints
  - Best for upper surfaces to collect “dust”
- Plan to use both

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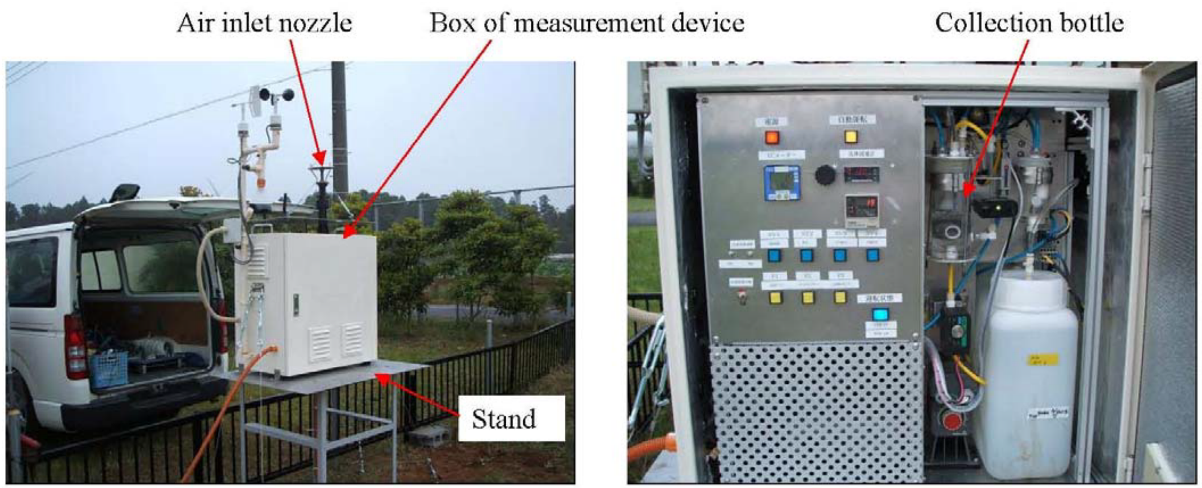
Generic External Environment Data Collection Plans

Air temperature & humidity

- Install devices at inlet and outlet

Salt content in air

- Install air sampler in vicinity of ISFSI



Outside view   Inside view

Size(Box of measurement device): 700 × 700 × 400mm
Weight: 60 kg
Power supply: 100V (20A)

CRIEPI Central Research Institute of Electric Power Industry

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Calvert Cliffs Marine Environment Inspection Schedule

- ✓ Salt Smart® qualification testing complete
- ✓ Tooling design complete, fabrication underway
- ✓ Functional test: 5/24-5/25
- Inspection: 6/27-6/30
- Environmental monitoring later

Future SS Canister Inspection Plans

- Prefer (initially):
  - Near salt water body
  - Long time in service
  - Low canister surface temperature (< 80-100^o C)
- Coordinate with other inspection activity if possible
- Develop inspection method to minimize dose

EPRI requested additional utility volunteers

7 utilities expressing interest to date

DOE will provide additional co-funding to support inspections through end of FY2013

Full-scale, High Burnup Confirmatory Data Collection ("high burnup demo") Plans

Confidence in understanding longer-term behavior of dry storage system requires

- Model development and benchmarking data
- "Separate effects testing"
- Confirmatory testing under "prototypic" conditions
  - Full scale
  - Representative dry storage conditions
    - Drying process and inerting
    - Thermal evolution
    - Geometry
  - Prefer multiple high BU fuel types (if possible)

High Burnup Demo Objectives

- Confirmatory data to support
  - Thermal models
  - Behavior of cask internal components (fuel, cladding, assembly hardware, baskets, neutron absorber)
- Avoid rewetting the fuel after initial loading

High Burnup Demo Activities

Industry desire to keep this short

- Obtain “t=0” data from sister rods
  - Profilometry
  - Cladding properties (hydrogen content and initial orientation, mechanical, internal gas content)
- Modify existing cask with a special lid that includes
  - Thermocouples
  - Gas sampling
- Load cask and emplace modified lid
- ***Data collection through lid begins immediately***
  - Capture temperature and gas evolution during drying
  - Continue temperature measurements and periodic gas sampling
- After X years (TBD), re-open, remove rods, visually inspect for degradation
  - Rods for destructive exams to compare to “t=0”
  - Option to perform exams on internals

