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Metallurgy and Reactor Fuels Subcommittee

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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METALLURGY AND REACTOR FUELS SUBCOMMITTEE

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WEDNESDAY

MARCH 23, 2016

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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 8:30 a.m., Ronald G. Ballinger, Chairman, presiding.

COMMITTEE MEMBERS:

RONALD G. BALLINGER, Chairman

DENNIS C. BLEY, Member

CHARLES H. BROWN, JR. Member

DANA A. POWERS, Member

JOY REMPE, Member

PETER RICCARDELLA, Member-at-Large*

GORDON R. SKILLMAN, Member

DESIGNATED FEDERAL OFFICIAL:

CHRISTOPHER L. BROWN

ALSO PRESENT:

HUDA AKHAVANNIK, NMSS

MICHELLE BALES, RES

KRISTINA BANOVAC, NMSS

JANA BERGMAN, Curtiss-Wright

DONALD CHUNG, NMSS

AL CSONTOS, NMSS

KRIS CUMMINGS, NEI

BOB EINZIGER, NWRTB

STEVE FRANTZ, MLB

DONNA GILMORE*

NICHOLAS HANSING, NRO

MATT HISER, RES

ANTHONY HSIA, NMSS

MATT KEENE, Duke Energy

SUZANNE LEBLANG, Entergy

MARVIN LEWIS

HAILE LINDSAY, NMSS

MARK LOMBARD, NMSS

KARAN MAUSKAR, Areva TN

ROD MCCULLEN, NEI

GREG OBERSON, RES

TERRY PICKENS, Xcel Energy

PAUL PLANTE, 3 Yankees

MERAJ RAHIMI, NMSS

WENDY REED, NMSS

STEVE RUFFIN, NMSS

NORMA GARCIA SANTOS, NMSS

PATRICIA SILVA, NMSS

DAVID TANG, NMSS

JEREMY TAPP, NMSS

RICARDO TORRES, NMSS

BRIAN WAKEMAN, Dominion

KEITH WALDROP, EPRI

BERNARD WHITE, NMSS

JOHN WISE, NMSS

EMMA WONG, NMSS

JIM WOOD, Exelon

*Present via telephone

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Adjourn

P R O C E E D I N G S

8:31 a.m.

CHAIR BALLINGER: Okay. Ready to go? The meeting will now come to order. Boy, I can hear myself.

This is the meeting of the Metallurgy and Reactor Fuel Subcommittee. I'm Ron Ballinger, Chairman of the Subcommittee.

ACRS members in attendance, Dick Skillman, Dana Powers, John Stetkar in spirit, Charles Brown and Joy Rempe. And Pete Riccardella, I believe, is going to be here on the phone, on the bridge line.

MEMBER RICCARDELLA: I'm on. Can you hear me?

CHAIRMAN BALLINGER: Oh, great. We can hear you great. Thanks.

Chris Brown of the ACRS staff is the designated federal official for this meeting. The purpose of this two-day, approximately, meeting is to receive a briefing on the framework for storage and transportation of spent fuel. I might add that this has been ongoing for quite a while. A long time.

In particular, we'll hear about the ISG

on spent fuel retrievability, updates and licensing of high burnup spent fuel and storage and transportation, as well as NUREG-1927 on renewals. We'll also hear from EPRI and NEI on the subject matter mentioned.

The rules for participation in today's meeting were announced as part of the notice of this meeting previously published in the Federal Register on March 8, 2016. We have received no written comments or requests for time to make oral statements from members of the public regarding today's meeting.

A transcribe of the meeting is being kept and will be made available as stated in the Federal Register notice. Therefore, we request that participants in this meeting use the microphones, myself included, throughout the room when addressing the subcommittee.

Participants should at first identify themselves and speak with sufficient clarity and volume that can be readily heard. Please silence all beepers. Thank you.

Since today's meeting is open to the public, we have an additional bridge line, Pete Riccardella is on it, set up for folks who have

requested a call in.

The phone line is in a listen-in mode at this time and will be opened at the end of today's meeting and tomorrow's half-day meeting.

Dr. Rempe has been identified as having a conflict of interest and will limit her participation, if that's possible, during certain presentations.

We have scheduled a spent fuel retrievability and NUREG-1927 for the April -- a meeting on NUREG-1927, the April full committee. However, the subcommittee will determine if it is necessary to go forward with the retrievability topic to the full committee at the end of this meeting.

We've had, as I said before, a couple of meetings on NUREG-1927 on April 8th and a subcommittee on high burnup fuel on June 8th in which we provide comments back to the staff on their work through the subcommittee.

We will now proceed with the meeting and I'll call on Mark Lombard, Director, Division of Spent Fuel Management, to give a brief introduction and introduce the speakers.

MR. LOMBARD: I was trying to hide over

on the side and Kris moved me up to the middle here.

So, we appreciate the subcommittee's time that you've set aside over this next day and a half to talk about spent fuel issues.

We'd like to start off with an overview of the spent fuel world. It's a large world, but we're just going to -- I'm going to provide an overview of some of the key topics.

Some of the things we're going to talk about in detail, but some other things that you may or may not be aware of relative to spent fuel storage and transportation, as well as radioactive material transportation which is part of our responsibilities in spent fuel storage and transportation business line.

So, the agenda for today for my talk is to go over roles and responsibilities. The spent fuel puzzle, the spent fuel world has a lot of pieces. And some of them grow and shrink and move, and some of them don't.

Seems like most of them do grow and shrink and move as we try to get our arms around this puzzle. And we're not sure exactly what the picture is going to show over the long term, but

we're trying to keep up with those puzzle pieces as they do move.

We'll be talking about specific topics today which I'll go over and I'll just briefly touch upon them, but I want to provide that overview and then introduce the topics.

So, we'll talk about roles and responsibilities as a business line, the work that we do in the Division of Spent Fuel Management, but we also have several partners around the NRC that help us out, as well as national labs and other consultants that help us.

Overview of what we do under Part 71 and 72. 71 for transportation and 72 for storage. The new paradigm. There's really a pair of paradigm shifts that have occurred over the last 15 to 20 years. Some of them more recent. A second paradigm shift has been more recent. I'll talk a little bit about that and how that's affected our work and the way we approach our work going forward.

A few words about interim consolidated storage, because it does have an impact. It's really that second paradigm shift that we've seen.

And then what I call "The Perfect

Storm," which is our workflow projections in the FY16 through FY20 period. There's a lot of things that are affecting us and it is driving our approach to the work going forward. Touch upon the ACRS topics, and then talk about successes that we have had in this new paradigm.

MEMBER SKILLMAN: Mark, before you change --

MR. LOMBARD: Yes.

MEMBER SKILLMAN: -- I would like to ask this question, please. I understand Part 71 and Part 72. I'm curious why you don't identify 49 CFR as part of the complex of regulations.

I ask that question because in our campaigns to shift the fuel from Three Mile Island, we found ourselves confronted by 49 CFR issues that we had never imagined and political issues dealing with Pennsylvania to Ohio, Ohio to Indiana, transport through Chicago, the almost untangleable knot of politics to ship that fuel on those rights-of-way and it seems that that is an integral part of what we should be talking about here in terms of transportation.

May I ask you to address that, please?

MR. LOMBARD: Sure. That's a very good

point. Part 49 transportation regulations are an integral part of the overall transportation picture.

As you know under Part 71, we certify the packages, the transportation packages. The Department of Transportation is the competent authority within the United States. So, they really regulate the transportation piece of it.

Now, there's an interface there and sometimes that interface is not always a bright line, but we do rely on them to do -- take care of the transportation end of it although we have some transportation security requirements within the 71 regulations and, in part, 73. But, again, that 49 is really mostly in the DOT's ball -- most of their ball to carry forward.

MEMBER SKILLMAN: How is that interface integrated or harmonized as we talk about what we are going to speak about for the next day and a half?

MR. LOMBARD: The next day and a half is going to be focused on 72 on storage primarily and we won't really get into Part 71 on the transportation side.

MEMBER SKILLMAN: Okay. Thanks, Mark.

MR. LOMBARD: Okay. Thank you.

So, roles and responsibilities, what we do. We do licensing, certification and inspection under Part 71 and Part 72. Part 71 includes not only spent fuel transportation packages, they're the ones that are most talked about within the business line's activities, but we also do radioactive material transportation package certifications.

Again, some of them in concert with DOT, some of them we do for the DOE National Nuclear Security Administration, but that's a big part of our work. It's about a third of our resources and about three-quarters of the cases we do every year. And those certifications usually move a lot faster than the storage certifications.

Part 72, spent fuel storage facilities, spent fuel dry cask storage systems, both the ISFSIs, the Independent Spent Fuel Storage Installations, and the spent fuel dry ask storage systems that are certified for use on those sites, we look at those as well.

And then as part of both the 71 and 72 activities and vendor, quality assurance and ISFSI inspections, we provide regional resources for them

to do the ISFSI inspections. We support wherever they request us to and respond to their technical assistance requests and other activities we get involved with there as well.

Vendor inspections, we have the three main vendors making systems today not only in the United States, but overseas they have some facilities overseas that they do fabrication. So, it's a pretty wide range of activities there and they've covered a lot of ground.

Our vendor inspectors cover a lot of ground over a three-year period. They're inspected every three years, every one of those facilities.

We coordinate with state and federal agencies. Most notably DOT, as we just talked about on the transportation side.

Part 49 we have regular conversations with DOT. They're coming up, I think, tomorrow for a meeting, an all-day meeting with some of our folks, but also EPA.

EPA doesn't get involved in a lot of our transportation storage activities. Only when we're working with ISFSIs we will interface with them to make sure, again, there's a clear handoff between our regulation and their regulation.

Foreign and international regulatory agencies, the IAEA, we've very involved with the IAEA and their work under the TRANSSC, the Transportation Safety Standards Committee. They have built an international set of regulations and requirements -- not necessarily the regulations, but requirements for transportation.

We look at those standards every time they're reissued. We were looking at the 2009 -- we did the 2009 incorporated back into our Part 71 regulations and that was complete last year. Last summer I think that changes to 71 went live.

We're now looking at the SSR-6, which is the new TSR1. It's their same set of regulations. They just changed the name and number for some reason. And we're looking at the 2012 version again to see what needs to be pulled into Part 71 to make sure our regulations are in appropriate conformance with the international requirements.

Native American tribes, we had a lot of interaction with the Prairie Island Indian communities. We were reviewing their ISFSI for renewal. And we have other Native American tribes that we do interface with on a fairly regular

basis.

The last one, the public outreach, it's been public outreach and in-reach and sideways-reach. We've had so much public interaction over the last three years. It's amazing.

It seems like from California to Massachusetts, from San Onofre to Pilgrim, folks are getting more and more interested in spent fuel storage and that we're glad to have that interest and we've spent a lot of our time interfacing with them through our Category 3 public meetings, other public meetings. And we also get direct interaction with them through emails and phone calls and that type of thing, but it has increased tremendously over the last three years.

Our division branches. We have primarily the top three are the technical review branches and they're primarily set aside by the technical discipline that's involved in each one of them; confinement, structural, thermal branch, or CSTB; criticality, shielding, dose and risk assessment --

MEMBER POWERS: Mark, I wonder if you could speak a little more about the -- what I'm interested in is the adequacy of expertise in

calculational tools for criticality, shielding analyses.

You do primarily confirmatory analyses there?

MR. LOMBARD: That's -- it's -- I'm glad you asked that question. That was really on my last slide of things looking forward.

We do some confirmatory analyses. And we do some review of the calculational methods that are used by the applicants, the vendors. And that's something that we're looking at very closely now going forward of are we doing the right amount of confirmatory calculations? Are we using the right tools? Are we looking at the right margins from the thermal criticality and other technical areas.

MEMBER POWERS: What I'm most interested in is the availability of adequate expertise and the availability of calculational tools that are readily used.

MR. LOMBARD: For criticality we use the scale software and it's been readily available and kept up to date. I think it's based in Oak Ridge; is that right, the scale system? It has been kind of our go-to tool for criticality

analyses.

MEMBER POWERS: Well, it is for a lot of people. The question is not so much what the tool is, but how useful is it? Is it taking huge amounts of manpower? Because you have --

MR. LOMBARD: Limited resources.

MEMBER POWERS: Well, and somewhat complicated situations that --

MR. LOMBARD: Yes.

MEMBER POWERS: -- and things like that. And, but primarily I'm interested in availability of talent with the right kind of training and things like that. Are there problems here or that we can forecast, or not?

MR. LOMBARD: Well, if I could phone a friend here, Meraj Rahimi is in charge of the CSRAB.

MR. RAHIMI: Yes, criticality, shielding and risk assessment branch is my branch. And in terms of the expertise, first of all, the tools, scale, as Mark mentioned, is the codes that in the late '70s it formed the entire development of SCALE package by the NRC in the late '70s.

And NRC has been the major contributor in development and improvement of that code.

That's our main tool.

Of course my folks, you know, they also -- we use MCNP as well, which normally if the package comes in, you know, they've used SCALE, will try to use a different code and to cross-check the results.

And we have been funding the improvement in terms of cross-section, updating cross-section for the past, you know, many years. 30-40 years. And roughly, you know, the funding from the NRC part is about 700k a year.

And the SCALE team at Oak Ridge National Laboratory also gets fronting from DOE, from NNSA. So, the funding for that tool, the improvement of that tool is about, you know, two to three million dollars a year.

And so, we are constantly improving and very -- in this fiscal year we're trying to make a tool -- what is called a template base to be very easy to use and quick to use because when we get application, we don't have that much time for modeling. So, Oak Ridge is developing templates, fuel templates, cask templates, canister templates for us. So, it's constantly we're improving that tool and about a dozen of engineers, mainly nuclear

engineers in my branch, and they are very versed and very qualified and very capable.

MEMBER POWERS: Well, I have no doubt about that, but tell me about 2020. Are you still going to have the same cadre of folks, or do you have to improve, or what? What's the situation?

MR. RAHIMI: There is same -- pretty much I guess my unit, my branch, as far as I know. The folks, they don't have any plans leaving. And we've got people with a lot of experience in there. Maybe by 2020 we'll have one or two individuals leaving, but we're constantly, you know, hiring people.

I mean, about, I guess, two years ago we got a Ph.D. from Penn State, you know, he was -- all his research was in cross-section development. He joined our team. So, we're constantly looking ahead and --

MEMBER POWERS: So, you don't see any problems with the manpower and expertise in this area?

MR. RAHIMI: I don't believe so, because we have a very good support from Oak Ridge National Lab. The people who have developed the codes, you know, when we need to, we always go to

them.

And in terms of any difficult issues, problems or phenomena that we see from using the codes, we have a very good support from Oak Ridge National Laboratory.

MEMBER POWERS: Thank you.

MEMBER SKILLMAN: Let me build on Dr. Powers' question. Sir, how is the institutional knowledge retained? I mean, these are smart people that they may retire or go someplace else and this is a fairly sophisticated technology in of itself.

So, how is the institutional knowledge maintained so that future certificate seekers benefit from all of the learning?

MR. RAHIMI: Good question. Two years ago we instituted developing an in-house training course in terms of the people who are new joining our team, the knowledge is transferred from more senior people.

So, we gave our first in-house training course, which the staff will be working for the past decade on doing confirmatory calculation. Based on their knowledge they put together this course and this was on the shielding side.

This April we are completing our second

training module, which is the criticality safety, which again the entire staff has put together the course and that is going to be our tool to transfer the knowledge from the more senior people to junior people, the two in-house training courses.

MR. LOMBARD: The other piece is when you look at the documents, the deliverables that we issue when we issue a certification review or approval, it's really in the SERs.

The SERs have a lot of that background information of the basis for the finding and our Office of General Counsel is very good at keeping us honest from that standpoint and making sure we have a solid basis for each finding that we make.

And when you look back at what applicants used to look at in the future to try to determine how much of an in-depth review we're going to do in a specific area, I really think the SER can provide that, that feedback for them.

MR. RAHIMI: I would like to add one more thing that in addition to that, that -- over the past several years we have formed technical committees. And there are two specific technical committee in my branch. We call them -- one is the Grand Criticality Council. The other one, Dose

Busters.

These are the two technical teams that they bring up the issue of the day. If one person has work on a case which is unique, they bring to everybody. Everybody shares the knowledge and we get together both of these technical disciplines on a monthly basis to share their experience/knowledge from each different cases.

MR. LOMBARD: We also have the Sizzlers, don't we?

MR. RAHIMI: We have several other technical -- we have the Sizzlers. We have the Leakers. These are all the technical groups we form to get together and discuss, transfer knowledge and share the information.

MR. LOMBARD: Next branch is the materials and renewals branch. And this is a branch that really came out of our merging with FSME back in October 1st -- or October 6th of 2014, when we merged together to create the new NMSS and we had some organizational changes. Renewals, materials branch is really one of those large changes.

And we set up that branch to really become the focal point, because as you look at

renewals for CoCs and ISFSIs they're really materials focused. So, we wanted that branch to take the lead, put our materials folks into that branch, all of our expertise there, and then also project managers.

So, when we -- the next renewal that comes in, the North Anna renewal which is coming in, in May of this year, the Renewals Branch will take care of that. They'll project manage it, it won't go to the Licensing Branch. They'll project manage it and have all the technical expertise within that same branch to move that forward and take care of that review.

And then after that, the project managers will be -- are responsible for the rest of the licensing actions that we do both on the transportation and the storage side and the primary project managers with the branch chief.

We have our fifth branch is QA, Inspection, Oversight and Rulemaking, the IOB, Inspections and Oversight Branch. They take care of the cats and dogs of the rulemaking process, oversight that they interface with the regions frequently on, the inspections going on in the regions.

They do the vendor inspections and other activities to all the assurance plan reviews and that type of thing.

And there's a sixth branch within the division now that didn't make it to this slide. I'm sorry, I had an oversight. It's the Long-Term Spent Fuel Management Branch. It's a branch that we lost the branch chief last year, last December. He took one of the early outs last December.

(Laughter.)

MR. LOMBARD: He probably foresaw that. I don't know. But that branch was set up to take care of primarily extended storage and transportation activities. That's something that was initiated through an SRM back in the 2010 time frame to look at storage periods of 120 years and beyond, which means really 60 years of wet storage, 60 years in dry storage and then look at that storage period beyond that second 60 years.