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High Burnup Demo Option that Keeps Startup Time Short

- Initiate the demo at a reactor site
  - Avoids up-front transportation to a national lab
  - Avoids having to wait for a full-scale hot cell to be funded and constructed
  - Keeps costs low(er) prior to test initiation
- Dominion-TN propsal (start test in 3-5 years)
  - Willing host (North Anna or Surry)
  - Multiple, high burnup fuel types
  - Partner with a cask vendor supplying cask(s) at low cost
  - EPRI providing funding for instrumented lid design
  - Looking for co-funding

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Together…Shaping the Future of Electricity

U.S. DEPARTMENT OF ENERGY | Nuclear Energy

DOE Efforts on Extended Storage and Transportation

ACRS Meeting of the Subcommittee on Radiation Protection & Nuclear Materials

Extended Storage and Transportation (EST) Safety Basis

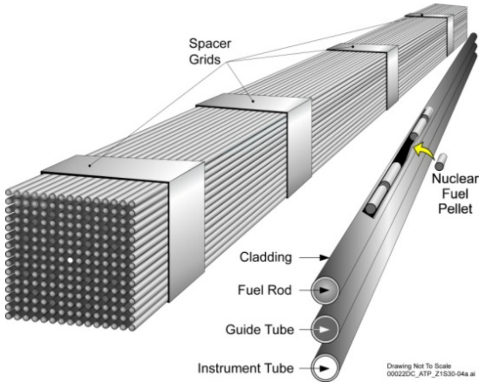
Jeffrey Williams, Deputy Director
DOE-NE Office of Nuclear Fuel Disposition Research & Development

June 5, 2012
Rockville, Maryland

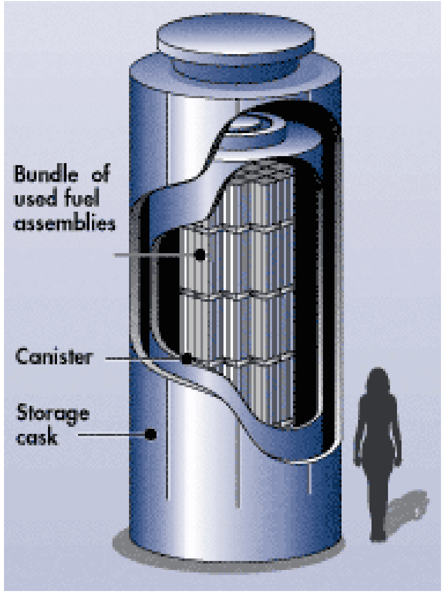
U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Contents

- Overall Storage and Transportation Objectives
- Major Activities
- Collaborations



http://energy.gov/sites/prod/files/styles/



www.nrc.gov/waste/spent-fuel-storage/

www.connyankee.com/

Storage and Transportation Objectives

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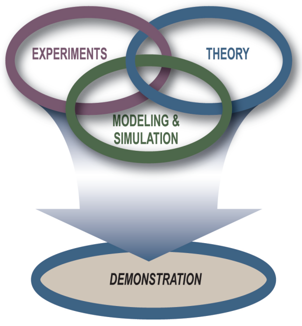
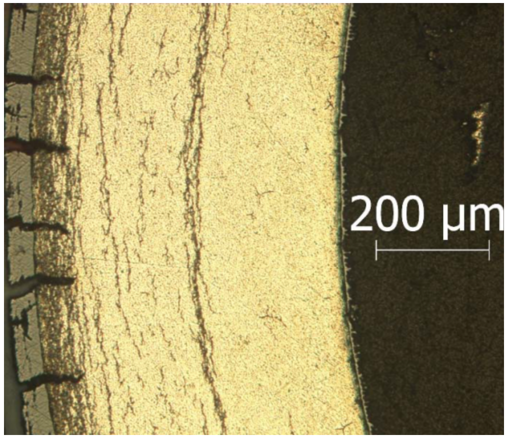
Nuclear Energy

Overall Objectives:

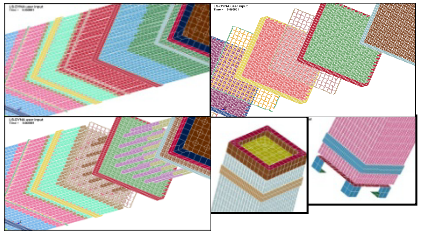
- Develop the technical bases to demonstrate used fuel integrity for extended storage periods.
- Develop technical bases for fuel retrievability and transportation after long term storage.
- Develop the technical basis for transportation of high burnup fuel.

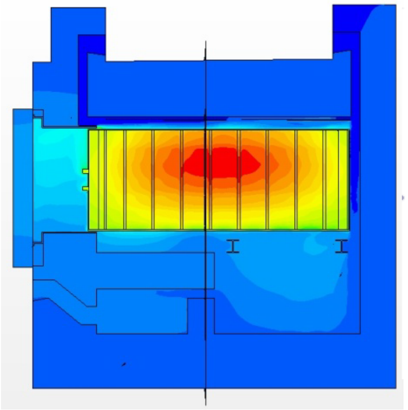


Science based, Engineering driven



Billone, Liu; Argonne





Wagner, Adkins; ORNL

'Jones 2010.ppt',
Calvert Cliffs Dry Fuel Storage
and Industry Lessons Learned

Storage and Transportation Major Activities

- **Five major activities are designed to define the work to address the objectives**
  - R&D Investigations
  - Engineered Materials – Experimental
  - Engineering Analysis
  - Field Testing
  - Transportation

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R&D Investigations

Scope & Status

- Refine last year's Level 1 Technical Data Gap Rpt
- Review of identified data gaps relative to external studies
- Develop Aging Management Plans for storage system safety components

Gap	Likelihood of Occurrence	Consequences	Difficulty for Remediation	Importance for Licensing	Importance for Licensing
Cladding – annealing	3/2	2	3	8/7	MH/M
Cladding - H2 effects, reorientation and embrittlement	4/4	3	3	10/10	H/H
Cladding - H2 Effects, DHC	3/4	3	3	9/10	MH/H
Cladding - Oxidation	1/1	3	3	7/7	M/M
Cladding - Creep	3/3	2	3	9/9	MH/MH
Assembly Hardware – SCC of lifting hardware and spacer grids	2/2	2	3	8/8	MH/MH
Neutron Poisons - Thermal aging effects	4/4	3	3	10/10	H/H
Neutron Poisons - Creep	1/2	2	2	6/7	M/M
Neutron Poisons - Embrittlement and cracking	2/3	3	3	8/9	MH/MH
Neutron Poisons - Corrosion (blistering)	2/2	2	2	7/7	M/M
Welded Canister - Atmospheric corrosion	4/4	4	3	11/11	VH/VH
Welded Canister - Aqueous corrosion	4/4	4	3	11/11	VH/VH
Bolted casks - Thermomechanical fatigue of seals and bolts	4/4	4	2	11/11	VH/VH
Bolted casks - Atmospheric corrosion	4/4	4	2	11/11	VH/VH
Bolted casks - Aqueous corrosion	4/4	4	2	11/11	VH/VH
Concrete Overpack - Freeze–thaw	2/4	1	1	4/6	ML/M
Concrete Overpack - Corrosion of embedded steel	2/4	1	1	5/7	ML/M