We define it to be really the 120-year to 300-year time frame. And as Al did such a good job, and Kris Banovac and John Wise and Ricardo and the rest of the team did such a good job building this new regulatory framework for renewals, we found that that framework is so sustainable,

predictable and reliable going forward that we didn't really need to focus our energies on those extended storage and transportation issues, because the renewals framework is taking care of those as they go. It's a learning -- sustainable framework going forward.

Next slide, please.

MEMBER SKILLMAN: I need to ask one more question.

MR. LOMBARD: Yes, sir.

MEMBER SKILLMAN: This one has been eating at me since I read the revised ISG and particularly the comments from industry.

You present here what are really review branches that are fairly sophisticated in their analytical approaches to this whole issue.

Who gives consideration to the practical stuff? To the mechanics, to the technicians, to the rad techs, to the people who have to hop around and deal around with these casks, who take the shield overpack off, unweld the lid or reweld the lid or ensure the lid is put on properly so it doesn't leak?

And I'm going to keep on this theme through this whole presentation. I'm going to pour

in on the ability to safely remove with no operational safety problems. That's a new addition to ISG-2, I think, but at least in my mind it brings up a whole host of practical issues.

For instance, you can have the greatest shielding, confirmation that k-effective is less than 0.5, so you're very comfortable, you have no criticality issue, but working the cask can be an absolute nightmare because the lid is too small or it's complicated.

And if you get a container, a subcontainer caught or stuck if there's no shielding problem, if there's no radiological problem, but it's a situation where the cask is in between and the whole operation at the site comes to a halt because it's series process, is that an operational safety problem? I'm not sure.

Hence, I can see comments from industry raising that issue. And so, I raise that here. Which of these branches is really looking at the practical stuff that really impacts the people who own and operate these cask systems? Where is that addressed?

MR. LOMBARD: So, it's a great question. It's something that we kind of fell upon

over the last few years. And the IOB, the QA inspection folks, we have four awesome inspectors, at least one of them is here today in the back of the room, and what we do during the reviews is get them involved in reviews to the maximum extent possible.

And at the same time, we're also trying to get more of our reviewers out to actually see these things during loading campaigns and dry runs just to make sure that they don't just think it's a piece of paper with a large drawing on it, that these things are 150-ton massive structures sitting out on the pad and that there's a lot that goes into the operation, a lot that goes into the loading and the drawing and vacuum drawing of these systems and in the transfer, you know.

So, it is something that we were sensitive to. We haven't -- we don't do it as much as we'd like to, but we have a thought, you know, trying to get those inspectors involved in every review that we can possibly going forward.

So, there's two that are very vocal, right?

MR. RAHIMI: Let me just add that we're aware also that we don't want to be an impediment

during operation, as well. So, most -- as part of the qualification process for technical reviewers in the three different branches there, one of the -- so, as part of the qualification process for the technical reviewers in those three, they have to go out to do some sort of inspection or some seed of practicality that you're asking.

We tend to send them off to dry runs for the campaigns, because we don't want -- I came from an experience where I think it was somebody from an Exelon plant in Chicago area. I can't remember which one, but to do an inspection of pipe there was 12 people overseeing three people. Several from the state, several from NRC and, you know, we're aware of that.

So, that's -- in this case, it's part of the qualification process to be qualified technical reviewer for the technical disciplines and we send them out to these dry runs rather than direct, you know, when you guys are -- when plants are operating.

MEMBER SKILLMAN: So, to repeat back what I think I just heard, there isn't any specific discipline. It is really handled through the oversight of the process.

MR. RAHIMI: It's in the IOB branch, and the IOB branch reaches out, because they're the ones that interface with the regions and with the inspectors. And they reach out to the technical branches for the specific technical disciplines and it's up to the branch chiefs to get the right person involved.

And we've had instances in the past and we've had to deal with just exactly what you're saying and looking at what the impact of doing some sort of repair or replacement action. Last year we've probably about three or four, right, of them and get the right people involved and look at the total picture. Not just compliance, but also safety for, you know, for everybody.

MEMBER SKILLMAN: That seems to me that -- and I'll hang onto this through the rest of the meeting, calibrating the people who are interpreting the ability to safely remove with no operational safety problems. If those are the IOB people, that's where the calibration and that language needs to connect accurately so that a practical problem that is truly a non-safety issue does not get interpreted to be a safety issue.

Because once it's interpreted to be a

safety issue, that poor licensee is stuck. And so, there needs to be the recognition that sometimes a sledgehammer to take a subcask out is sufficient and appropriate and that is not a safety problem. That's a practical issue that people at the plants work with every day.

MR. LOMBARD: Absolutely.

MEMBER SKILLMAN: So, we'll talk about that later on.

MR. LOMBARD: And they're good at those -- solving those operational problems. Absolutely.

MEMBER SKILLMAN: Okay. Thank you.

MR. LOMBARD: Many of us have come from operational backgrounds and spend time at the plant sites. So, we're very sensitive to that as well. So, I appreciate you bringing that up.

MEMBER SKILLMAN: Thank you.

MR. LOMBARD: Part 71, transportation of radioactive material, about a hundred active certificates in compliance that we have right now.

We do 50 to 70 or so transportation cases each year, including spent fuel, medical and industrial applications, medical sources that are used for cancer treatments, other sources used in radiography devices and well loggers, power

research reactors, fuel cycle facilities.

So, it's a lot of the work that we do every year. As I said, about a third of our resources are in Part 71, transportation -- radioactive material transportation.

We work closely with DOT on Part 49 in both domestic and international transportation. Issues come up with transportation packages. We're typically called in to help DOT assess in any issues that come up with transportation packages.

I will say the Type B transportation packages, there's about three million transportations every single year. There's probably one going by the building right now actually in the back of a FedEx truck. About three million a year throughout the United States of those Type B packages, which are moving medical sources around the United States and around the world.

We coordinate very closely with Department of Energy, NNSA, states and IAEA on international transportation, international transportation requirements, but also with the nuclear navy.

As you probably are aware, we've

reviewed both the M-140 and the M-290. Transportation systems for spent fuel from the Enterprise is the M-290. It's a large 200 and some -- 220 some tons. Sits on a railcar with, I think, 15 or 18 trucks on it. It's very large and we actually did kind of a courtesy certification of that system for the nuclear navy.

Part 72. There is a picture of a HI-STORM 100 storage system there on the right. It's a canistered system. You see the canister in the center and the concrete overpack on the outside and the lid -- shielding lid going on the top.

About 12 active storage CoCs right now. Again, three main vendors. Although, there's four with active -- well, actually more than four with active CoCs, because there's some storage even outside.

There are three main vendors right now, you know, Holtec, NAC International and AREVA-TN. There's another one, Energy Solutions, has about three sites. Their systems are at three sites now and there's one or two other cats and dogs out there, but really 12 active storage CoCs right now.

20 to 30 storage cases each year. We coordinate closely with DOE. I don't know if

you're aware, you know, but within DOE Nuclear Energy there's really two legs within their organization that we deal with and we try to meet with them on a quarterly basis.

One is the project planning site, which is looking at what does it take to deploy storage sites and repositories with the United States although their level of activity in both of those areas is somewhat relative, but we deal with them pretty much on at least a monthly basis in looking at supporting to the extent that is reasonable for us, their consent base signing activities that are ongoing now at the meetings that they're planning starting next week around the country.

The other side is the research and development organization. Now, we do research. They do research and development. We don't do development, we don't promote, we're just an independent regulator, but we do work with them to make sure that the dollars that taxpayers give both of us are spent appropriately on research and development activities and we're solving the right problems.

We try to define the regulatory issues, the technical issues related to the regulatory

issues that we try to solve within each one of those activities and, again, collaborate on those activities going forward, make sure we're solving the right problems. And at the end game, the outcome is clearly defined when we start off on a research activity.

Significant engagement with stakeholders, as I said, from California to Massachusetts. We actually have a lot more engagement with stakeholders around the country and we expect that to continue going forward.

So, here's kind of our world at least in the United States, the world of spent fuel storage around the country. 60 reactor sites that have general license ISFSIs, 15 with specific license ISFSIs.

There's two that have one of each. North Anna and Surry have one of each. They have a general and a specific ISFSI. They're separated by a fence between the two pads. And it's interesting -- I don't know if you've dug into Part 72, but it's -- the way we define the difference between generals and specifics if you have an operating reactor Part 50 license for a reactor and you want to start an ISFSI, essentially send us a letter.

You pick a CoC, an active CoC that matches your fuel type and your needs for your operation of considerations and you're ready to go as soon as you build the ISFSI pad.

You build it in accordance with your requirements and your Part 50 license and any state and local requirements that you have to meet and you're good to start operating the pad after we do inspection on the security and also the safety side to make sure that you're complying with the Part 72 requirements.

The specific licensed ISFSI is a little different. You don't necessarily have to pick a CoC. You can start off from scratch with a new system that again meets your operational needs. And we would do it from scratch a review on the safety, security and environmental aspects of your ISFSI application.

Now, there's a couple different kinds of ISFSIs, site-specific ISFSIs. Maybe three different kinds. As I said, North Anna and Surry both operating nuclear reactors. They have a general and a specific licensed ISFSI.

There are other sites like the Yankees that have -- they don't have -- they decommissioned

and dismantled their reactor. All they have is an ISFSI there and then those are general licensed ISFSIs.

And then you have wave reactor ISFSIs. Those like PFS that's been licensed, but never constructed or operated and a couple that we're going to talk about in a few slides here, interim consolidated storage facilities that would eventually planning to be away from reactor ISFSIs under Part 72 and it would be specific licensed ISFSIs.

So, what is the new paradigm? When spent fuel storage was first envisioned, it was envisioned to be a very short duration by -- I think the time frame was 1998 we thought that Yucca Mountain would be taking spent fuel and putting it in the repository there.

That hasn't worked out as planned. So, the first paradigm shift was longer storage periods much longer than the initial 20 years. When we first started licensing storage systems, we did license them only up to 20 years.

The second paradigm shift was now as a potential interim consolidated storage, two potential sites in the United States. Now, we're

looking at the paradigm of the 72-71-72 paradigm meaning storage followed by 71 transportation, followed by storage.

And then if the Department of Energy implements its entire strategy that they issued in January of 2013, there would be a repository into that as well with potentially another Part 71 transportation and then storage interim repository.

The DOE TSAR, DOE is thinking about building a topical safety analysis report for consolidated storage. I think the quotes I've heard from DOE is that more is better, more storage sites are better and they intend to submit that to us in the near future for our review and approval.

It would be, again, a generic topical analysis report. Nothing specific, nothing site specific, but provides some bounding considerations that would be part of the topical safety analysis report.

MEMBER POWERS: You're not responsible for the proposal of interim consolidated storage, but it seems -- it always seems remarkable to me you do have all these sites that you are responsible for and now somebody wants to create the megasites.

Do you have any views on that?

MR. LOMBARD: We have a lot of views on interim consolidated storage, which could take --

(Laughter.)

MEMBER POWERS: Do you have any views you'd care to share with us?

(Laughter.)

MR. LOMBARD: It's, you know, from our standpoint, from a safety and security standpoint it doesn't matter whether you have distributed interim consolidated storage facilities, the 75 or so sites that are out there, or you have consolidated storage, they still meet the -- as long as they still meet the requirements, it doesn't matter to us.

As a taxpayer, it seems like there are some economies of scale that could be appreciated if you do the consolidated storage, but again it depends on what is that end game? What happens after that point? Where is it going from there?

Because we know what we hear are about the communities are interested in having --

MEMBER POWERS: Well, I mean, it seems to -- just offhand to me, I mean, you've got places to store fuel. Now, you want to pack it up and

ship it to another place. That seems an unnecessary shipping step which necessarily involves some risk.

MR. LOMBARD: Yes.

MEMBER POWERS: Now, we're assured regularly it seems that that risk is truthfully very, very small, but it's risk, nevertheless.

MR. LOMBARD: Yes, and you're right. It's very, very small. We were here before you, I think, two years ago to talk about the spent fuel transportation risk assessment showing that he risk of transportation is less than that that you would get from background radiation.

So, it is very small, but, yes, you're right, there is an increase in risk when you start to transport.

And it's -- there's a lot involved in the transportation. So, the -- the best solution might be if you had a consolidated storage site that's very close, if not right on the same site that you're going to use as a repository, but that doesn't seem to be the case with the two that potentially submit applications in.

So, interim consolidated storage. Right on cue. We have received two letters of

intent, one from Waste Control Specialists and one from Holtec/Eddy Lea Alliance, to submit applications in 2016.

We actually a week ago Monday, we went up to Columbia, AREVA-TN's offices there, and took a look at the draft Waste Control Specialists' application for consolidated storage just to do an audit, as you're very familiar with the new reactor operations. They do look -- they do audits on -- pre-application audits of different applications.

We took a cue from them and did the same thing just for several reasons. One, to get our eyes on the application and get a feel for, you know, is it a 15-volume reactor application, or is it a couple of volume, you know, application for consolidated storage? And it's more the two-volume size. And also to get familiar with it. What kinds of things is this going to contain?

Not many folks, I don't think anybody is around that actually reviewed the PFS application in the mid-'90s. So, we're starting from scratch from a learning curve, a knowledge management curve, although we have interfaced with at least one of the project managers that was on the PFS review and trying to kind of drain his

brain a little bit of some of things they looked at, what are the challenges, what are the things that we could learn from him in the review of that PFS application going forward.

We also have a lessons learned document that was put together soon after PFS was approved. And we've taken a look at that and that's helping us to define our project strategy going forward with the two applications.

As mentioned, a potential DOE TSAR, which will be a generic system defined, this generic storage -- consolidated storage site. It's not site-specific. Hopefully we'll provide some bounding for the environmental conditions and the seismic conditions for that site in a couple years in the future for another entity who would want to submit an application for consolidated storage.

Part 72, this is a question that came up a lot a couple years ago. Can you license these facilities under Part 72? It is adequate as written for storage and packaging.

Folks have asked is it adequate for repackaging? And when we look at repackaging, it's just packaging again. So, yes, Part 72 does cover packaging adequately.

We continue to monitor and coordinate as appropriate with DOE and industry. Again, we have those quarterly meetings with the DOE project planning side who's responsible for development of the TSAR.

We have a little bit of a tricky relationship there as they get to the point where they actually start developing an application or developing a TSAR. Then we switch over from government-to-government to government-to-licensee. Feature potential licensees so that our relationship for that specific activity would change and we would start having public meetings on that specific topic and move forward on that.

And in industry, we participate with NEI and other industry members directly, licensees directly in many different situations, topics and issues on a very frequent basis.

So, the perfect storm. It's something that we started working on a few years ago. We actually, I felt that what -- our ship there in the middle that's raging along in the high seas, it really looked more like an old World War II battleship a few years ago.

We had a lot of things that we have

changed in our process, in our technical approaches, and we feel that we're a little more sleek than we used to be. We have a little less baggage, little less weight than we were carrying before.

And you see our normal workload there on the top left and that continues to be the hurricane that it's always, always there.

The DOE TSAR, we don't know exactly when that will be submitted. We're thinking it's probably in the '17 time frame, but DOE hasn't gotten far enough long on --

MEMBER POWERS: Where is your biggest man-hour burden?

MR. LOMBARD: The biggest man-hour burden, most of our resources are in the storage side -- on the storage side, storage application reviews.

MEMBER POWERS: In the reviews or the monitoring and --

MR. LOMBARD: Mostly on the reviews. The monitoring, the oversight is not as big as our reviews, for sure. It takes -- storage applications, they're getting more complex as we go forward. They're getting -- they systems are

bigger, the higher heat loads. There are some -- I wouldn't call them necessarily -- well, yeah, I guess I would say exotic materials in some cases that have been used for basket materials and other materials of construction.

So, it's caused us to really sit back and really learn what are those materials, what are the material properties, how are they going to change over time over the license period for that system?

So, yeah, they have gotten more complex. So, we are making -- we're spending more time as we go forward on each individual application in general.

CHAIRMAN BALLINGER: So, are you spending time -- to follow through on that, what you're saying is you're spending time allowing staff to become more educated on these materials and other things so that they can do a proper review?

MR. LOMBARD: Absolutely. Friction stir welding is a great example. And how did we do that? Well, we sent them over to the site to watch friction stir welding, get very familiar with the materials, the process and made sure that they

understood everything that we needed to understand to make a safety finding on that particular operation.

So, we try to do the hands on, get your eyes on it and see what actually goes on there.

MEMBER POWERS: Are there technological improvements in software, things like that that could reduce your man-hour requirements in that area?

MR. LOMBARD: That reduce man-hour requirements? Initially, no. But long-term, yes. When you look at modeling, CFD modeling has tremendously improved over the years, you know, from the two-dimensional modeling to three-dimensional modeling now. And you -- it takes you some time to get familiar with modeling strategy and to understand what kind of result it's going to give you.

But in the long-term, they're giving us better results, I think, and helping us to look at can we now slim down those margins that we've been using in the past to --

MEMBER POWERS: Yeah, I'm just looking to, you know, how can we -- can we use technology to -- in the place of man-hours? In this sort of

thing are there expert systems that would assist? Anything you can do to cut down on your man-hour requirements because, I mean, quite frankly, man-hours are expensive.

MR. LOMBARD: Yes. Absolutely. And that's a good point. If you have any ideas, we'd love to hear them. We have a few that we have in play, but if you have any other ideas we'd like to hear them, too.

MEMBER POWERS: I don't, but, I mean, it seems like -- it seems like that's where I would focus my attentions where you're expending the most man-hours --

MR. LOMBARD: Right.

MEMBER POWERS: -- because small -- relatively small improvements can make big dollar changes.

MR. LOMBARD: Yes. Absolutely.

CoC and ISFSI renewals, you'll see a graph here in another slide or two that will talk about the timing of the ISFSI renewals and CoC renewals going forward. And then you see the twin storms there, WCS and Holtec.

We didn't have in our FY16 budget, we did not budget for review of two consolidated

storage facility applications. So, we're reprioritizing our work going forward to make sure we have the resources available for that purpose.

So, our topics, our meeting topics today, there's a lot of pieces to this puzzle and only a few of them are shown here. The ones that are rimmed in black, black borders, are the ones we're going to talk about with you today and tomorrow morning.