Impact

- This prioritization informs the experimental and analysis work

FY13

- Accelerate experimental work on hydride cladding and SS canister corrosion

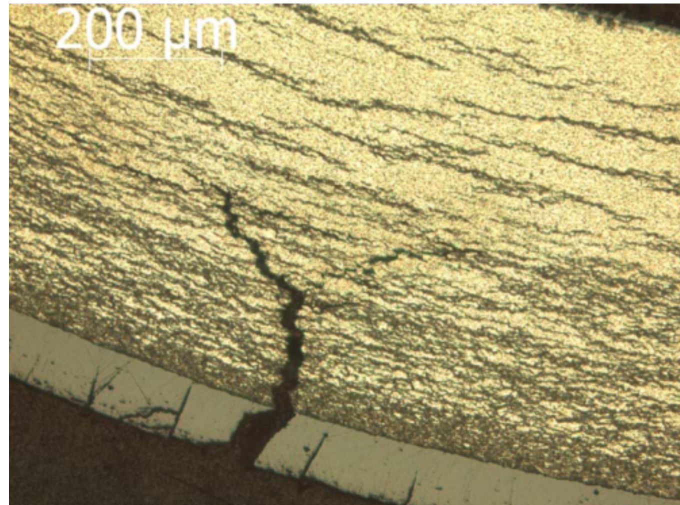
Two high priority technical issues need to be addressed in the near term:

- *hydride effects on cladding integrity for high burnup fuels*
- *general corrosion and SCC of SS canisters storing fuel*

Engineered Materials - Experimental

Scope & Status

- Conduct ring compression tests on used fuel cladding
- HFIR cladding tests
- Conduct SS canister corrosion tests



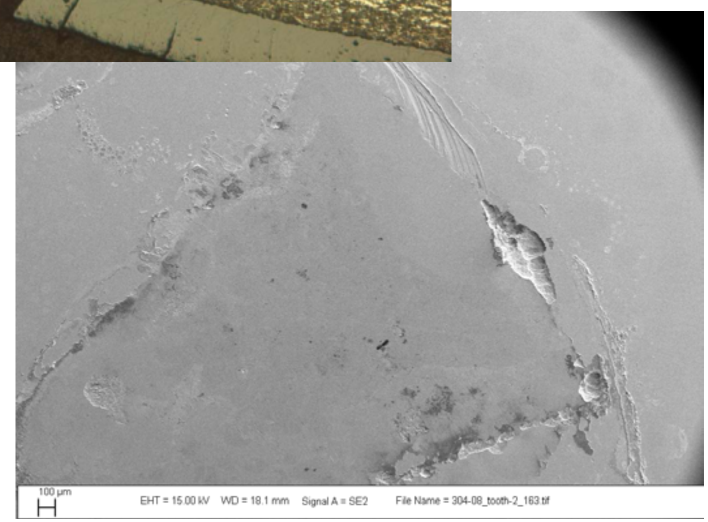
Ring compression test on HB Zry-4
Billone, Liu; ANL

Impact

- This testing addresses high priority gaps identified for cladding and canisters

FY13

- Accelerate cladding and canister testing



304 SS 100µg/cm^2 corrosion test
Bryan, Enos; SNL

Engineering Analysis

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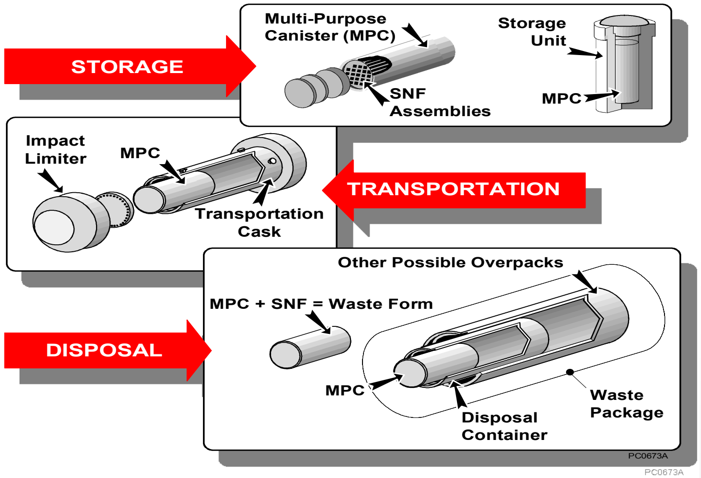
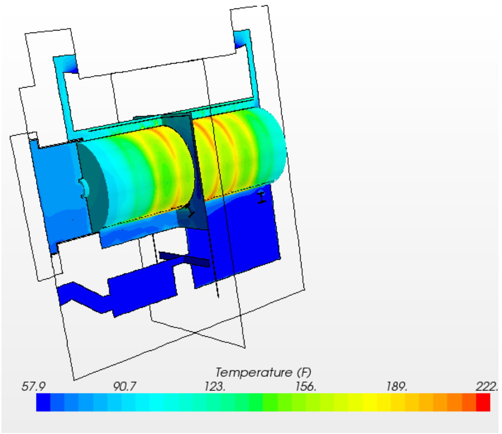
Scope & Status