But if you look at storage on the left, things on the bottom, dry storage system performance, extended storage, as I said earlier, we're looking to start to close those out, those activities out this year and we're going to be sending a memo up to the Commission in the May -- by end of May telling them that we're essentially closing out extended storage activities going forward because Al overachieved on his renewal framework that he built for the renewal, so ISFSIs and CoCs going forward, which is a good thing.

Initial storage terms, again, we were at 20 years initially when we thought that there would be a repository available. We eventually changed the requirements. They could get a renewal term up to 40 years or even initial term up to 40

years. So, we're learning as we go forward and changing our approaches.

The top three, risk informed, fuel performance and renewals you'll hear about this morning and a little bit more on renewals tomorrow.

Retrievability is really the link that links storage and transportation together and then obviously have fuel performance not only in storage, but in transportation as well.

So, the first one is renewals. And you see our little graph there on the top right. You see for the first few years we have a single application. The dark blues are the site-specific, the ISFSIs, and the light blues are the CoCs, certificates of compliance.

And this year we have one coming in, and that is North Anna. Two coming in next year. When you see in 2020, we hit a large peak. There's four -- one, two, three, four, five, five CoCs and one ISFSI renewal in 2020.

So, we looked at -- luckily we looked at this a couple years ago and said there's a bow wave coming. We've got to do something about it. How are we going to handle this within our resource constraints? Because everybody has resource

constraints.

And we thought about what are the -- what are the key aspects of renewals that we really need to focus on and aging management programs, time-limited aging analyses are required in the Part 72 requirements for renewals. Aging management programs is the area that we felt we should focus on because they're materials driven.

So, we built an operations-based system for aging management programs going forward. NUREG-1927 Rev 1 is a key piece of that going forward. It's going to feed other documents that we have going forward, the MAPS report, the Management of Aging -- I always have trouble with the P -- Management of Aging Process for Storage.

We almost called is a storage aging management program, but SAM just didn't -- we didn't want people to get confused with SAMGs as going forward. So, we --

MEMBER POWERS: Our former chairman would have loved it.

(Laughter.)

MR. LOMBARD: So, part of this, again, the focus or renewals is aging management programs. The focus of aging management programs are the

inspections that have to be conducted under that aging management program. We looked at what are the appropriate monitoring and inspection techniques and time frames.

And as you can imagine, the systems weren't necessarily designed for that up front. So, the industry, we are promoting within the industry, we're encouraging them and pushing them in many cases to develop better techniques, better ND techniques for monitoring storage canistered systems, for example, monitoring the surface of a canister, monitoring the heat effective zones of the welds on those canister, how can you detect cracks, how can you detect the depth of cracks. And those are the types of things we want to see and those utilized as part of the aging management program inspections going forward.

And then also assessment of the monitoring data and inspection findings against acceptance criteria. Reporting, aggregating and trending of operating experience, because as you can imagine, we, the collective we, and I mean us in industry, haven't really collected all the operating experience information that we should have been collecting over these last 20 plus years

of storage.

So, as part of the renewal framework, it requires operating experience to be collected. And I give the industry kudos, because they've worked with INPO and they have an agreement now within -- with the four main vendors of actually they're building a program. They're going to start actually feeding information to it that will have some access to, level of access to, and the individual vendors will have access to as well going forward.

MEMBER SKILLMAN: Mark, wouldn't the -- excuse me.

MR. LOMBARD: Go ahead.

MEMBER SKILLMAN: Mark, wouldn't the corrective action programs --

MR. LOMBARD: Absolutely.

MEMBER SKILLMAN: -- from the past couple decades provide a treasure chest of information? I would think reporting on site would provide at least a pointer to we've got a leak, or we've got a crack, or we've found something.

MR. CSONTOS: So far those don't -- well, in the past they haven't expected the canisters. So, that's the only thing that we would

find out about is whether or not there was a nest in one of the thermal vents, you know. They would take those out. Was there any dosimeters around the periphery of the pad would something happen there?

But, you know, in this case we do have some OpE for certain types of tasks. But a canister that have an overpack on the is a different animal.

North Anna, for example, pinks their casks. Their casks are carbon steel, not stainless steel. And so, you can easily see a rust spot and they -- we have -- we have heard about the corrective actions they've done there. They repaired those locations.

Those are easy to get, but the other ones looking inside a canister, that's fairly new.

MEMBER SKILLMAN: Thank you.

CHAIRMAN BALLINGER: I can understand all of the local inspection things that we've talked about many times. I'm curious as to whether you've explored more global inspection techniques that don't require a lot of effort to go down inside and look for cracks and things like that.

Have you explored techniques that would

tell you that you need to focus more carefully on one particular cask, but from a more global perspective so that you can reduce the burden and workload of having to do a lot of inspections on casks?

Maybe I'm not wording it right, but simple -- very simple things that you can measure with respect to these casks that tell you that you maybe should go a little bit more carefully rather than sort of just inspecting everything.

MR. LOMBARD: And you don't inspect every one. There's a strategy associated with that, a sampling strategy. If you identify anomalies, then you increase your sample just like you do in the corrective action program for any other issues.

CHAIRMAN BALLINGER: But an anomaly doesn't necessarily mean a leak.

MR. LOMBARD: Absolutely.

CHAIRMAN BALLINGER: Okay.

MR. LOMBARD: But we want to identify the precursors. If there's general corrosion on a canister, then that would implement -- you go to the next step and --

MR. CSONTOS: So, what are you asking

about? Are you asking about the temperature, relative humidity, all those --

CHAIR BALLINGER: Those kinds of things.

MR. CSONTOS: Yeah, so EPRI -- and EPRI can discuss this when they're up here. You can ask questions, but there's a chloride SCC susceptibility report that they just published, I think, September of last year or last fall. And what it goes into, it goes into all those different parameters.

And for the -- and we just wrote a letter, gave comments back to EPRI. We're going to be closing out the chloride SCC RIRP program. I think it's regulatory -- Regulatory Issue Resolution Protocol. That's the NEI protocol, right.

CHAIR BALLINGER: That M-10?

MR. LOMBARD: Correct. Yeah.

MR. CUMMINGS: Kris Cummings, NEI. So, yeah, a lot of questions that you're asking we'll be able to address either in my presentation or Keith Waldrop's presentation from EPRI on the things the industry has been doing working with the NRC, proposing some things. You talked about the

aging management INPO database. We'll be collecting that information.

One of the things to your question, Gordon, about the previous OE catch programs is we will be looking to entering in that information into that database as we get it up and running and collecting new information.

CHAIR BALLINGER: Because this is the first presentation that I've seen here in two years with the words risk-informed are actually on one of the slides.

MR. CSONTOS: Oh, yeah. This is, you know, the extent of condition, you know, we're going to -- the criteria for how to inspect, which ones to inspect, how many to inspect, that's ongoing through the ASME code because of -- we're not operations folks, you know.

So, what we did is we asked the ASME code, because we brought in all the vendors, the licensees, the people who are doing this work to come up and help us with let's focus what we need to do in terms of inspections.

So, it's ongoing right now, but the point is, is that we have criteria that we can do to focus onto one or two canisters at a site. And

then from there if we do find something on those higher risk canisters, we then have to look at extended conditions corrective actions. And that's all licensee-driven, will oversight -- give oversight to those processes, but that's primarily what we're doing is we're giving the tools back to the licensees to go ahead and figure out what those steps are and start off with an initial set going into a larger set if need be.

CHAIR BALLINGER: I'll keep bringing that up.

MR. LOMBARD: Sure. Please do. That's a good point.

MEMBER REMPE: Talk a little bit about orphan sites and what happens with the license when it goes from an operating plant to a shutdown plant.

Are any of the ones on your earlier map, orphan sites?

MR. LOMBARD: Yes.

MEMBER REMPE: Are there minimum requirements like they're got to maintain the capability for repackaging required for an orphan site, or is there anything -- what happens with orphan sites?

MR. LOMBARD: They don't require to maintain the capability for transfer. It is not required.

MEMBER REMPE: But isn't that something that's required of the utility when they were operating the plant? They have to be able to ship the stuff offsite?

MR. LOMBARD: It depends on the system. There are some system tech specs that have that requirement to maintain that capability to repackage, but it was something that wasn't put in for -- due to a safety concern.

MEMBER REMPE: Okay.

MR. LOMBARD: And, actually, we're actually processing some revisions to those amendments now to take that requirement out of the tech specs.

MEMBER REMPE: Okay. And the renewal when it goes from an operating plant to a shutdown site, there's nothing that changes the ISFSI and the licensing on that until it comes up for a regular renewal?

MR. LOMBARD: Only the imposition of aging management requirements.

MEMBER REMPE: Okay. Thank you.

MR. LOMBARD: You're welcome.

So, moving on to fuel performance, this is one of my favorite topics. And the system that I was referring to at North Anna is a TN-32, just so you know. It's a TN-32 metal system, metal exterior vertical system.

And they also have -- that's if they're a specific-licensed ISFSI. And if they're a general-licensed ISFSI, they have the NUHOMS System, which our canistered system -- just to be clear on what they have at North Anna. And the NUHOMS are the horizontal systems.

So, fuel performance, we spent a lot of time talking about it and looking at fuel performance as part of our reviews of each system, transportation and storage system that we look at.

Two main aspects. One is a demonstration project, the DOE industry demonstration project. You see there on the right, microscopic views of fuel clad hydrides. The top left is a circumferential hydride that -- for high burn-up fuels. You'll -- depending on the hydrogen uptake capability of the cladding, those are subjected to high temperatures during vacuum drying.

Those circumferential hydrides can reorient to radiohydrides and can create a design -- DBTT, ductile-to-brittle transition temperature, which would be more -- actually be more accurate to call it a less ductile transition temperature. It's not necessarily ductile-to-brittle transition temperature. It's somewhat of a misnomer, but you'll see there that's the mechanism that we're concerned about when we look at these.

Now, our position is -- our position is that long-term storage and eventual transportation of all cladding types we've reviewed and approved to date is safe.

We've never identified a safety issue with those that caused us to not be able to approve the systems that we have put into play.

The demonstration project is intended to take four fuel cladding types for North Anna. And North Anna has submitted a license amendment request for this TN-32 system that will be used to actually house this, the demonstration project. And we're -- that's an active amendment that we're looking at now. So, we can't talk about that aspect of it, but just the science piece is the actual fuel itself, four different fuel cladding

types placed into this TN-32.

It will be monitored, pretty much online monitoring of temperature, and off gas will be monitored every, I think, two to three times during the ten-year planned storage period of the system.

At the end of that time, the plant is to send that cask to an area that has a hot cell that can remove the fuel and do some material property testing of the fuel itself.

Now, fuel pins have been removed from the assemblies already. They've been shipped to Oak Ridge, right? Oak Ridge. And those will be tested to set up some baseline material properties for those -- the four different cladding types.

We're closely monitoring it. We did make comments on the test plan and reviewing, as I said, the license amendment for the demo cask itself. But, again, our position is that long-term storage and demonstration of all cladding types, including high burnup fuel, is safe. And that's being further demonstrated by the testing we're doing at the Oak Ridge National Lab taking some high burnup fuel samples from H.B. Robinson plant, putting them into a CRIFT, I think it is, which is

a device that provides a moment on the sample itself, actual sample of the fuel assembly or the fuel rod or fuel pin and subject it to a higher than the loads that we would expect to see during normal conditions of transportation and we're seeing some very good results from that testing going forward.

We issued the Phase 1 test report last summer and we're going through the Phase 2 testing now.

MEMBER POWERS: How do you know what normal loads are? I mean, some of the roads are pretty spectacular in this country. Some of the roads are excellent. And, I mean, how do you know what the normal loads are?

MR. LOMBARD: Lucky for us DOE's done some testing of that. They've taken a dummy fuel assembly, not an actual fuel assembly, but a dummy fuel assembly and they've measured the loading that you would see during some pretty crummy roads, I think, there in New Mexico. So, they have some idea of --

MEMBER POWERS: All of the roads in New Mexico are pretty --

(Laughter.)

MEMBER POWERS: I'm here to testify. And we all drive very fast.

(Laughter.)

MEMBER POWERS: And long distances.

MR. LOMBARD: So, we do have some feel for what the normal loads are.

CHAIRMAN BALLINGER: I mean, don't most transportation vehicles that are related to nuclear have accelerometers and all kinds of stuff on their packages anyway? So, they pretty much know what the roads are like.

They actually have a recording for -- if you're delivering fuel, they actually have a recording of all of the various things that go on in transportation between the site -- between the fabrication facility and the site, right?

MEMBER POWERS: I suspect they haven't driven past my house. You would be more terrified.

(Laughter.)

CHAIRMAN BALLINGER: By the sandbags.

MEMBER POWERS: Sandbags? How about deep pits.

MR. LOMBARD: Meraj Rahimi will be talking more about that in fuel performance going forward.

So, this is Dr. Ballinger's favorite slide so far, I think, risk-informed regulatory framework. This is something that we knew we had to do. As we looked at our environment, our world at the NRC in a world of spent fuel, we knew we had to start looking at risk-informed.

And, actually, the RMRF, the risk management regulatory framework folks put together the document NUREG-2150, I think, is the number. And spent fuel, transportation spent fuel storage were parts of that document that was issued and had some recommendations for us to consider in a spent fuel world.

So, we've taken those recommendations to heart, we've built an approach and we're off and running to implement that approach and to find for storage at least initially, to find a regulatory framework that we could use that would better inform our decision going forward with the focus on safety and security, obviously, going forward, but to be more effective in the decisions that we make to be more sensitive to the fact that these are very large, robust systems.

And there were two pilot PRAs done some years ago. One done by the NRC, one done by EPRI,

Electric Power Research Institute.

They looked at latent cancer fatality risk over the first year of operation, which included loading and transfer to the pad and sitting on the pad for about a year. And they came out with about a 10 to the minus 12, 10 to the minus 14 range of latent cancer fatality risk.

We're very cognizant of the fact that those two pilot PRAs came up with low risk of spent fuel storage, but I think part of that is because the systems are so robust.

And in this world of when you look at -- I guess I keep thinking from a risk informing standpoint you look at a curve and the operating experience is something that as we go over time and build more and more documented operating experience while there is some operating experience out there now that we can tap into, but as you build that database and learn more and more about these systems, the risk that's defined by operating experience goes down. Your known risk goes down. But as you go forward in time to longer and longer storage periods, your potential material degradation mechanisms can potentially go up as well.

So, you've got some -- and those aren't the only two considerations to be thought of, but you have some potentially competing consideration from a risk standpoint and we want to come up with this risk framework that puts that in on a piece of paper so we can all point to that and say this is the process we use going forward.

CHAIRMAN BALLINGER: Have you -- this is a real issue for me, because 10 to the minus 12, 10 to the minus 13, 10 to the minus 14, who's counting?

MR. LOMBARD: Right.

CHAIRMAN BALLINGER: It's still six orders of magnitude below anything that we care about and have you thought about what the increase in risk is for a leaking canister?

MR. LOMBARD: For risk, and what's your safety goal? And that's -- we're in the process now defining a safety goal. Is it latent cancer fatality, is it breach frequency? It's not CDF, right? It's not core damage frequency. So, we're trying to look at the qualitative health objectives and come up with a reasonable safety goal --

CHAIR BALLINGER: Because there's a site boundary limit, 25 MR, right?

MR. LOMBARD: Right.

CHAIR BALLINGER: So, have you thought about an overall program to minimize the workload and the -- of a lot of inspections and stuff like that because if the canister actually does leak and you have to take action, of course you have to detect it if it leaks, but does that affect the 25 MR boundary limit?

In other words, does a leaky canister make a difference?

MR. LOMBARD: And you --

CHAIRMAN BALLINGER: Other than a political difference, does it make a difference?

MR. LOMBARD: That's exactly right. You're asking a great question and we've thought about it and talked about it several times and we know that we want to do a consequence analysis. But when you think of dry cask storage, what's the driving force?

It's not a LOCA, right? It's not a core-to-floor. You've got -- what's going to happen? What will happen is you'll get a crack -- if one starts, you'll get a crack, you'll leak a few molecules a second over time. Pretty soon that helium over pressure will be gone, but that's --

that's over time and then what happens? Then you have no driving force.

If there were any radioactive material inside the canister or in a dry cask storage system, what would happen? I don't believe you, for normal situations, you would detect it at the site boundary.

MR. CSONTOS: And I think we have to take a look at it on an even bigger scale than that just not from the public health and safety, you know, issues. It's also looking at -- for storage, I mean.

But if you're taking a look at cracked canisters, we look at one. What about if a site has 200 or 300? Or in the case of Consolidated Storage, it could be a lot more, okay.

So, you have individual, you have aggregate considerations to think about. You also have to think about what that -- that that impacts operations. What state of degraded conditions is acceptable for you to be able to pick up, move, handle. What is the dose to the workers? What are -- these are all things that we're considering in terms of risk informing. It's not just risk to the public, but risk for the whole site and aggregate.

CHAIRMAN BALLINGER: And you started with 10 to the minus 12.

MR. CSONTOS: Correct.

CHAIRMAN BALLINGER: Let's say you go up.

MR. CSONTOS: We know that. We are well aware of that, yes.

CHAIRMAN BALLINGER: Okay.

MR. LOMBARD: Absolutely. And Donald Chung will be giving you that presentation later on this morning. We look forward to it, because this is something where it's not easy. It's not straightforward to move forward.

We define defense-in-depth criteria and built some matrices of what defense-in-depth means to the different important safety functions, how you would apply them.

But in the end when you get through all those criteria, in the end you still have emergency planning at the end of it. That's part of your mitigating strategy if you have such a bad situation it would end up in dry cask storage, which I don't think it would.

And, again, we plan to do a consequence analysis over the next year or two to help support

our risk informing framework going forward.

Retrievability. So, this is one of my favorites as well. It's one of the industry favorites, too. It's something back in 2001 we defined retrievability on a fuel assembly basis.

And it was a different environment back then in 2001. The '90s were just finishing up and we're into a new century. And we were thinking of repository. We were thinking of what are the operational considerations.

But in reality when you look at what are the safety considerations that need to be taken care of in dry cask storage, defining retrievability in a fuel assembly basis in light of the new paradigm, the pair of paradigm shifts that have occurred, didn't really seem to be practical.

Part of that is because that definition could drive people to think that you are going to be requiring actual fuel inspections. And we don't want to drive fuel inspections. We don't think based on the information we have -- and if you look at -- if you look at the environment in a reactor versus a -- that fuel would experience inside a reactor versus what it would experience in dry cask storage, they're very different.

The environment in a reactor is much more severe especially if you talk about accident conditions, than what you're going to see in dry cask storage. So, we are confident based on the information we have from fuel reliability in the reactor, information we're receiving that we have conducted in our research activities, and research and development that the DOE has done at different national labs and the work we continue to do, the industry continues to do in confirming that really the robust nature of cladding is very good. It's very good performance going forward.

When we linked all the information and wrapped it together, we said we really need to look at ISG-2 and provide a broadened definition in ISG-2 to give an option.

If an applicant wanted to come in and use the retrievability definition on a system basis, we would give them that option in ISG-2.

Now, it doesn't come without some baggage. And if you -- I'm sure you've read ISG-2 in detail. It also have some requirements to look at aging management from day one to make sure that that system is maintaining its important safety functions going forward, but it does allow options

to the approach and Emma will be giving you that talk a little bit later on this morning. She's our expert on retrievability.

MEMBER SKILLMAN: Mark, let's back up just for a second.

MR. LOMBARD: Sure.

MEMBER SKILLMAN: I understand what you've just said and I generally agree with your comment. Fuel in a reactor is definitely in an environment different than fuel in a dry cask storage status.

So, in one case we've got temperature, we've got neutron flux, we've got gamma flux, we've got all of the water chemistry issues and the debris issues that are part and parcel of operating fuel at power.

When you remove the fuel, you attempt to dry it out and put it in a can, but now what we're talking about is not only the condition of that cladding, whether it's low burnup or high burnup fuel, but we're also talking about the physical condition and protection of the can in which the fuel is resident.

And so, now we have a couple of different things that are vastly different than

fuel that is, in a way, "protected" is probably the right word, in an operating core.

Now, this fuel is supposed to be dry. We think that clad is going to be sufficiently ductile and intact for many, many years, but now we're concerned about its container. We're concerned about the environment in which that container resides and we have some other things that are going on.

Al pointed to one, nests. Like could be birds' nests, mice nests. One I'm very familiar with is osprey loving to be on top of a thing that's out in the middle of nowhere. It's warm. And that brings its own chemical problems on top of whatever container those osprey have chosen to live on.

MR. LOMBARD: Yes.

MEMBER SKILLMAN: So, this idea of retrievability brings with it the ability to get to the top of that container, or access to that container in a way that enables the machinery and the workers to get that fuel. So, I think it's narrow to think of this only in the context of fuel in a container that's nice and happy and protected for a long time.

There are a lot of other things that can happen on that cask that make getting to the topic of retrievability very complicated.

MR. LOMBARD: Absolutely. A couple of things. We wanted to put our inspection eggs -- we wanted to put our eggs in the inspection basket, because those are the things we can inspect and control without experiencing a significant dose or additional resource requirements for the licensees. So, we're focusing on the aging management program, inspections of what is accessible from the outside.

And that includes canister systems. you get into the surface of the canister and we're, again, encouraging industry to come up with better methods to do just that without having to pull a canister and open it up and go through all of those operational considerations and challenges and does to workers as well.

Now, having said that, if operating experience over time whether it's domestic or international, if it shows that there is an issue with fuel that would require a system to be open to determine if it is an issue with a specific type of fuel or specific system or potential vacuum drying issue that you need to resolve, we will take a hard

look at that and would take the appropriate action at that point.

MR. CSONTOS: That's good you brought up the fuel, the canister inspections and such. One of the things I didn't bring up during the discussion of the risk is right now with our aging management programs there is no aging of the fuel, because it's an inerted environment on the inside.

There is no active degradation modes that we can -- that we've identified for the fuel inside of an inerted canister.

You'll be in an unanalyzed condition if you do have a through wall crack and what is the state of the fuel, what is the state -- these are things that we can evaluate, but it's in one of those conditions -- it's in a state where we will have to do some more work.

So, I think that's why, as I mentioned, that's the other aspect to what we were talking about with the risk and then looking at retrievability from, you know, a canister basis versus a fuel basis.

MEMBER SKILLMAN: Well, it's not just the canister. It's the overpack in the container.

MR. CSONTOS: Absolutely.

MEMBER SKILLMAN: And so when we talk about this, we need to be, at least in my mind, thinking about all of those items that will confront those who would attempt to retrieve.

MR. CSONTOS: Right.

MEMBER SKILLMAN: So, it's not just the nice shiny container that's sealed down in the concrete cavern inside the -- inside the, if you will, storage module, it is all the top work and all of the things that have to be addressed in order to get into --

MR. CSONTOS: Right.

MEMBER SKILLMAN: -- that protected area. And I would just offer there can be a lot of furs, fangs and fins on top of that machine or other things that are really not anticipated. And those are -- actually, they present a real challenge to people who do this work.

MR. CSONTOS: You're absolutely right. Our OpE shows right now that we have -- we have more indication of corrosion of the support structures especially on the horizontal modules, than the canisters themselves. The canister themselves have been pretty -- they're looking pretty good.

MEMBER SKILLMAN: Thank you.

MR. LOMBARD: Any comments?

So we have a list of future documents that we'd like you to think about. If you want to see them, 1536/1567. So, we have four SRPs now for -- two for transportation, two for storage. And we're consolidating them into one each, one for transportation, one for storage. So, as we move forward with that project, it's about a two-year project.

September 2016 proposed final of this first SRP for consolidation of the storage review plans. If that's something you'd like to take a look at, we'd certainly be happy to come in and talk to you about that.

The high-burnup fuel regulatory issue summary is something that's caused a lot of discussion over the last year or so, or two years now, I think, since we actually started talking about it. Proposed final is December of '16.

The MAPS report, thank you, there it is, managing aging processes in storage, that's January 2017 for proposed final.

Now, this other set of SRPs, the transportation SRP's proposed final in May of 2017.

And lastly the high-burnup fuel technical basis NUREG, which is really tied in with that -- I'm sorry, where it is? High-burnup regulatory issue summary, second one from the top, and the last one are tied together.

The last one, the NUREG, really takes the information from the RIS itself, the regulatory issue summary, and puts it into a NUREG format. So, something we'd ask you to think about. And if you want more information about each one of those before you make a decision, we can certainly provide that.

And the last one is our successes. And I know you've seen Kris Banovac a few times here in front of the ACRS. On 1927 Rev 1, it's something that it couldn't -- wouldn't have been possible without extensive collaboration with the industry. And I want to thank NEI and other folks that have been very much involved in the discussions that have gone on for the last two plus years on NUREG 1927.

It's a collaborative effort. Folks in the industry have heard me say that several times, but, again, it could not have been done, it could not have gotten to the version that it has, the

benefit that it really has and the version that it is now.

Now, that NUREG-1927 also has an industry guidance along with its that's -- I'm sorry, NUREG, not NUREG. NEI 14-03, right? Right number?

MR. SPEAKER: Yes. Correct.

MR. LOMBARD: So, an associated NEI guidance out there. We intend at some point maybe not in this revision, but at some point we would endorse all or part of the NEI guidance going forward because, again, it reflects our thinking, the collective "we" thinking that collaboration is going on in renewals going forward. And you'll be hearing more about that later on this morning.

Rev 2, ISG-2, Rev 2 we have talked about a lot. When we looked at our world a few years ago, there were several things that we felt were lacking. And the renewal framework was the first one we looked at.

Retrievability was another one based on what we knew about our current environment and we wanted to put several initiatives in play and our folks had just been fantastic at really coming alongside and seeing the value of these initiatives

and turning them into actual documents. So, the NUREG-1927 and ISG-2 Rev 2 are two great examples of that.

The testing we're doing at Oak Ridge on high-burnup fuel samples, the Phase 2 testing going on now, being great successes so far not only just defining the actual how the testing is to be done, but shepherding of the testing as it goes forward.

The review strategy for consolidated storage, although I have to say with Oak Ridge, and Michelle Bales was here, but she has stepped out, our folks, our partners in research have been just a key to us in going forward with all the research that we're doing and especially the Oak Ridge testing.

Our review strategy, we've got a great review team set up for consolidated storage, both WCS and the Holtec applications now. We're finalizing the review strategy to do the best job we can to get that review done.

If we get a high-quality application, we want to get it done in three years, both the environmental and safety and security side.

And you'll hear from Donald Chung a little bit more this morning on risk-informed

framework status. We've defined the defense-in-depth and the safety goals. At least we have a good draft safety goal that's up for discussion now. And after we talk to you, we'll be scheduling a meeting with industry pretty soon on that one as well, a public meeting to talk about the safety goals.

And licensing process changes, we've implemented several changes over the last two years especially we've looked at acceptance reviews to really hone in on what is the scope of acceptance reviews and make sure they get done in a timely manner, as well as other process changes.

And it's a testament to the folks that work for us, the tech reviewers, the folks that have kind of crafted these initiatives and brought them to fruition. It's -- they've done such a great job in all these areas to help us be successful and make us what we are today.

So, if there's any questions or we can move on to the next.

MEMBER POWERS: Mark, this was an ambitious title, but I have to say you've succeeded admirably.

MR. LOMBARD: Thank you.

MEMBER POWERS: This is easily one of the best presentations I've experienced and I've been here a while. So, it's --

MR. LOMBARD: Thank you so much.

MEMBER POWERS: -- really superb.

MR. LOMBARD: Thank you.

MEMBER POWER: Really very, very, useful.

MR. LOMBARD: Thank you.

CHAIRMAN BALLINGER: Ditto.

MR. LOMBARD: Oh, thanks. Thank you.

CHAIRMAN BALLINGER: Carry on.

MR. LOMBARD: Okay. Would you like to switch chairs with me, Kris?

MS. BANOVAC: No.

MEMBER POWERS: Kris, this is a little bit being stuck following a movie star or something like that.

(Laughter.)

MS. BANOVAC: So, we're about 20 minutes behind actually, but Mark --

MR. LOMBARD: Let's not get too over the top.

MS. BANOVAC: He did a superb job, but I think I can breeze --

(Laughter.)

MS. BANOVAC: So, hopefully we'll get back on time.

MEMBER POWERS: Well, just at any rough points, well, Mark already covered this.

(Laughter.)

MS. BANOVAC: So, thank you, Mark. My name is Kris Banovac and I'm a project manager in the Renewals and Materials Branch in Division of Spent Fuel Management.

And going back to Mark's figure, in my talk today I'll be talking about the work that the staff is doing to create the sustainable framework for renewals as we are expecting longer storage durations and possibly multiple renewal periods. So, I'll be talking about the work that we're doing and that we're involved with.

So, in my presentation today first we'll start by just going over the requirements for spent fuel storage renewals. I'm going to talk about our efforts to identify needed updates to the storage renewal framework.

I'll provide an overview of the work that the NRC is doing, and this is both ongoing and future planned work.

And then I'm also going to provide an overview of some external work that is also being done to create a sustainable framework for the future. And this is work that NRC is involved in.

On the next slide, this is just a recap of our requirements for renewal of specific licensees for independent spent fuel storage installations and also certificates of compliance for storage system designs.

NRC's regulations allow for renewal of ISFSI's and CoCs for a period not to exceed 40 years given that specific regulations that ensure that the storage systems perform as designed and the period of extended operation are met.

The renewal applications must include time-limited aging analyses and must consider the effects of aging on structure systems and components that are important to safety and it assesses their capability to continue to perform their intended functions in the period of extended operation.

The renewal applications must also include aging management programs. And those are for the management of aging issues that could adversely affect the structure systems and

components important to safety.

And in order to NRC to approve storage renewals, licensees need to demonstrate that any aging effects on the dry storage systems will be adequately and safety managed and addressed so that those systems can continue to perform as they were designed.

MEMBER SKILLMAN: Kris, let me ask this: Is there any intentional connection between subsequent license renewals for the ISFSIs and the topic of life after 60, SOR, for the Part 50 licenses?

MS. BANOVAC: Yes. So, we actually have benefitted greatly from the reactor renewal experience. We'll talk a little bit about our storage renewal team and we really reflected on the reactor renewal experience since most of the reactors have gone through renewals.

And now, you know, we're just starting our first renewal for storage and reactors are now considering subsequent license renewal. I know there were a few sessions at the RIC just a few weeks ago. So, we will be -- we've learned already from the NRR review experience for the reactor renewals, and we will continue to learn from them

as they go through their subsequent renewal periods.

MEMBER SKILLMAN: Okay. Thank you.

MS. BANOVAC: In February of 2011 we updated Part 72 to include these specific requirements. And also at that time in March of 2011, we issued the accompanying guidance for that rulemaking. And that guidance is the standard review plan for storage renewals and that's NUREG-1927 Revision 0, which Mark mentioned in his talk.

So, over the past few years the NRC staff has reviewed renewal applications for both specific ISFSI licenses and also CoCs for storage system designs. And what we found through those reviews was that the guidance and NUREG-1927 Revision 0 needed to be expanded and clarified in several areas.

And since we're expecting to receive about 15 renewal applications within the next several years, in the bow wave that Mark mentioned, we did establish an interagency storage renewal team and we had folks from the Division of Spent Fuel Management, we had our research counterparts, we also had our general counsel counterparts to help us with that work and we looked at the storage

renewal framework to figure out what changes we needed to make to NUREG-1927, but we also thought about what other guidance development or other infrastructure development was needed to support this work going forward so we could have effective and efficient renewal review since we will be getting so many of them all at the same time.

And so, during the past couple years we've also had extensive stakeholder engagement. And we received a lot of valuable input from the stakeholders.

I think we had over 20 NRC staff-sponsored meetings. A couple meetings were focused specifically on changes we were planning to make to our guidance. And so, we got some really good stakeholder input.

We, of course, came to the ACRS subcommittee last April when we got some good input at that meeting. And so, all along the way we've been getting this input from stakeholders and industry to help us with our guidance development and help us to identify what our needs are for creating the stable framework.

We also learned from our national and international colleagues through our

participational workshops and conferences and other work, and that's our improved our knowledge and our capabilities and assessments to understand aging mechanisms and how they should be managed in a period of extended operation.

MEMBER SKILLMAN: Kris, let me ask this: As I read the, I would say, extensive public comments on this there are embedded within numerous of those comments what I consider to be just raw fear, concern about a crack, a leak, the perception that these containers are sitting two miles from my home or within 50 miles of eight and a half million people.

And I lived through a time when I listened to the public fear, and I understood that that fear was palpable and real. I mean, those people are truly afraid.

And I lived through a time where we went through an extraordinary effort to reach out to those who were fearful to attempt to address the fear. Here we have these facilities all over the United States and, in certain areas, a great deal of public fear.

What's being done to address that? I mean, we talked about these technical issues with

such precision and such specificity and we kind of had the code talk, we understand what we're talking about, we've got eloquently qualified people to address the technical issues, but here is the soft issue that in my view is just as real to some of the technical issues that we talked about.

So, what's being done to address that?

MS. BANOVAC: Well, I'll start out and I'm sure Mark and Al may have things to say as well. So, one of the things that we are trying to do not just here, but agency-wide, you know, the word "plain language," we throw that out a lot, you know.

The work we do, it's a lot of scientists and engineers here on the staff, you know. We use very technical terms, very scientific terms that really are understandable to a member of the public. And so, we're really trying and I hope we've succeeded in our responses to the public comments, but in any -- I guess any documentation we have whether it's even our standard review plan, you know, we tried to make that in plain language as well, but we really tried to explain these terms and ideas that I think the staff and industry has a great understanding for. We tried to explain this

so they make sense to everyone else.

I know with high-burnup fuel, you know, and Marge will be addressing that a little bit later, we've developed a one to two-pager, I think it was, to really try to describe what is high-burnup fuel, you know, what are some of the things we're looking at in research.

And so, we're creating some tools like that to put out there to try to share information in maybe a more understandable way, but it's something I think now at our core we're always -- whatever we write whether it's guidance, whether it's responses to public comments, one-pagers, backgrounders that we're putting out there for public consumption, we're trying to explain things and we're trying to explain NRC's robust framework and what we're doing and why we're doing to make sure that these things are safe.

And I think really it's a translation. I think it's a translation issue. And so, we're really -- I would say I think that's really where we're focusing on is on translating what we think is a safe and robust framework in industry and translating that to others so they can understand.

MR. LOMBARD: It's interesting that you

made that observation and my folks have heard me talk about this several times over the last couple of years -- well, since -- after the Fukushima accident we went -- we, the NRC, went off and built an expedited transfer study, we did an expedited transfer study whether it was prudent to require utilities to transfer fuel out of spent fuel pools to increase the distance between the spent fuel assemblies and prevent, if it were necessary, in order to reduce the likelihood. .

And I sat through one of the public meetings. And I think they only scheduled a two-hour public meeting the first time they wanted to engage with the public on it. And they thought this would be two hours and we'll gather all the comments and we'll be done with it.

As I sat there during that meeting I kept hearing one person after another call in and express their fear of nuclear power. As I was sitting there, I'm thinking I've been in this business for 35 years. Why am I not afraid of nuclear power?

And I start thinking back to my experience. Well, because I spend time at the plants, I've written procedures, I've gotten them

through the Plant Operating Review Committee, I've come to the NRC, I know all the rigor that's applied to each one of those steps.

And I hold up Terry Pickens and the Prairie Island folks. They've engaged so well with the Prairie Island Indian community that they have a person who's spent -- many times he's come to watch loading campaigns, he's seen other evolutions at the plant. He's gotten more comfortable with the fact that with the level of rigor that the plant applies to plant operations, but these folks haven't had that experience.

All they know is that this is radioactivity. This is really bad stuff. If this -- if I -- if they spilled it on my front doorstep, my whole family would be dead within seconds. And it's true depending on the type of material you're talking about.

So, we've really stepped out in this area and have increased our engagement with folks not just having public meetings, but engaging with them directly, phone calls with them --

THE OPERATOR: Please pardon the interruption. Your conference contains less than three participants at this time. If you would like

to continue, press *1 now or the conference will be terminated.