- Develop multi-purpose canister system concepts
- Conduct thermal analysis on Calvert Cliffs Canister
- Hydride re-orientation
- Support mechanical analysis of transport testing



Impact

- This testing addresses identified high priority gaps
  - Used fuel and canister thermal profiles
    (relates directly to canister corrosion issue)
  - Cladding integrity
    (focus on hydride development in cladding)

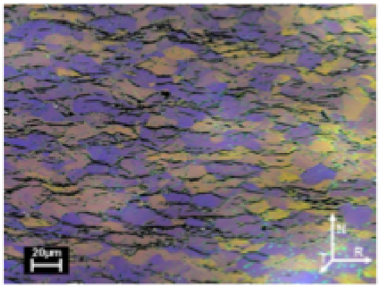


NuHOMS thermal analysis
Adkins; PNNL

FY13

- Continue cladding and canister analysis
- Support transportation loading tests

Preliminary hydride analysis
Tikare; SNL



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Field Testing

Draft UFD test plan
Salt content sampler
Weiner; SNL

Scope & Status

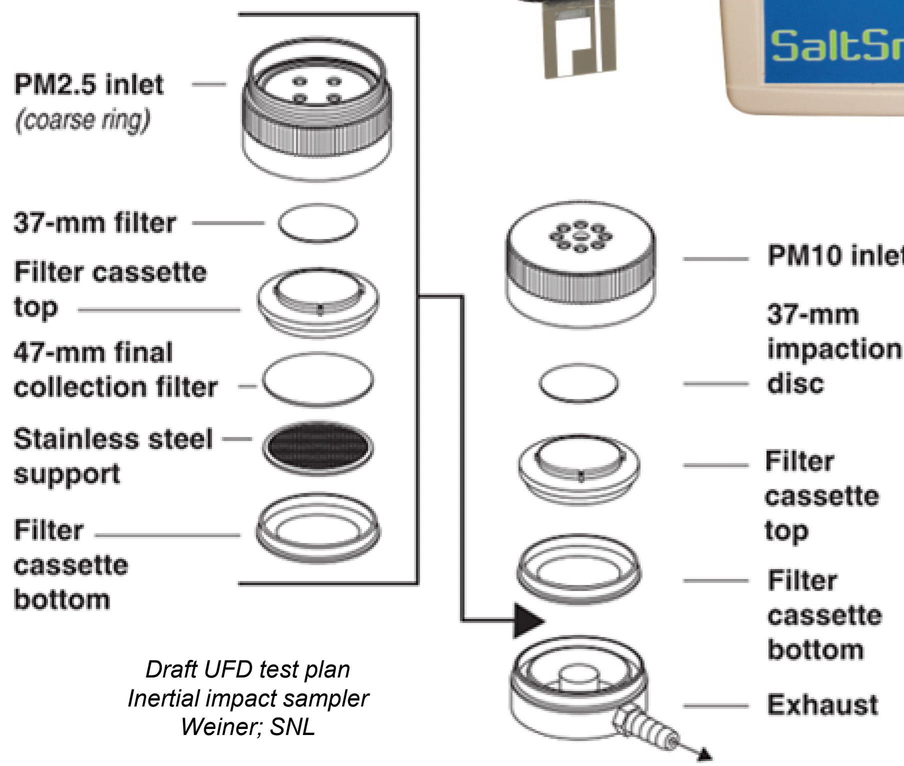
- Write Storage/Transportation RD&D Plan
  (defines near-term separate effects testing needs based on gap analysis)
- Develop collaborative test plan with EPRI to assess on-site canister corrosion
  (obtain in-situ atmospheric and canister performance data)