CHAIRMAN BALLINGER: I'm assuming he's pressing *1.

(Laughter.)

MR. LOMBARD: So, we have engaged with members of the public, not just members of the industry, but members of the general public who are afraid of nuclear power.

And I don't, you know, in Canada they've done a great job over the years. They spend millions of dollars engaging the public. And in many cases they have folks who were intervenors before, and now they're promoters of nuclear power.

That's not my goal. My goal is just to educate folks and have them understand who we are, what we do, why we do it and how we do it so they'll be at least a little bit more comfortable with the job that we do here at the NRC to make sure that it is safe and that the public is -- if we continue doing our job the way we have been and we plan to do so, that they're not going to be impacted.

MR. CSONTOS: Let me just add that some of the tangible things that we've done, we've done

blog posts, we've done one-pagers so that people will be able to read and see, you know, one page at a high-level, plain English type of feedback to the public.

We've also gone to certain types of decommissioning meetings that are there so that when they're decommissioning, they're taking the fuel and we're talking about how it goes to a spent fuel -- from a spent fuel pool to the canisters and talk about what we do in terms of our reviews and all these things that we're doing.

We did the 20 public meetings, because these were -- this is such a hot issue for the public. The public is, like you said, they are really afraid.

And I know Mark and I have been -- emails, phone calls. I've been here until nine o'clock at night with some folks, you know, talking to them because of their concerns.

And they, you know, what we try to do is try to explain why we're doing what we're doing. And there are a lot of educated folks out there that really, you know, they get what we're doing and they have a lot of questions on it.

And I think that there is an underlying

piece that is, I think, a national issue, which is the American public's distrust of government. And I think there is an underlying piece of that that they're not sure if they can trust what we're saying. And that's a hard, hard barrier to break through. I'll just say that.

MR. HSIA: This is Tony Hsia from Division of Spent Fuel Management. I just want to add that we want to thank our NRC's Office of Public Affairs.

We have a concerted effort working with them to have a series of blog posts. Right now we already have four that's posted. A couple of them are called Dry Cask 101, How Do We Manage Heat? And there are other ones right now under the review such as inspections, such as ISFSI review, and probably another dozen or so has been planned. So, that will continue that effort. And I want to thank OPA for this effort.

And also like Mark and Kris and Al mentioned that whenever we go to a public meeting with our representation, we really gain the public trust. Once that trust is established, then we can communicate much more effectively.

MR. LOMBARD: Thank you.

MS. BANOVAC: Okay. So, based on our work we identified, as Mark mentioned, we need an operations-focused approach for storage renewals.

I think Mark went over that. The one aspect that I do want to highlight is we do have a learning aspect to our operations-focused approach. And the thought is that aging management programs, you know, those are submitted as part of the renewal application, but our thought is that those are not static, that those are dynamic and that they should change over time to respond to operating experience that's either applicable to that dry storage system, that site or maybe even other applicable operating experience throughout nuclear industry and maybe even outside of nuclear industry.

So, there is a learning aspect to our approach and you'll be hearing more about that in tomorrow's meeting also.

As we mentioned, the framework has to be sustainable for the future for possible multiple renewal periods just within certainty in the back-end of the fuel cycle.

And also, we think that the framework needs to have the flexibility to be changed. So,

as we get new operating experience, as we continue to do our research and get our research results as new information comes in, the framework needs to be flexible to be able to be changed to respond to that.

And so, given those overarching needs, we did identify specific needs for both NRC-led guidance development, and also external infrastructure development, which I'll get into some detail on.

This slide is just a pictorial display of the various past, ongoing and some of the planned work in the area of updating the storage renewal framework.

Some of the work is NRC-led, some of the work NRC is involved in, and the work is interrelated and there's many parties that are working together to -- and collaborating to make sure that we do have a sustainable framework going forward. So, there is a lot of work being done inside and outside the NRC.

MEMBER BROWN: Could I ask you to go back? I just want to make sure I understand Slide 6.

MS. BANOVAC: Six.

MEMBER BROWN: I guess I -- maybe you can -- maybe I confused myself. What do you mean by an operations-focused approach?

MS. BANOVAC: So, the thought is that instead of analyses, you know, doing analyses to show, okay, everything is looking great, we want to look. So, want to monitor, we want to inspect.

We talked a little bit already, we're going to hear a lot more tomorrow, but, you know, the canister inspections. So, we actually want to go out, look, monitor and inspect to find any degradation before a loss of intended function.

And the thought is, you know, we're looking, we're using the right techniques, the right people looking for the right things. And we're looking, in time, to catch any degradation that could impact a safety function well before it would impact that safety function.

MR. CSONTOS: We were looking prior to this, we were doing a lot of research to look at what's going to happen in a hundred years. And inherent to that is the difficulty in artificially aging things to simulate what would happen in a hundred years and there's the unknowns-unknowns that you don't know that you don't know. Okay.

And so, rather than hypotheticalizing everything going out to the next 300 years, which could be an infinite amount of work, let's focus on what we can do in an operations-focused way where we do things like we inspect, assess, evaluate and then do whatever we need to do to corrective actions to then get us back into a state of where the regulations are -- you're in compliance with the regulations if anything does happen.

MEMBER BROWN: Okay. But what type of operations are you looking at? I mean, if casks are dead, these pieces, they're dead weight sitting in a facility or in the outdoors or wherever they are, I mean, you have to define the operations that you're going to deal with. You've got to inspect something. What are you inspecting on it? How they pick up a cask and move it, or how they open a cask and look at it, or how they do what? What operations?

MR. CSONTOS: Degradation. It's like what we do in the plants, you know. You're looking at how things degrade as a function of time. It's infrastructure degradation, basically.

MEMBER BROWN: Well, when you talk about -- excuse me -- infrastructure meaning the

facility that it's in, or the cask itself?

MR. CSONTOS: Overpack, the concrete pad, the -- if it's important to safety and the canister or cask, looking at it to make sure that things aren't degrading more rapidly than you anticipated. We planned for certain things and so these are the things that we're talking about. That's the operations part of it.

MR. LOMBARD: If you think about it, it's a reality-focused approach. It's what's really going on with --

MEMBER BROWN: No, I'm not disagreeing. I'm just trying to --

MR. LOMBARD: Right. What operations are --

MEMBER BROWN: -- connect some of the dots as to how you go about doing it. I mean, if you've got a facility that's got 500 casks in it, inspecting 500 casks is a fairly laborious and difficult task.

So, you've got to develop some type of -- if it's just sitting there, some type of methodology to go do that. Some sample that would give you -- that seems to me if you do the sample approach, you're right back into you've got to have

some analysis basis for saying that my sample of operations are going to be effective at identifying degradation.

MS. BANOVAC: And that's exactly what the aging management programs do. So, we'll get into this in a lot more detail tomorrow, but in the guidance in NUREG-1927 we talk about the aging management programs and the 10 elements of aging management program and you step through that thought process to figure out, okay, what do I need to look for, number one, how do I look for it, how often do I look for it, what is my sample size?

And so, the aging management programs sort of take you through that thought process to figure out what you are going to do and inspection space, essentially, in the period of extended operation. And so, we will get into that a little bit more detail tomorrow, but that is something that would be essentially embedded in the aging management program.

MR. LOMBARD: Especially specific to the potential material degradation mechanism of concern for that specific system and that specific requirement.

MEMBER BROWN: Other operations, I

would think, you mentioned in one of the pieces of paper that we got for review was how do you open the cask and what are the processes you do for that? Is that going to be part of your subsequent discussions or is that not part of this overall --

MS. BANOVAC: Probably hear about that a little bit more in the retrievability presentation that will be right after our break this morning.

MEMBER BROWN: Okay.

MR. LOMBARD: And we hope we never see one open.

MEMBER BROWN: And where you talked about your new paradigm, your 72, 71, 72. So, I presume you're taking it out of one place, transporting it and putting it someplace else.

Are there specific, I mean, I look at a cask. You've got to go pick it up, carry it, put it on something, you've got to hold it down. I view those as operations.

Is that a part of this overall process or thought process you're going through?

MR. LOMBARD: Once you do that, you're out of the storage realm and into transportation.

MEMBER BROWN: Okay.

MR. LOMBARD: Which is a whole different discussion.

MEMBER BROWN: That's true. Okay. All right. Thanks.

MEMBER REMPE: You're aware that the research reactors are thinking about or trying to go forward with this non-expiring license.

Have you ever thought of doing that with the storage especially for the orphan plants to have a non-expiring license? You're monitoring them. You're not --

MS. BANOVAC: I'd like to address that.

MR. LOMBARD: No, no, go ahead.

MS. BANOVAC: Because this was a question I think Dr. Powers asked us, you know, the last time we were hear having this license in perpetuity.

You know, one of the thoughts for having the license term is that, you know, there is a technical -- there is a technical basis for a license term.

In the 2011 rulemaking for Part 72, we did extend the license term to 40 years. It went from 20 to 40 years. And, you know, part of the basis for that was the demonstration at Idaho on

the low burnup fuel where we opened the cask and we looked at the fuel.

And so, you know, you do have a term that is based on -- has a technical basis, but I think another unique thing with storage is we say and we continue to say that the Part 72 ISFSI, it's not the final step.

In this country, and I know right now it's sort of in a state of uncertainty, but eventually there will be geologic disposal. These ISFSIs will not be the final resting place for the spent fuel.

And if you offer a license in perpetuity or just a license that has no end date, it kind of says a mixed message. Are you saying, oh, these really, you know, this is going to be the final resting place for this fuel?

And I know our stakeholders, we were just talking about the public fear and concern, I would imagine they would not be very fond of an open-ended license for storage.

And I think maybe industry as well, because they're still holding onto that fuel, they're still responsible for it, they're still paying for it.

So, I guess in our view having sort of this open-ended license is not the best idea just from a kind of perception standpoint, and also you want a technical basis for your license term. So, we're very comfortable with having right now our 40-year terms.

MEMBER REMPE: Thank you.

MEMBER BROWN: Yeah, but you -- I want to ask a follow-up on that. But in your paperwork you gave us, you comment, and you just commented, you did that based on the results you got from your low burnup fuel and the inspections and testing that you actually did on that.

The stuff you actually did, but yet you were -- you extended it and then you made a comment that, as I read it, you're kind of basing it on hope, because you've got a future testing for high-burnup fuel where you're going to be trying to confirm -- so, you've already extended the license, but you don't have any data other than the low burnup fuel information; is that correct?

MS. BANOVAC: And that's exactly -- we have a high-burnup fuel. I guess it's technically an AMP, but we call it a monitoring program. And we'll actually talk in detail about that tomorrow.

Meraj may even touch on it a little bit in his presentation, but essentially for -- to be able to go past the 20 years for high-burnup fuel because the demonstration that was done was only on low-burnup fuel.

You know, what we're saying is so far all the information we're seeing, all the research, all the short-term data is showing us that high-burnup fuel is looking okay, but there's no confirmatory data like there was for the low-burnup fuel.

And so, that's exactly why this demonstration is being explored with DOE and EPRI. And so, what we do with our framework and with our renewals is if there is high-burnup fuel at that site, there's a high-burnup fuel monitoring program where essentially a licensee will be monitoring the information that would come out of a demonstration project for high-burnup fuel and essentially looking for that information to confirm what we think will happen.

Now, if information came out of a demo that was, I guess, contrary, now it would be upon the licensee to say, well, what does that mean for my fuel now? Will there be any reconfiguration of

the fuel? Will there be any damage to the cladding? So, that is exactly why we have our high-burnup fuel monitoring program that we do have as part of our renewals for licensees that store high-burnup fuel. And we can get into more detail on that tomorrow, if you'd like.

MEMBER BROWN: Okay. I'll hold off.

MS. BANOVAC: Okay. Thank you.

Okay. All right. So, this slide just lists the NRC-led guidance development that I'll talk about in the next few slides.

So, first of all, we did identify the high-priority need to update our guidance NUREG-1927. We did develop a draft revision 1 to the guidance, and we made updates throughout the guidance.

We did include three example AMPs as part of Revision 1. And those were for localized corrosion and stress corrosion, cracking of stainless steel canisters. One for reinforced concrete structures, and then the high-burnup fuel monitoring program that I just mentioned.

We did publish our draft guidance for public comment last July. And we have a separate meeting tomorrow morning where we'll talk about the

public comments that we received how we considered those in the proposed final guidance.

And I think Dr. Ballinger mentioned if we need to go to full committee, we have that scheduled for April 7th. And finally, we expect to publish the final guidance in the summer.

We also identified the need for a new guidance document that was already mentioned. And this is the Managing Aging Processes and Storage, or MAPS for short. And essentially this will provide an acceptable generic approach to identification of what are the credible aging effects, and what are the appropriate aging management activities to manage those effects.

MAPS will be comparable to NUREG-1801, which is the generic aging lessons learned or goal report for reactor licenses. It will provide descriptions of the different storage systems, the technical bases for determining what are the credible aging effects, system-specific tables of the subcomponents, their environments and applicable aging effects for those materials and environment combinations and also example aging management programs.

We think that the development of this

document will increase efficiency both for applicants in development of their applications, and we think it's also going to increase efficiency for NRC staff as we can focus our review on areas where licensees or applicants propose things that are alternative to the guidance in the generic MAPS report.

As far as where we're at with the process, we're currently working with our contractor to develop draft guidance. We plan to engage with stakeholders over the coming months hopefully to have a public meeting on -- before we go out for public comment.

This was on one of Mark's slides. If this is something that you think you might be interested in looking at, we would propose coming to you with a propose final guidance. So, after we publish the proposed guidance this summer, we would consider public comments and just like NUREG-1927 we'd, you know, address those comments in the proposed final.

And currently, we plan to have the proposed final guidance ready in January of 2017. So, if ACRS was interested in seeing that, that would be the time we would be ready to provide

that.

Finally, we would hope to publish the final guidance in Summer of 2017.

MR. CSONTOS: Can I just say that we prefer to go out for public comment. I think the industry would like to have this guidance as soon as possible. So, I think --

CHAIRMAN BALLINGER: On the MAPS report.

MR. CSONTOS: On the MAPS report. And so, it would -- we would love to go out for public comment as soon as possible rather than wait until, you know, later.

I know we're talking about -- I think you have various field trips in the summer?

MS. BANOVAC: I think with the timing, so we'll be ready with the draft this summer. And I know, you know, talking with Chris Brown and staff with scheduling with ACRS in the summer, we would be waiting essentially three months to publish our guidance if we needed to wait for to meet with the ACRS this summer.

And so, that's why we're proposing if we could just some with the proposed final in January of next year, then that way you would see

all the public comments we received on the MAPS report, how we're proposing to address those comments and the proposed final --

MR. CSONTOS: We can provide a version for you all in a few weeks so that you can take a look at it to see what it's looking like bake that determination.

CHAIRMAN BALLINGER: You mean in a few weeks.

MR. CSONTOS: Right.

CHAIRMAN BALLINGER: Okay. That was going to be my next question. We have to discuss it amongst the subcommittee.

MR. CSONTOS: We just received it last Friday from our contractor. We're changing it to what we want and then we're going to be putting it out onto the ADAMS website for the public consumption so that you can take a look at it to see can we go out for public comment with this version as it is.

And we'll have many more bites of the apple, but really it's the applicants who really want this to inform their applications going forward.

CHAIRMAN BALLINGER: But how strong is

their connection between 1927 and this?

MR. CSONTOS: It's really close.

MR. LOMBARD: Pretty strong.

MR. CSONTOS: 1927 is basically like the SRP for -- it's like 1800. And then you have 1801 which is the GALL.

MEMBER POWERS: I would not make decisions on this now, because --

MR. CSONTOS: Right.

MEMBER POWERS: -- of new ACRS staff members that are coming on board where all this stuff probably ought to transfer over to the nuclear materials subcommittee meeting, the subcommittee to waste material storage.

CHAIRMAN BALLINGER: Oh, I see. Okay.

MR. LOMBARD: So, if I may a little bit of the why, why do we want to get it out for folks to see and start using and give us feedback on, because that renewal bow wave, folks who are preparing renewals now and we want them to have as much information as possible as soon as possible so they can put them together in accordance with what we're already thinking.

And actually there's been a lot of collaboration on all these products. So, we expect

that there's not going to be significant surprises out there with the industry, but we want them to have it to use as soon as possible.

MEMBER POWERS: The closer you can get it to a template, the better off you are.

MR. LOMBARD: Exactly.

MR. CSONTOS: Absolutely.

MEMBER POWERS: If that's what we -- if there is one lesson we've learned from license renewal, it is templates help a lot for you to look at.

MR. CSONTOS: That's exactly why we're doing what we're doing. Yes, that's right.

CHAIRMAN BALLINGER: Yes, it's probably a combination of this committee, plus the new waste --

MEMBER POWERS: Yeah, it seems to me I would just move all of this stuff that's coming up in the future over to waste. And where they have materials issues, they can always call in the Materials Subcommittee to help.

CHAIRMAN BALLINGER: I'm trying to sort out the difference between 1927 and the MAPS.

MEMBER POWERS: I don't think I would worry about it.

CHAIRMAN BALLINGER: Okay. Well --

MR. LOMBARD: The MAPS will be a pick list, essentially, by system by system of aging management requirements.

MR. WISE: Is this on?

CHAIRMAN BALLINGER: No, or you're too tall.

MR. WISE: Now, it's on. I'm John Wise, NRC staff, the Renewal Materials Branch. Just to give you a perspective, I know everybody in here is probably familiar with the GALL report, right?

I mean, it basically comes up with a determination of which are the relevant aging effects and the aging management programs that staff feels are appropriate to manage those impacts.

And so, that's not something -- that's in 1927 right now, right? Because the 1927 is our methodology for how to staff, you know, the criteria by which they go through to determine whether an application is acceptable.

But just like the GALL report, the MAPS report is going to be and here is a generically acceptable approach. So, here are the aging

effects we think are relevant and here are specific aging management programs we think are appropriate to address those aging effects.

And so, in a sense, it rolls up the experience we've had in the recent renewals. And so anybody that's reviewed any of the recent license renewals in the ISFSIs and people that are familiar with the GALL report, you'll look at this and you'll say, oh, this is very familiar. I mean, it's not going to be very surprising. It's really a rolling up of all of the experiences we've had both in the ISFSI renewals, as well as some lessons learned from the reactor license renewals. And so, but again it's different than 1927 because it gives that here is one acceptable approach.

1927 has a couple of aging management programs, example ones, and the MAPS report will just expand on that. It has five or six aging management programs, because the 1927 examples were just that, a couple of examples. So, it just takes a much more thorough look at the -- at all of the system structures and components in the storage systems.

MR. CSONTOS: And it's system-specific. So, kind of like what you see in the GALL report

where you have a BWR/PWR version there is a, you know, NUHOMS System, there is a Holtec System, blah, blah, blah. And so, there are all these different systems.

And then how you port the aging management programs to those structure systems and components according to safety that are related to those, you know, individual components, what are they made out of, what's the environment, all that stuff. So, it's a real template, I think is the best way to say it, for licensees to use.

CHAIRMAN BALLINGER: Yeah, I mean to follow up on what Dana was mentioning, I'm just trying to get a reading on what you would like from us going forward and the timing that that may be, because, for example, are you interested in us providing some feedback on 1927 now, or if it's connected very, you know, with the MAPS report, is there a reason to wait and take them as a bundle, if you will, but then there's ISG-2 stuck in there as well.

So, I'm trying to get a feeling for --

MR. CSONTOS: We'd like to get 1927 out the door and published, you know, fully done. So, hopefully get -- we're hoping to get -- we were

going to talk about this tomorrow, but --

CHAIRMAN BALLINGER: Okay.

MR. CSONTOS: We were hoping to get a letter from you on that to go ahead and get the approval to publish that.

The MAPS report, we're hoping that we can go out for public comment early this summer. So, that has to look at the timetable for you all to -- or the Nuclear Materials Subcommittee, how that all meshes up, because we'd just like to get out faster.

And then you'll see the public comments for the MAPS report if you want to take a look at it again, you know, when we go out for final publication.

CHAIRMAN BALLINGER: Okay. We should probably be moving on here --

MR. CSONTOS: Yes.

CHAIRMAN BALLINGER: -- because there are people getting antsy to go to the --

(Laughter.)

MS. BANOVAC: Okay. We'll keep on going.

So, the next slide is Slide 11. We also identified the need to develop guidance for

NRC inspections of licensees' aging management activities.

We're currently developing a temporary instruction and that's for inspection of licensees' programs and procedures for implementing their aging management programs or any conditions that were approved as part of the renewal.

After we develop the temporary instruction, we'll then develop an inspection procedure. And that will include more technical detail regarding licensees' aging management activities. And so, that we'll be inspecting to make sure they're doing their appropriate inspections and monitoring assessments, and also that they're taking timely and effective corrective actions as needed. And so, that's something we'll work on in the future.

We also are considering development of our regulatory guide to discuss how these various pieces of the guidance framework fit together, the 1927 and MAPS. And also there, the reg guide can serve as a potential vehicle for endorsement of NEI 14-03. I know Mark already mentioned this. And so, the reg guide would be the vehicle we would use for that.

Outside of the NRC-led guidance development, there's other important work that's going on to develop this surge renewal framework.

The NRC requested ASME to develop a consensus code case for inservice inspection of canisters. And this would be a way to leverage the extensive experience in the field, to develop a methodology to inspect, assess and determine any corrective actions for canisters.

ASME Section 11 created a new task group on inservice inspections of spent fuel storage and transportation containments. They had their inaugural meeting in April of last year and the NRC is involved in that continuing work. And we hope to have a consensus code case by 2020.

We also continue our involvement with the American Concrete Institute, or ACI, Committee 349, which develops standards for nuclear safety-related systems and structures.

And a concrete expert panel was held in 2015 and the panel determined that the revised ACI 349.3R guide on evaluation of existing concrete structures could be used for aging management inspections for dry storage systems in the first renewal period.

The panel also identified some future enhancements to the guide. And those would be to address aging mechanisms in subsequent renewal periods. And so, we're going to continue to engage with the ACI to assure that any future changes to the guide will be applicable to inspections of our dry storage systems.

NEI is leading the industry effort to develop guidance for storage renewal applicants. So, this would complement the guidance and NUREG-1927. And this is of course presented in NEI 14-03.

The NRC is currently reviewing Revision 1 to NEI 14-03. And if we determine that the guidance or any portions of the guidance can be endorsed, we may do that through a reg guide that I mentioned on the previous slide.

NRC also continues to assess the capabilities to inspect the dry storage systems and particularly the capabilities for in situ inspections. So, being able to get instrumentation that can navigate the close confines of the canister within the overpack.

And the industry is currently developing delivery devices or systems to be able

to use already demonstrated inspection techniques and methods, but just within the close confines of the canister within its overpack. And I believe Keith Waldrop will be speaking to that later this afternoon.

Also, we're currently considering participating in an IAEA effort to develop guidance for aging management of dry storage systems.

So, in conclusion, we continue our work to update the storage renewal framework so it is a sustainable framework for the future. The updated framework has been informed by the staff's renewal review experience over the past few years, operating experience and also renewal experience for reactors, and also past and ongoing research and work.

We feel that the framework is learning and that aging management programs will continue to be informed by future operating experience, results of research and we'll be able to respond to that as the ISFSIs and dry storage systems enter the period of extended operation.

The guidance documents will be living. So, we'll update those over time to include any new information, knowledge or experience in the future

regarding aging management.

And in this way, we feel that the framework will be able to be applied to the first renewal and also subsequent renewal periods so that we can have continued safe storage of spent fuel for extended periods.

And my last two slides are just a list of references and acronyms and I'll be happy to take any other questions although I know we are running over time.

MEMBER SKILLMAN: I have a brief question back to Slide 11. Temporary instruction inspection procedure. The agency has well-developed inspections for AMPs and life extension 7100 series, 71002 and 3 really provide excellent guidance for those inspectors.

Should we presume that what would be developed here would be, if you will, a version of the very same type of inspection procedure much shortened and much focused on specifically these types of technical issues pertaining to casks and the overpacks and the concrete?

It seems that that -- you have a template that's used and useful, very well understood, inspectors know how to use it, the

industry understands what it is --

MR. CSONTOS: Right. Absolutely.

MEMBER SKILLMAN: -- would you be basically plagiarizing that and saying here's the new one?

MR. CSONTOS: Actually, the word I use is "let's plagiarize it as much as possible." We have a team working on this, the TIIP. And it's -- the first one is a TI, because we have plants that have been in -- that are through renewals right now.

We believe that they're -- we're giving now a -- first of all, there's two parts to it. One is the aging management activities itself. It's great that we do the aging management programs. It's great we review them and approve them, move on, but it's about, you know, really what the licensee is doing and taking those aging management programs, making them into aging management activities that someone actually goes out and does.

And so, what we're doing is the first part of this is to basically do what the, you know, the reactor site does which is are they doing the aging management activities in accordance with the

approved aging management programs? That's the simple part.

The second part is, is that we're giving change control authority to the licensees to change their AMPs as a function of time with new operational experience.

This is something that already on the reactor side it does very well because they have the INPO databases, they have all this other OpE that they collect and distribute and provide and reevaluate to.

Our side, we have a lower amount of -- a little bit less operating experience, by a lot. And so, as we go forward looking into this and they get more OpE, they can go and change their aging management programs as a result of, oh, well, that degradation mechanism isn't applicable here, because we're not seeing it for 40 years or 30 years.

So, part of it is the oversight process of the change control authority. What was changed? Did they use the 7248 process, which is the way to change this, appropriately? Did they, you know, just to make sure that we're not getting people who are just trying to get out of inspections.

It's for the public, you know, concerns on giving the change control authority to the licensees.

MEMBER SKILLMAN: Thank you.

MR. LOMBARD: There's another piece to this as well. We want to design these aging management program inspections so that they meld right into the ISFSI or the actual licensee's already existing inspection programs.

We don't want them to be different. We want them to be easily implementable by the individuals as well as ISFSIs.

CHAIRMAN BALLINGER: No more questions? Okay. Let's take a break until 10 of.

(Whereupon, the proceedings went off the record at 10:36 a.m. and resumed at 10:50 a.m.)

CHAIRMAN BALLINGER: We're back in session, I think. I've been told that there are some miscreants out there on the line that haven't gotten their phones on mute. So if you're out there and your phone is not on mute, what's happening is a lot of people are getting feedback that interferes with everything. So please, put your phone on mute and things will work out a lot better.

Our next presenter, Emma, has waited a very long time for this. There should be a round of applause --

MS. WONG: No, I don't need a round of applause. No. I have waited a long time to address the full committee. However, I think this will be a very good presentation. I hope you learn a lot from this. So thank you.

I'm Emma Wong. I'm going to present today on spent fuel retrievability and the draft ISG-2, Revision 2, that is now out there in the public. And hopefully, you've all reviewed it. Of course, Dr. Ballinger already mentioned that you will be making some decisions on whether or not this ISG-2 needs to go to full committee, so I just want to remind you of that fact.

Next slide, please.

So in the meeting topics we are at retrievability, is outlined here in red. So it's going from storage to transportation. Retrievability, I would like to highlight, is part of the storage regulations. So it's storage, retrieving the fuel to get it ready to be transported somewhere.

Next slide.

A brief outline of the things I'm going to talk about today. I am going to go into the history of retrievability, where it came from and how we got to where we are today. And also go over the regulations. Then I'm going to go into the guidance we have on retrievability and a little bit of the history about that and where we are today, the paradigm shift and how it changed our view on retrievability. And then, of course, I'm going to go into the ISG-2, Revision 2 into a little bit of that and how we updated that guidance.

So going into the history, it all started in 1982 with the Nuclear Waste Policy Act and it has been amended. But in this act, it's stated and was a lot about the monitored retrievable storage, or MRSs. It stated that they should be designed, the MRSs should be designed to provide for ready retrieval of such spent fuel and waste for further processing and disposal. So this is what they had envisioned for MRSs. And that's all they had commented on in the Nuclear Waste Policy Act.

Now as the NRC, we had to do something

with that, so we codified all this information in the 1988 rulemaking to add this into our regulations for Part 72 for MRSs. However, we also deemed that the same retrieval or retrievability for the fuel that MRSs had to go through should also apply to ISFSIs. And this was codified in our regulations as 10 CFR 72.122(l). And I'll go into that a little bit more in the next slide.

Later, in 1990, we had another rulemaking to add 10 CFR 72.122(m) for Certificates of Compliance to consider retrievability to the extent possible in the design of their storage system.

Next slide.

So a little bit more about the regulations. I just mentioned to you regulations. They are going to be here for your viewing. For storage, which is 10 CFR 72.122(l) which is retrievability. That's what came out of the Nuclear Waste Policy Act and what we thought, we needed that in here. It states that "storage systems must be designed to allow ready retrieval of spent fuel, high level of radioactive waste, and reactor related greater than Class C waste for

further processing or disposal." I would like to highlight this regulation is that the design must be there to allow that you have ready retrieval.

This regulation only applies to general and specific license ISFSIs, and not to Certificates of Compliance. There is a difference and a lot later in the presentation I can kind of go over that also. The next regulation that I had mentioned is 10 CFR 72.236(m) which applies to Certificates of Compliance which states "to the extent practicable in the design of storage casks, consideration should be given to the compatibility with removal of the stored spent fuel from the reactor site, transportation, and ultimate disposition by the Department of Energy." So this is the part where retrievability is considered in the design of a Certificate of Compliance for the design of a dry -- or design.

So with that being said, what does retrievability really mean? I mean those are just the regulations.

MEMBER BROWN: Okay, before you go on, I've still got a little bit of confusion. I read

your stuff and I read your other history and I'm -- the difference between this regulation and the other regulation. And in one case you have to be able to retrieve and in this case, maybe, maybe not. If it's not practical, we're not going to bother with it. We got a certificate, so who cares? I mean really this seems to be pretty indefensible that you don't have to have a practical means of retrieval if you've got a CoC. I just -- that went down difficultly. Let's put it that way.

MS. WONG: So a Certificate of Compliance is given to vendors.

MEMBER BROWN: Who design?

MS. WONG: Who design the dry storage system.

MEMBER BROWN: I'll look at this as just not casks, but also the facility in which they're stored. Is that correct? Or is it just the casks themselves?

MR. WHITE: This is Bernie White. I'm senior project manager at NMSS, Spent Fuel Licensing Branch. The storage casks, vendors design the storage casks themselves. The pads they

sit on and where they sit at the reactor facility are done by the licensee. It's incumbent upon the licensee to ensure that it chooses a storage cask design that can be retrievable since retrievability is a requirement for licensees.

MEMBER BROWN: If you make that clear, that's one of the other comments in this thing that the licensees are still required to comply with the other ones. It just seemed to be incompatible. I mean doesn't this backfit -- I mean if you look at this on a -- if the general licensees are required to comply, how in the world can a cask storage designer not comply? No, excuse me, maybe I have that wrong. Maybe I've got that backwards. But it just seemed to me --

MEMBER POWERS: It's a little simple, Charlie. If you cannot comply and never sell this product.

MR. WHITE: Right, when most cask vendors come to us, they have procedures for loading as well as unloading the storage casks. The unloading process or the removal of it from storage and putting it into a transportation overpack is what we look at in terms of

compatibility with removal from storage. Unloading in a pool, in the event that they have to do to repackage it into another overpack for transportation off site. So that's where we look at that piece of it from the vendors for a Certificate of Compliance.

MEMBER BROWN: All right.

MS. WONG: It is a little confusing. I was confused the first time I looked at it.

MEMBER BROWN: I'm just a simple-minded guy.

MS. WONG: The vendors get the Certificate of Compliance. It's hard for them --

MEMBER BROWN: The cask vendors.

MS. WONG: The cask vendors. They get their Certificate of Compliance. It is hard for them to comply with retrievability because they don't know what site it's going to be on, so they can't actually comply with retrievability. But for the general licensee, they have their site. They have their CoC. They need to make sure everything goes together to comply with retrievability. So it's their responsibility as the general licensee. They take something that the vendor has, they bring

it to their site, and they make sure that it can comply with retrievability. Does that help? No.

MEMBER BROWN: It seems to me that the licensee can't ask -- seems to me the cart is before the horse. Somebody can't design a cask unless you know where it's going to go. And you're telling me they don't know that and unless somebody asks them to design a cask to put in my facility, they don't have a product that's sitting there. They've got to do it from scratch after they've got a request to design a cask for the licensee's facility. It just seems to me when -- I've brought a lot of stuff and I would have never ever brought anything in this manner. It's just insane.

MR. WHITE: Well, when a storage cask vendor designs casks, they design it to site characteristics, generic site characteristics. The reason that we have 72.212 which is the evaluations that the general licensee has to do is to ensure that the cask matches its site characteristics. It's not common for us to get in a storage cask design for a certain site characteristic and then in two or three or four amendments because well, it doesn't match this site, the design basis

earthquake isn't high enough for this site or for this site or we need to add this fuel for this site. We have amendments which build upon the initial design which account for site-specific characteristics once they have a contract in place.

MEMBER BROWN: I'll turn off my mic.

MS. WONG: All right, as we go through the presentation we can talk more about this at certain points if you're still confused.

MEMBER BROWN: I just wanted to get it on the table.

MS. WONG: Okay. All right, fair enough. So this a very over simplified diagram to try to put in perspective what retrievability was. As I said, when I was new to this retrievability, I did not really understand what it was and where it fit in into the big picture. So this diagram is trying to relay that information.

At the top there, you do have storage. It could be wet storage. It could be dry storage. You do have a little icon there for a pool and one for a dry cask. If you do have wet storage you can do retrievability by fuel assembly base. You can pull fuel and put into whatever container you need

it to go into to go for transportation. That would be retrieving it or retrievability and then prepping it for transportation.

Of course, there's a lot more things that go into that. There's inspections. That's why that's on there. Repairs and replacements, you probably aren't going to repair or replace the fuel, but you could put it into a secondary container or a can which they can then be prepared for transportation.

MEMBER BROWN: When you say pool, I think stuff I've been familiar with before is the plants' spent fuel pools. This is not -- that pool is not referred to -- that is not a spent fuel pool in a nuclear power plant.

MS. WONG: That is correct.

MEMBER BROWN: Okay, it's a separate facility like a dry cask -- okay, that's fine.

MS. WONG: It's more of a dedicated pool that is for storage.

MEMBER BROWN: I've got it.

MS. WONG: Okay. For dry casks or dry cask storage you could do retrievability. You have to do it in two ways. You have to pull the cask or

canister from its storage site and you probably need to do some sort of inspections, maybe some repairs or replacements. We hope not, but then you prepare it for transportation. That is the big thing is you're retrieving it to prepare it for transportation.

And once it's ready, then it goes into the transportation part. And it can be transported, a lot of that I think you already know. DOT regulates the whole transportation part. We look at licensing the packaging and the packages. And then it's transported off to disposal if there is a site on the interim consolidated storage or it could go to other like another ISFSI site if needed. Some people have needed to maybe do that if they don't have some of the facility on site to do some repairs or replacements or other things that they need to do.

I do have a lot of dotted lines on there and that is going from that gray area in the middle and so if you are repairing or you're doing inspections and you're not ready to transport it yet, it could go back to the storage site to sit there until you are ready for transportation.

MEMBER REMPE: So earlier today, I asked Mark about what about orphan sites and I believe he responded back that there's no requirement that an operating plant or orphan site has the capability to prepare the fuel for transportation. But your diagram doesn't reflect that. Maybe I misunderstood Mark's response.

MS. WONG: So you mean an orphan site with -- it's just the pad.

MEMBER REMPE: A shut down plant and they've left. If they have spent fuel, they've got it -- I'm talking hypothetically. Maybe this doesn't exist, but I would think that it's going to exist in the future with the plants shutting down that there will be plants with just a dry storage facility and they no longer have the operating reactor or the spent fuel pool where they can bring the casks back in and -- or the canister back in and reopen it.

And so I was just kind of wondering -- you were talking about if they have to do any repairs, we hope that doesn't happen, but -- or if they go to a larger storage system, how -- if they don't have a requirement for transportation off

site, how do they deal with that? Is it true they don't have a requirement to transport the material off site eventually?

I mean we talked today about we don't have to have license perpetuity because the licensees don't want that because they do want to have it moved off site. So I'm a little confused of what's required and not required.