Impact

- The RD&D report supports readiness for the BRC recommendations.
- This testing addresses identified high priority gaps
  - Thermal profiles
  - Cladding integrity

FY13

- With EPRI and industry cooperation, expand canister corrosion testing to multiple ISFSI sites



Draft UFD test plan
Inertial impact sampler
Weiner; SNL

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Transportation

Scope & Status

- Criticality analyses

  (assess margin on k_{eff} for damaged fuel scenarios)
- Moderator exclusion

  (concept development to assure moderator exclusion during transport accident events)
- Transportation test

  (obtain data on realistic loadings transmitted to fuel during transport)

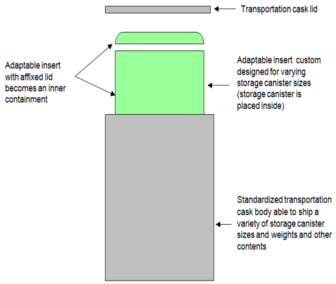
Impact

- Address alternate paths to transporting used fuel without the full suite of cladding data

FY13

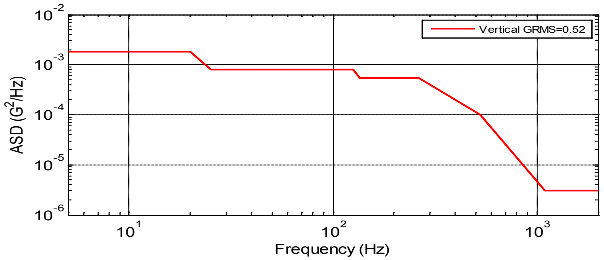
- Continue analyses and testing to support transport of HB used fuel
- Conduct data analysis to support planning for transport of fuel to support BRC recommendations

- Basic principle of defense-in-depth is the use of multiple barriers

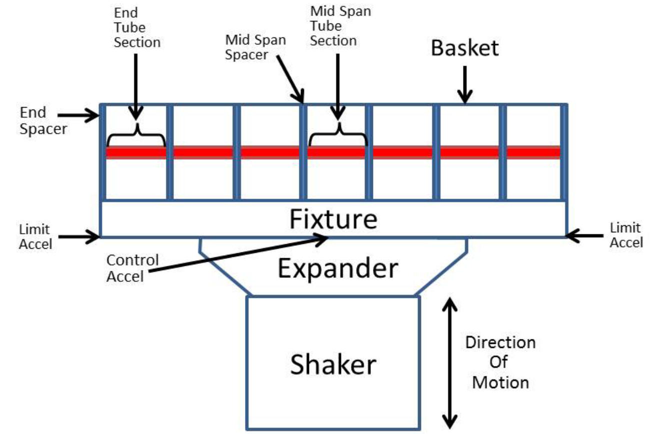


- Use of an inner containment depends upon the functionality of the storage canister

Moderator exclusion concept: INL



Assembly vibration analysis SNL



Vibration test frame concept: SNL

Conclusions

DOE/NE is supporting development of the technical basis for certification of very long term storage of used fuel and subsequent transportation. Programmatically, this includes:

- ***development of a plan to support experimental data gathering to address gaps in the existing data base,***
- ***conducting experiments to gather needed data,***
- ***working with the NRC to properly integrate data needs perceived by both the regulator and industry,***
- ***working closely with industry,***
- ***working closely with our international partners, and***
- ***development of the technical basis documents.***

Work aligns with recommendations published by the Blue Ribbon Commission

Extended Used Fuel Storage and Transportation Safety Basis

Industry Perspectives

NRC Advisory Committee on Reactor Safeguards
Subcommittee on Radiation Protection & Nuclear Materials
June 5, 2012