MS. WONG: ISFSIs are not meant to be a permanent repository. We know that. So they do need to have retrievability which then infers that they need to be able to transport it somewhere.

MEMBER REMPE: It infers that.

MS. WONG: It does.

MR. WHITE: The infrastructure needed to transport a storage cask off site or a canister off site exists. The storage cask vendor, all the storage cask vendors either have or will have a transportation packaging available for transport off site. They also have the lifting items to transfer casks, the items that lift the canister out of the stored overpack, put in a transfer cask, move it over to a transportation packaging, put it in place, prepare that and then ship it off site.

What they don't have is a pool and the event that for some unknown reason they'd have to open up a canister to do some sort of inspection, repair, replacement. We don't anticipate that that's going to happen.

In terms of when we do our safety analysis, the evaluations of the safety analysis reports, there aren't any accidents or mechanisms that could cause us to have to open up one. The aging management plans that we're working that you've heard about earlier and will hear about later, those are designed to ensure that they remain safe and intact.

MEMBER REMPE: I could almost even think you could put an over-canister --

MR. WHITE: Absolutely.

MEMBER REMPE: -- such a thing like that, too. What I'm wondering about are there any of these fuel storage systems that are so large that you can't transport them? I don't know. I'm just wondering --

MR. WHITE: No, they can all be transported. Most of them are by rail.

MEMBER REMPE: So there's nothing --

MR. WHITE: They're specially designed rail cars that can handle that and they may have to use certain tracks or certain locations because of potentially bridge weights or things like that, but that's well beyond what we would evaluate.

MEMBER REMPE: That helps. I just was curious about that. Thank you.

MS. WONG: Sure. Any other questions about this diagram and where retrievability fits in the big picture? If not, I will move on.

So now I'll go into a little bit of the guidance of how to meet retrievability. There have been several guidance documents on this. So after the rule on retrievability was issued in 1998, the guidance on retrievability was then issued in 1998, which was ISG-2 or Interim Staff Guidance 2, Revision 0. This guidance explains how the rule was put into the regulations and that dual purpose canisters were a means to meet retrievability since it could be taken off the storage area and put into a transportation cask without having to handle individual fuel assemblies in a spent fuel pool.

Later though in 2001, this view changed to requiring that each individual fuel assembly be

retrievable by normal means as a means to meet the retrievability regulation. This was then clarified in guidance in 2010 in ISG-2, Revision 1. In this guidance it states that "ready retrieval is the ability to move a canister containing spent fuel to either a transportation package or to a location where the spent fuel can be removed. Additionally, that ready retrieval also means maintaining the ability to handle individual or canned spent fuel assemblies by the use of normal means." So both of these conditions had to be met in order to meet retrievability in this guidance document.

This clarification of the individual fuel assembly handling by normal means reflects a time of anticipated near term repository. Also, it was thought at this time and Mark had already mentioned this, that the fuel would only be stored for one to two storage periods before being transported away. So therefore that's why they thought they would probably need to maybe repackage these and that was the thought at that time.

MEMBER BROWN: When you say one or two storage periods, are you referring to the 20 year

and then another 20 years after that?

MS. WONG: Correct. So a total of 40 years.

MEMBER BROWN: Thank you.

MR. LOMBARD: But it could be up to 40 years.

MS. WONG: But not at that time.

MR. LOMBARD: Not that time. New renewals are up to 40 years.

MS. WONG: Correct. So now we would more likely think one storage period, but at that time it was one to two which would be 40 years. It's a good clarification. Thank you.

Also during this time, due to the -- well, it's the current time also, due to the uncertainty in the national strategy for the back end of the fuel cycle, a paradigm shift is happening to consider longer periods of time in storage which is why we got to the 40 year time period.

In 2009, a COMDAC 09001 had actually asked the staff to develop to review the regulatory --

MEMBER BROWN: Can I? I want to try to

understand something. When you talk about a paradigm shift, and I didn't ask this question in a previous presentation.

MS. WONG: Okay.

MEMBER BROWN: It seems to me the paradigm shift was driven by the fact that we don't have a long-term repository.

MS. WONG: Correct.

MEMBER BROWN: So it wasn't some great mental leap where we decided to do this. It was that the government has failed to provide the promised long-term repository.

MS. WONG: Right.

MEMBER BROWN: I don't want to get into the politics, but that's fundamentally where that goes. Is that correct?

MS. WONG: That is correct and we are reacting to the reality.

MEMBER BROWN: That's fine. That's reality. I'm happy with that. Thank you.

MEMBER POWERS: No, you aren't.

(Laughter.)

MEMBER BROWN: You are correct, Dana. I am not happy with that. I tend not to work on

things I can't control. I think about them, but don't work on them. Thank you.

MS. WONG: Okay. Thank you. So in response to all of that, we did have a COMDAC which asked the staff to develop a plan to review the regulatory programs for storage and transportation and their adequacy for long-term storage that would be in addition to leveraging on-going licensing program improvements that were already ongoing.

In response to this COMDAC, the staff issued COMSECY 10-007 in 2010 which included a plan for near-term licensing and inspection program improvements.

Also, we have been looking at the long-term performance of some of the internal components which fuel is one of those components. And that's also the current focus of some research as being done by the Agency and the industry. And until additional research has been conducted in this area, there may be unintended consequences in assessing these internals that could lead to inspections, repairs, and replacements or mitigation of the internals that could lead to unnecessarily needing to open the cask or canister

and in doing this may increase the worker dose and degrade the confinement boundary.

Also, in considering all of this, we, the staff, did a review of the compatibility between the storage and transportation frameworks. It was determined that the guidance on retrievability needed to be reevaluated to address the longer storage duration and the potential for multiple storage locations and associated transportation of the stored spent fuel into ultimate disposal.

Therefore, in 2011 and through 2012, the NRC held two public meetings to do some outreach where retrievability was discussed and we got some feedback from external folks and then subsequently in 2013, the staff issued a request for public comment on retrievability where we asked a series of questions that the industry and other stakeholders did respond to in public comment. So we have that feedback on that retrievability.

After 2013, the work on retrievability was delayed due to the storage renewal license framework, so basically we needed to get the storage renewal framework better looked at and on

its way we would look at retrievability again. But in 2015, the work on renewals was far enough along that the work on retrievability was then restarted. This is why there's a gap of about two years between the year 2013 and '15.

So in July 2015, the staff held a public meeting and the idea of revisiting the guidance on retrievability was reintroduced and additional feedback was received from external stakeholders. With this feedback and the feedback from 2011, 2012, and the 2013 public comments, we used all of this information to order to develop the draft ISG-2, Revision 2. And this draft was issued for public comment on October 21, 2105 with a 30 day public comment period which ended on November 20, 2015.

Additionally, the staff had a public meeting after it was issued for public comment to discuss any clarifications on the draft, so the public could make more informed comments to us.

The draft ISG focused on maintaining the public health and safety, ensuring that the spent fuel could be retrieved from storage safely and provides guidance to the staff on licensing

reviews.

So just a quick reminder about ISG-2 and the current revision one which is the current guidance out there right now, you have to have the ability to move a canister containing spent fuel to either a transportation package or to a location where spent fuel can be removed, and you would need to have the ability to handle individual or canned spent fuel assemblies by the use of normal means.

The use of normal means means you have a crane and grapple and basically you can pull the fuel without extraordinary circumstances.

In the draft Revision 2, be more focused on safety and design bases to allow maximum flexibility to maintain safety for a undefined storage period.

So now I'm going to go into the draft guidance, but before I go into that I would like to mention that we have received public comments. We have responded to the public comments. The public comments and any clarifications that we had in the draft ISG is reflected in this presentation and additionally, as a reminder, we would like to understand whether or not you would like to have a

full committee meeting on this in April.

So I'm going into it. We have gone back and we made changes to the definition of ready retrieval which now states the ready retrieval is the ability to safely remove with no operational safety problems the spent fuel from storage for further processing or disposal. Now the words "no operational safety problems" is defined in the SRP. I think it's 1567. And it refers back to compliance with the Part 20 requirements which is dose requirements.

MEMBER SKILLMAN: I made a comment on this earlier and I would like to do it again. It seems to me with the addition of that phrase that this is either so broad as to be paralyzing or so vague it can be misinterpreted. It would seem to me that it would be wiser simply to say the ability to remove, safely remove the spent fuel and leave it at that.

By introducing the notion of no operational safety problems it just strikes me that you invite an innumerable number of questions and challenges. I think the people that are handling the casks and the fuel assemblies have a pretty

good understanding of what is safe.

And when you introduce the idea of no operational safety problems, now the issue is is there an inspector there with a stop watch and if it doesn't go as quickly as you hoped, if you're suspended because your crane is broken or you have some unexpected event occurring, because the time is delaying? Is that a safety problem if it's slightly --

MS. WONG: It is not a safety problem as long as workers are not getting more dose than they're supposed to be getting.

MEMBER SKILLMAN: Well, suppose they are getting a few more millirem? Supposing that they are, but they're still in the 10 CFR 20 limits.

MS. WONG: That's fine.

MEMBER SKILLMAN: Then introducing that phrase really doesn't add anything. It just introduces in my view, an operational complication because the people who are doing this really do know how to do it, believe me. They do. And they are the ones who are going to protect themselves. I mean you're not even going to go near that cask

until you have your HP set up, until you have your monitoring set up. You probably have done some dry runs, rehearsals. You've confirmed your equipment is ready to go.

Just as I read that phrase and I actually read the comments from the people who are out in the field, they pushed back on that phrase. NEI did. Yankee and Connecticut Yankee, the plants up to the north that have all those facilities pushed back saying we really don't need that phrase. So I'm kind of a practitioner kind of a guy and I've lived through campaigns like this and I would find that phrase to be one that could only be used to create a violation. I don't think that helps.

MS. WONG: Okay. Thank you for your comment.

MR. RAHIMI: Meraj Rahimi, NRC. So what Emma is showing really that phrase comes the genesis of that phrase. It is in 72122(h). Because that was the basis for protecting cladding at all times.

MEMBER SKILLMAN: Wait, wait, wait, wait. That's nice that you said that, but that's

not what Emma said. Emma said it has more to do with radiological safety. You say for clad safety. Those are two very different issues.

MR. RAHIMI: I understand that. But what I'm saying -- that genesis, it goes back to radiation protection. When the applicant submits a design, we review the operating procedure, the loading procedure. We review the detailed dose assessment that they have done under their radiation protection chapters. They estimate the hours of loading, unloading. Based on those that come up with the exposures requirement. So as long as they are within those limits, it goes in the tech spec later on, as long as they are within those limits, they are fine.

We review those operating procedures. It is based on the dose calculation. If there is a hang up, actually we had a case on the lightweight transfer cask. The licensee wanted to use a very light transfer cask because the crane couldn't take it. They wanted to take the shelling off and back at the time of the transfer. And they came in -- that was an exemption request and we reviewed that and we ended up approving that exemption request.

But what we approve, we look at the operating procedure and the applicant, they do the dose assessments, what they believe the normal operating procedure is going to result in, the dose assessment.

So if they are within those dose limits that some of those dose limits goes into the tech spec, and also with the site-specific requirements, they are fine. So that phrase is not going to really try to cite a violation for any smallest change in the operating -- they have flexibility because in the tech spec and in the operating procedure that we review and approve, it's all embedded in there.

MEMBER POWERS: Let me ask you a question. Can I safely remove spent fuel from storage with operational safety problems?

MR. LOMBARD: I think you bring up a good point. How about we take the action to look at the value that that phrase adds?

MEMBER SKILLMAN: Thank you. That is the only point I'm making, Mark. What I'm suggesting is by introducing that, my view is that creates a complication for the men and women that

do this work. And I can understand an individual saying oh, you can't do that. That's not safe. That's an operational safety problem.

MR. LOMBARD: Exactly.

MEMBER SKILLMAN: And the individual who's operating the crane or the manipulator or the device might say wait a minute, just because my scale is not calibrated doesn't mean I'm unsafe. I do not have an operational safety problem. We have done this a hundred times and we know it's safe. And I'm not worried about that device. Leave me alone. Bingo, violation.

And I'm saying wait a minute. Those poor people don't need that complication. If you remove that phrase, I submit that work can be done safely anyways.

So to Dr. Powers' question, without that phrase, can you do it safely? Yes, you really can. And sometimes when you have a safety problem, that's when it's essential that you proceed. You've got to put things back in the cask and keep the shield.

MR. LOMBARD: Right. I agree. It's either redundant at minimum or it may introduce

another interpretation which is not a good thing.

MEMBER SKILLMAN: Thank you.

MR. LOMBARD: It's a good comment. Thank you.

MEMBER SKILLMAN: Thank you. And you thought this would be easy.

(Laughter.)

MEMBER BROWN: We actually read it.

MS. WONG: I'm impressed. Okay --

MEMBER BROWN: That's what happens when you give us something that's only five pages long.

MS. WONG: I'll take a note of that.

(Laughter.)

MEMBER BROWN: Don't.

(Laughter.)

CHAIRMAN BALLINGER: I've just been notified by my handler that there are still people out there on the line that have not muted their phone. We don't hear all of the cross talk and stuff here, but apparently it's significant. So if you're out there on the line and you're not wanting to talk, please mute your phone.

MS. WONG: Okay, to keep going and we're going to ignore the operational safety

problem statement that's going to appear in the next few slides so just ignore that for now.

CHAIRMAN BALLINGER: Can you quickly edit this thing?

(Laughter.)

MS. WONG: Chris? No. It's already printed and everything. However, these are the options that we have developed in order to comply or you could comply with ready retrieval. It is the ability to do at least one of the following options.

And there are three options here. A is the remove to the individual or canned spent fuel assemblies from wet or dry storage. B is to remove a canister loaded with spent fuel assemblies from a storage cask or overpack. And C remove a cask loaded with spent fuel assemblies from their storage location.

MEMBER SKILLMAN: I've got to ask you a question here.

MS. WONG: Sure.

MEMBER SKILLMAN: There was my late at night review comment to myself. How is this guidance ensuring the outcome desired? How does

stipulating at least one of the following ensure the outcome that this ISG is really trying to accomplish?

It seems to me that the wiser way to write that guidance would be the ability to do either A or B or C or any combination thereof. Because it could be that in certain sequences you might have to do C before A or A before C or some permutation and combination that isn't clearly permitted by the way you write that first sentence.

MR. WHITE: That's the intent of it, a licensee can comply with either B or C or BC moving it off the storage cask into a facility and they're removing a single fuel assembly.

MEMBER SKILLMAN: Then I would suggest words should be something like ability to perform any of the sequences below that ensure that the outcome is successful.

MR. WHITE: And we can revisit the language, but that was the intent of at least one. Because we have dual-purpose canisters and dual-purpose casks. All they have to do is be removed from storage, prepared for transport, or put in a transport packaging and then shipped off site. We

would never have to do A. But you can do B or C, depending on what your cask looks like.

MEMBER SKILLMAN: Okay. Thank you, good.

MEMBER BROWN: I would just amplify that because you said either any one of which option A is one. But on -- several paragraphs later, you say if an applicant is relying upon A, then he must demonstrate retrieval under B and C as well which seems to be inconsistent, so he can't rely upon A unless he does B and C. So you could say I can only rely on A that you're saying well, you can't really. You have to do something else. I see it as an inconsistency, that's all.

MR. WHITE: Well, B or C is to remove the storage cask from its storage location to a place where you could do A which would typically be a spent fuel pool. That was the intent of that.

MEMBER BROWN: It didn't come across. It was beyond my comprehension at that point.

MR. WHITE: And then, of course, you have places like GE Morris which is a wet pool. They can only do A. There is no B or C for them. They have no cask. They have no canister.

MEMBER BROWN: Okay. You ought to try to make that a little clearer. That's my only thought process. It just seemed to be inconsistent. If you're reading this absent the practical application, you can see why you get trapped somewhere along the line, that's all.

MS. WONG: So hopefully, the slides are clearer. We can revisit the language later. So this is one of the combinations you could do. You pick option A with B or C and this currently is what all sites are complying with, so there would be -- if this were to go final, all the sites would already be complying with a combination.

So option A again, is fuel assembly removal and option B or C would be either cask or canister removal, depending on what you had on your site. So you would pick B or C.

As you see in this little graphic here, looks like they have -- it's a vertical storage system and horizontal storage system in this picture. And just ignore that last bullet. Ignore it on all these slides here.

Okay, and also from that last slides that's all for dry cask or canister storage. There

is not wet storage that I am aware of that has a cask or canister so they could never do B or C. So that's why we have this option where you could just do option A which is fuel assembly removal which could be for wet or a dry storage design or actually is a dry storage design that doesn't have a cask or canister that could be removed and they would have to use option A. This would be fuel assembly removal, fuel assembly removal - -you would have to be able to ensure that the fuel would not exhibit gross degradation. What that would mean is if you want to read more about it, this is in ISG-1, Revision 1. This really does mean that there will not be any gross ruptures that would lead to release of fuel particulates.

It does have the potential for gross degradation, then you could put the fuel into a secondary container such as a can and then put it and that would be a way to be able to remove it from storage. And again, you can ignore the last bullet there.

The last option that we saw was either just taking option B or C by itself which would be a canister or cask removal, depending on what you

had on your site. And if you did choose this, this option, this information would need to be included in your technical specifications in order to maintain this ready retrieval, that you would be able to do this and remove your cask or canister for removal.

The site may have a program to identify, monitor, and mitigate possible degradation because now you're just relying on this cask or canister removal. And of course, you still need to comply with all of your 10 CFR Part 72 requirements regardless of what option you pick. And ignore the last bullet.

So additionally, in the ISG there is guidance to the staff performing reviews. For an initial or an amendment application the reviewer should look at the system is designed for retrievability, that they identify important systems, structures, and components, and their subcomponents have been identified that would be pertinent for retrievability and that we do have tech specs in place to ensure that retrievability capability can be maintained.

And for example, this is something that

we currently do on sites and it is to maintain the as-loaded conditions and this is in the tech specs. And what this would mean is that you would need to know the loaded fuel condition and configuration. You would need to ensure that there is a dry inerted environment. You would need to limit the maximum clad or fuel clad temperature. And limit thermal cycling. If you can maintain that, going forward, that should be able to ensure that the fuel would be able to be remove individually by normal means because that is the current guidance that we have out there. And in doing this, we can ensure that the systems, structures, and components, their performance would not be degraded such that retrievability could be assured.