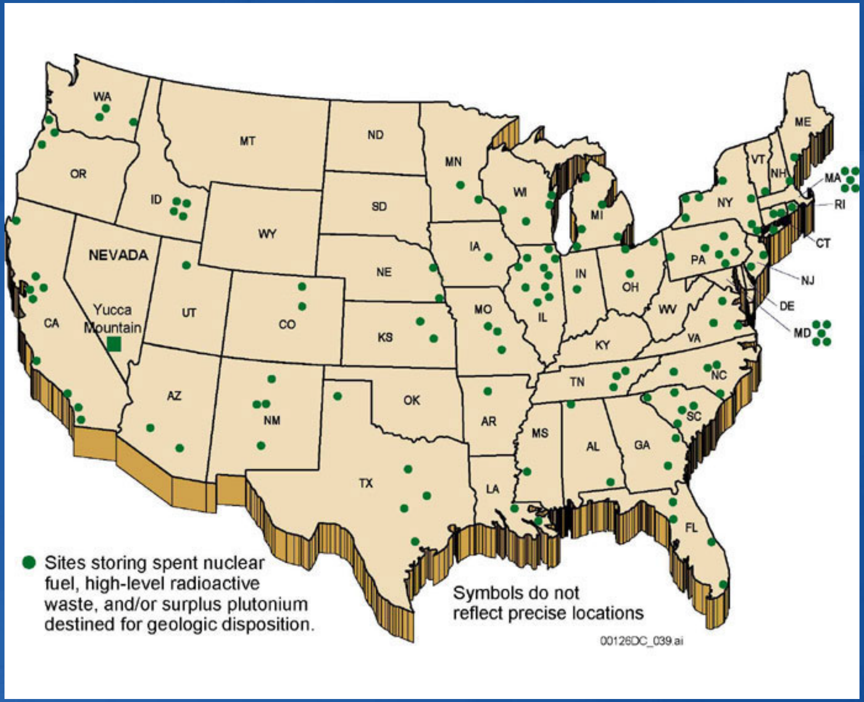
Rod McCullum

NEI

NUCLEAR ENERGY INSTITUTE

Used Nuclear Fuel in Storage

- **Used fuel inventory**
  - Approximately 67,500 MTU
  - Increases 2 - 2.4k MTU annually
- **ISFSI storage**
  - 64,610 assemblies
  - 18,100 MTU
  - 1,539 casks/modules loaded
  - 57 Operating ISFSIs
    - 1 pool ISFSI, 1 modular vault
- **Projections for 2020**
  - Estimating 88,000 MTU total
  - Estimating 31,000 MTU at ISFSI
  - 3,000 casks/modules loaded
  - At 76 ISFSIs
    - All plant sites + Morris & INEL
  - Fuel from 119 reactors



NEI

Historical Growth of Dry Cask Storage

DRY CASK STORAGE 1986 – 2011*

YEAR ENDING DECEMBER 31	NUMBER OF ISFSIs ADDED	TOTAL NUMBER OF ISFSIs	CASKS IN SERVICE	FUEL ASSEMBLIES IN DRY STORAGE
1986	-	2		
1987	0	2		
1988	0	2		
1989	0	2		
1990	1	3		
1991	0	3		
1992	1	4		
1993	2	6		
1994	0	6		
1995	2	8		
1996	1	9		
1997	0	9		
1998	1	10		
1999	1	11		
2000	3	14		
2001	3	17		
2002	6	23		
2003	4	27		
2004	1	28	664	22,644
2005	5	33	763	26,531
2006	3	36	848	30,032
2007	1	37	924	33,281
2008	8	45	1,073	40,280
2009	2	47	1,203	45,983
2010	5	52	1,351	52,381
2011	3	55	1,510	59,008

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* Does not include fuel at Morris (wet ISFSI), Fort St. Vrain (modular vault), or INEL (TMI-2) .

Extended Storage Safety Basis

- **Dry Casks are robust systems with no moving parts**
- **Part 72.42 rulemaking increased license/renewal terms from 20 to 40 years**
  - **"This increase is consistent with the NRC staff's findings regarding the safety of spent fuel storage as documented in the renewal exemptions issued to the Surry and H.B. Robinson ISFSIs"** 76 Fed. Reg. 8874 2/16/2011
- **Waste Confidence rulemaking**
  - **"studies performed to date have not identified any major issues with long-term use of dry storage"** 75 Fed. Reg. 81072, 12/23/2010
- **EPRI and NRC Dry Storage PRAs conducted in 2007**
  - **Annual cancer risk between 1.8E-12 and 3.2E-14 ***
- **Opportunities to further verify performance being pursued**

* Compares to 2E-6 LCF/yr. public & 1E-5 LCF/yr . worker thresholds of negligible risk from NRC's framework for "Risk-Informed Decision-making for Nuclear Material and Waste Applications", Revision 1, February 2008

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Performance Verification

- INL Dry Storage Characterization Project opened cask stored from 1985 to 1999 and verified "long-term storage has not caused detectable degradation of the spent fuel cladding or the release of gaseous fission products"
- Industry working with DOE to develop a similar demonstration program for additional data (including higher burn up fuel)
- EPRI is conducting inspections to verify canister performance in chloride rich atmospheres

Dry Storage and Transport Regulation

- **To be effective, regulatory process must**
  - **Assure safety**
  - **Be risk informed**
  - **Incorporate experience of mature used fuel dry storage industry**
  - **Be consistent with NRC Principles of Good Regulation**
  - **Be implemented in a stable manner**
- **As the process is faced with new challenges – e.g. extended storage – it must become more efficient**
- **Acknowledged need to improve regulatory framework**
  - **COMSECY-10-007 approved “advancing the regulatory process improvement review to identify near term efficiency and effectiveness enhancements”**
  - **NRC Risk Management Task Force recommended staff identify and pursue “selected guidance and rule changes”**

Regulatory Framework Improvements
Industry Priorities

- **Industry is interested in pursuing in the near term**
  - **Defined/standardized format and content for CoCs**
  - **Criteria for what is included in Tech Specs and CoCs**
  - **Backfit protection for CoC holders**
- **Industry has considered and decided not to pursue at this time**
  - **Changes to the CoC Amendment process**

Regulatory Framework Improvements
Longer Term Industry Priorities Relevant to Extended Storage

- **Retrievability**
  - Rethinking 10 CFR 72.122(l) and 72.236(m) requirements for retrieval could reduce importance of long term cladding integrity for storage
- **Moderator Exclusion**
  - Rethinking limitations on the use of moderator exclusion to demonstrate transportation safety in accordance with 10 CFR 71.55 could improve ability to assure transportability after periods of extended storage
- **Harmony Between Regulations**
  - Establishing the regulatory platform for storage (wet and dry), transportation, recycling, and disposal as an integrated system

Extended Storage in an Integrated System

- **An integrated system must, at a minimum, connect the following elements***
  - **Storage at reactor sites**
  - **Transportation**
  - **Storage at consolidated sites**
  - **Transportation (?)**
  - **Disposal**
- **Integration must be built on the system we have, not the one we wish we had**

*The deployment of recycling technologies will not completely eliminate the need for direct disposal of at least some portion of the used fuel inventory

Past Efforts at Systems Integration
Storage, Transportation, and Disposal Canisters

- **DOE Multi-Purpose Canister (MPC) System**
  - **1992, Feasibility Study**
  - **1994, Design Specification**
  - **1997, Funding/repository design uncertainties ended program**
- **DOE/Industry Transportation Aging and Disposal (TAD) Canister System**
  - **2005, Proposal based on mature Yucca Mtn. repository design**
  - **2007, Performance Specification**
  - **2009, Vendor TAD license applications to NRC**
  - **2010, Yucca Mtn. project terminated**
- **Direct Disposal of Existing Dual Purpose Casks**
  - **2008, 3 NEI contentions in the Yucca Mountain licensing proceeding asserted disposability of already loaded dual purpose canister systems**

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* Safety-01, Safety-02, and NEPA-01

Why direct dispose of already loaded canisters?

- **Maintain radiation exposure to workers As Low as Reasonably Achievable (ALARA)**
- **Avoid unnecessary costs**
- **Avoid interference with plant operations**
- **Avoid disposal of used canisters as low-level waste**
- **Overall risk reduction**
- **Alleviate need to assure retrievability after long-term storage**

Conclusion

- There is a strong basis to support safe used fuel storage for extended time periods
- Industry is working pro-actively to address future challenges regarding extended storage
- Regulatory framework improvements will enhance our ability to address extended storage
- Extended storage should be addressed in the context of the integrated system in which it exists