Additionally, for license renewals and I know a lot of it is in NUREG 1927, Revision 1, a reviewer should look to ensure that the design bases have been maintained, review the applicable aging management programs and time limited aging analyses, review any operating experience that has been shown are out there which would include any inspections that have been done and analyses of the structure systems and components and their

subcomponents. And of course, for more information on renewals, they really should be going to look at NUREG 1927, Revision 1.

So in the public comments, a lot of the comments allude to the fact that there was not enough clarity under retrievability and Certificates of Compliances. So I inserted a few slides on this to try to bring some additional clarity and additional words. Actually, I think there's a nice, big paragraph in there now, was inserted into the draft ISG.

First, I would like to remind everyone that for retrievability which is 10 CFR 72.122(l) which is the main requirement, is not a requirement for Certificates of Compliance. Certificates of Compliance are required to meet 72.236(m) to the extent practicable. However, if in the application for the Certificate of Compliance they do include information that there are retrievability aspects in their application, the review would considered these and ensure that whatever they're proposing would be okay in that Certificate of Compliance.

They would also -- the reviewer would also need to ensure that everything -- all the rest

of the parts, ensure the requirements are also met.

As we had previously mentioned, a general licensee does need to meet the retrievability requirement of 72.122(l). And what they would do is they would load in accordance with the Certificate of Compliance and then demonstrate that the cask or canister would meet the fabrication, loading, and preparation for storage requirement. They would also need to demonstrate that they would also meet the retrievability requirement.

For Certificate of Compliance amendments, a general licensee can voluntarily adopt a later amendment. And when doing so, the amendment, would need to be adopted in its entirety. So if, for instance, a Certificate of Compliance or a retrieval or retrievability in their Certificate of Compliance, they could submit an amendment. The amendment, if it was approved, would be there and the general licensee could go and adopt a later amendment. But they would have to adopt it in its entirety. So they would have to make sure they can meet everything that was in that amendment.

Another way that a Certificate of Compliance could revise what's in their certificate is to do a revision. And a revision process, however, would supersede the CoC amendment being revised in its entirety. So that amendment, when your revision, whatever, like Revision 1, that would be the current revision after that's approved. That would mean any licensee that is using CoC that's had a revision has to comply with that revision.

That being said, that CoC that has submitted for the revision process, that is subject to the backfit review because that would require anyone who is under that amendment to comply with that revision.

This is my last real slide. So we have received about 70 comments. And we did draft some responses to those comments and we have clarified and updated ISG-2, Revision 2 to these comments. I think we've gotten a few more comments from the subcommittee today that we will consider. Right now there haven't been significant changes and I think a lot of things you've also proposed would not really be significant changes to the guidance.

So of course, since this is the time line, we're here today on March 23rd for the subcommittee review. If we need to come back to full committee, we'd be more than happy to do that. And we are hoping to issue the final guidance in the summer of this year.

And all the rest of the slides are reference slides and abbreviation slides. Now I'll take more questions.

CHAIRMAN BALLINGER: Is Pete -- Pete are you there?

MEMBER RICCARDELLA: I'm here. I was on mute.

CHAIRMAN BALLINGER: Okay. You're the only person that's complied with the request. Do you have any questions?

MEMBER RICCARDELLA: No, I think as was said earlier, I think these are excellent presentations and I've gained a greater understanding on the subject.

CHAIRMAN BALLINGER: Okay. Thanks. Now, should we go around before lunch? We probably should.

Are there any members of the audience

that would like to make a statement? Dr. Einziger.

MR. EINZIGER: Bob Einziger from the --

CHAIRMAN BALLINGER: I think you've got to turn it on or get closer or something.

MR. EINZIGER: Is this better? Bob Einziger from the NWRTB. I had submitted this as a comment and I got a response back from the NRC which I'm thankful for, but I didn't agree with the response and I think that's because the comment might have been misinterpreted. If they decide to retrieve it on the canister basis, then the clause in the storage regulation that says that you can't have gross rupture unless you take -- and if you have gross rupture you have to take other steps such as to have operational safety.

By having the retrievability on the canister basis, you've essentially maintained your operational safety which means that there's nothing to prevent them from having gross rupture of the cladding and still meeting that clause. Now if in the condition where the fuel has reconfigured or had the gross rupture and still can meet all your other safety requirements such as totality shielding, thermal, what is to prevent the user

from saying I want to run this temperature on the fuel up to 500 degree C. To hell with what happens to the cladding because I've already mete all your regulations. Well, then this cask is sitting on the utility pad and the DOE eventually comes to take it to go take it to the repository wherever, but under the standard contract that's still there, it says it has to be retrievable on a fuel assembly basis or if they decide to repackage it, that means they've got to take things out and repackage the fuel. Isn't that essentially being incompatible with down the road with being retrievable for the purposes of final disposal, I think you said, repository?

MEMBER REMPE: These are just comments, and so you actually -- I'm helping the chairman here.

MR. EINZIGER: That's a comment for consideration.

CHAIRMAN BALLINGER: Given his eminence.

Is the outside line open? Is anybody out there? If you're --

MS. GILMORE: Hello?

CHAIRMAN BALLINGER: Yes, yes.

MS. GILMORE: This is Donna Gilmore. Can you hear me okay?

CHAIRMAN BALLINGER: Yes, we can.

MS. GILMORE: Okay, great. Mark had made a comment about there was a leak in a canister it would be a few molecules getting out. I have not been able to find any documentation that supports that scenario, but I've seen a lot of documentation supporting that we would actually even have an explosion if say five percent error gets in this set of canisters. I know this is just comments, but I really think there needs to be some kind of documentation that addresses what actually is going to happen with the canister in any of these approval documents, something to back up what's going to happen. I live five miles from San Onofre and it's critical information for those living near these nuclear plants. They have -- somebody making a statement without any technical documents to back it up. Thank you.

CHAIRMAN BALLINGER: Thank you. I thought I heard another person out there. Maybe not. Is there anybody else on the line?

MR. PLANTE: Paul Plante from 3

Yankees. On Emma's definition slide, you talked about GTCC canisters as well which as a canister they would be retrievable, but the GTCC gets processed at the sites in different ways, some of them cut up into small fuel assembly size, pieces, and put them in canisters that way. And some of them cut them up into large segments and put them in baskets. So certainly retrievability at GTCC would be on a canister basis. That's my comment.

CHAIRMAN BALLINGER: Thank you. Is there anybody else on the line that would like to make a comment? Okay, if there are no further comments, then we are adjourned until 1 o'clock -- recessed, excuse me. We're recessed until 1 o'clock

(Whereupon, the above-entitled matter went off the record at 11:49 a.m. and resumed at 1:01 p.m.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

(1:01 p.m.)

CHAIRMAN BALLINGER: Okay, we're back in session. Meraj.

MR. RAHIMI: Is it on?

MEMBER SKILLMAN: Yes.

UPDATE ON STORAGE AND TRANSPORTATION OF HIGH BURNUP SPENT FUEL

MR. RAHIMI: Okay. Good afternoon. My name is Meraj Rahimi. I am the Chief of Criticality, Shielding and Risk Assessment Branch in the Division of Spent Fuel Management within NMSS, NRC.

So this afternoon I'm going to talk about high burnup fuel. I don't know if you remember back in summerish we came in with really detailed presentation on the, both the testing that we are doing. Michelle Bales from Research, she presented all the tests. At that time we had finished the Phase 1 test and we had not started the Phase 2 test. And also, at that time we had John Scapioni from Oak Ridge presented detail on the consequence analysis.

So what really at this presentation I'm going to give really sort of a condensed, very

summarized version. And the purpose of the presentation is to see how this piece fits into the overall storage and transportation. That's the goal.

MEMBER SKILLMAN: Meraj, let me --

THE OPERATOR: Pardon the interruption. Your conference contains less than three participants at this time. If you would like to continue press star one now, or the conference will be terminated.

MEMBER SKILLMAN: Meraj, let me ask this. As I anticipate what you are going to present, is what you are presenting the analysis that in the RIS are identified as experimentally justified? Is that what we're really going to talk about here for the next hour?

MR. RAHIMI: It's one of the pieces. No, we're not going to go into details on the analysis. I'm going to show all the pieces that goes into the RIS, regulatory issue summary, and how we're planning. We haven't issued the final RIS. We have issued the draft RIS. And how we're writing now a new RIS that shows the implementation of that RIS and how does it really support the licensing and certification of casks with regard to

high burnup fuels.

So it's we're not going to go into detail. But I believe Michelle Bales is here if you would like -- if you have a detailed question, you know, about any of those parts we could answer the question. But the RIS really doesn't have the analysis. There are pointers in there and references, documents, NUREGs. It would be too much if I want to go into detail as a whole reference.

MEMBER SKILLMAN: Yeah, it was not my intention to challenge you for detail. I was just trying to get clear in my mind, throughout the RIS are these sentences that communicate, for instance, "release fraction values used as part of the confinement analysis for non-leak type casks should be experimentally justified."

And I'm thinking what you're going to present is at least the basis for those experiments and for that justification.

MR. RAHIMI: Yeah. Yeah, we, I mean we could talk about it but I wasn't planning on going into in detail sort of for containment what is or what are the analyses or --

MEMBER SKILLMAN: So the answer is

really no. You are not going --

MR. RAHIMI: The answer is no. I'm sorry. It's --

MEMBER SKILLMAN: No, no. No, no, that's fair enough. I wasn't suggesting that you should.

MR. RAHIMI: Okay.

MEMBER SKILLMAN: I was just trying to get clear in my mind what you're going to try to accomplish in the next hour.

MR. RAHIMI: Yeah, it was -- this is a piece of the really the big picture. As you could see, I'm going to focus on the two of those blocks. Actually, the other one should be red. The fuel performance, that's how this piece fits into the overall. And it's sort of from big picture point of view that if I can answer your questions. That was my goal.

MEMBER SKILLMAN: Thank you. That's fine.

MR. RAHIMI: Okay. So I think this morning Mark started, Mark is our division director, I guess our star, our movie star. Yeah, I don't promise you I'm going to be like him. He's tall and handsome; I'm not quite that.

(Laughter.)

MEMBER POWERS: This is on the record.

MR. RAHIMI: But I'll, you know, I'll try, you know to convey the message.

So fuel performance. This is, it is important. And it goes back a little bit to the issue of retrievability also, the reason really we tried to, you know, redefine the issue of retrievability. It was because of fuel performance. Because on the renewal, when we were looking at the renewal, the strict language that was in the regulation and the guidance we have put out in the ISG-2, Revision 1, regarding fuel performance retrievability had to be by individual fuel.

So when we looked at it we said, Okay, I mean what does that mean in the renewals? Do they have to, licensees, go and verify, open the cask, you know?

So that, it all went back to that. It all was connected really. The renewal and fuel performance retrievability. So retrievability being really the main part.

So I guess for the rest of the presentation I will try to give you the big picture

about, you know, how we are tackling the fuel performance in the context of spent fuel transportation, cask certification and dry storage licensing.

Just a little bit of background. What is it about the fuel? I mean when these casks are designed, what kind of safety role does the fuel play? Other than the need to design the cask, you know, to confine it and protect from the fuel, are we assigning any safety function in terms of performance for the fuel?

Historically, the safety analysis for both the storage cask and transportation packages have relied on the cladding integrity. First, you know, to confine, because in the area of containment, especially under normal condition, you rely for the cladding to be there. And also the rest of the structural assembly, the criticality safety relies on that to keep the geometry. Because the analysis that is done by the applicant it assumes that the fuel, spent fuel, it is in an as-loaded condition under normal, at normal accident condition. That's the assumption.

So that's what historically has been, the analysis has been done that the fuel geometry

does not change over, you know, 20 years, 20-year period of storage with the renewal and subsequent transport, something has been, that fuel remained intact. So that's your storage cask.

The other one is the transportation package. AS you can see, the transportation packages have these huge impact perimeters. And really the main impact of those impact perimeters is not only to lower the G load to the containment, cask containment, but also to the fuel. And the fuel typically, you will see under transportation, you know, sees about 45 to 50 G loads on the 30-foot drop. That's typically the G load fuel sees.

And on the storage side is from the tip-over from drop, you know, is fewer G's.

So, okay, what are the, under Part 72, what are the requirements under Part 72, especially, you know, with regard to spent fuel? So under 72, Part 72, under the normal -- we've got three type of condition: normal, off-normal and accident condition. And under those conditions there are dynamic and thermal loads that the fuel sees. And especially in thermal loads, the high thermal loads you see especially during cask loading, draining and drawing. So it's the first

time spent fuel has gone from an active cooling in the pool into a dry passive environment.

So of course the fuel is being cooled enough. That's part of the design, that can be cooled and the cladding can maintain, can be maintained below a peak clad temperature given a passive cooling system. So it's the first time fuel is in that environment. And generally it's during the when the cask is drained, you know, from the pool water. Has sort of a transient condition that the fuel temperature goes up. But again, the way it is designed and that we review, approve that making sure that the clad temperature, especially with respect to high burnup fuel, does not exceed 400 degrees Celsius because that assures, you know, cladding integrity.

And other things that the fuel, that we looked at off-normal condition, what are the off-normal conditions? Human errors, out-of-tolerance equipment, equipment failure, instrumentation failure, vent blockage, these are the what is called under Part 72 off-normal conditions. You know, you look at the fuel, is the fuel challenged if you have a vent blockage, when it's sitting out on the storage pad, how much does the temperature

go up and what's the ramification on the cladding integrity?

And, of course under Part 72, the accident conditions, we look at cask drop, tip-over, tornado. All these sort of are translated on the loads in the fuel, what loads fuel sees under those accident conditions.

Now, what are the transportation, what are the requirements for transportation of Part 71? Part 71 we have only two categories called normal and accident. We don't have such a thing as off-normal. And the dynamic and thermal loads from normal transport vibration that the fuel sees. 1-foot drop is considered part of the normal condition for the transportation packages. And extreme ambient condition also. Look at the, you know, minus 40 degrees Celsius and also look at the, you know, hot condition, 180 degrees Celsius.

And so the fuel is examined, it's behavior. Does it still maintain the cladding integrity and also the structural integrity, especially the structural integrity under 30-foot drop? Those are the accident conditions for transport which is sort of a very severe and is a bounding kind of condition. And that's the one

that they typically, of course depending on the transportation package design we're talking about 50 G's that the fuel will see.

And also we have a what is called for specific, for spent fuel packages we have a 50-foot immersion under transport accident condition in terms of the pressure, you know, on the containment boundary, not so much on the fuel because fuel is inside of containment boundary.

So those are, those are the conditions that I've summarized both, under both regulation Part 71 and 72. That's relating the context of what fuel can see inside the task.

MEMBER SKILLMAN: Why don't these requirements include some communication, whether it's in Part 71 or 49 C.F.R., for the radiation levels adjacent to the cask?

Here's why I ask that question. When we went through this for TMI we had hysteria in a lot of areas. People were just terrified. Until people realized that those of us who were doing the work had the identical concern that they had, and that is our wife and children were stuck on Route 95 on their way on vacation and they were next to a tractor-trailer that had casks.

So the question was, what is the exposure to our wife and kids when we are the engineers who are working on this activity? And when it became clear that the exposure levels were the same as taking an airplane flight across the country or sitting at the beach for a week, by bringing it to that level of practicality, an awful lot of the fear disappeared.

And so I'm wondering why when we talk about the accident, submersion, the drop from the pin, the 10-meter drop, why we don't also in the same context talk about the proximate radiation levels when these casks are under way? Because that's the piece that people think about. They don't think about some of these more arcane analytical issues, that are very important, but they're not that practical to the men and women for whom the fear is so great.

So why don't we talk about the radiation levels too? That's my question.

MR. RAHIMI: Okay. Yeah, I think the radiation levels are explicitly, you know, written in the regulation that thou shalt not exceed those radiation levels.

For example after drop, puncture, fire,

which is done in sequence, that's how we look at it, that package under accident conditions, we're talking about accident condition -- the normal condition is 10 millirem per hour at about 6.6 feet from the cask. That's your normal condition of the task going down the road. And that's what they are limited to. They cannot emit any radiation doses more than 10 millirem per hour at 2 meters from the cask.

So those are explicit. They actually in Part 71 are cited. And, yeah, it's a good idea when we present this stuff to put it in the context that the -- but normally since it is written in black and white in the regulation I don't go into details, you know, because I would be repeating what the regulation states.

MEMBER SKILLMAN: Okay, that's fair. Thank you. Okay, that's good.

MR. RAHIMI: Yes. And under the accident condition, again, these casks are designed that under those accident conditions done sequentially, you know, is the drop, puncture, fires, they confine, they contain their content. They have to maintain the containment.

And in terms of the doses are a little

bit higher. It's about 1,000 millirem at 1 meter. That is for the first responders. That's what that requirement is set really.

So now, so spent fuel cladding I just want to show, you know, because of these thermal structural loads under these normal, off-normal accident condition, sort of plays a role. And because the assumption is made, the analysis that is done, even under accident condition, historically that the fuel assembly, even after those sequential events, maintains its geometry, and even when it's subjected to 40 to 50 G loads.

So that has been the assumption historically. Then in just recent years some research was done. Actually, one of the examples of the research, Mike Billone from Argonne was -- there's an international body -- there might be some evidence regarding with respect to high burnup fuel -- again, high burnup is defined as any spent fuel that has been burned or in the core more than 45 gigawatt-days per MTU.

Beyond 45 there might be some issue with respect to the mechanical properties of cladding. Given that it goes through these conditions, drying conditions. As I said that the

drying condition when you load the cask it is the first time that the cask is outside the active cooling system in the pool, but is, occasionally this comes out enough that you desire that you can withstand a passive cooling system.

But during that time if the temperature goes up and there are some hydrides in the cladding because these are the cladding from spent fuel that has been in the core for three cycles. And you have corrosions on the cladding.

And because of the corrosion, the chemistry, some hydrogen that is produced from corrosion has seeped into the cladding. And those are corrosion layers. When these hydrides are in there in the form of the circumferential because of the pressure inside the spent fuel rod, but when it goes through the drying the temperature goes up. The hydrides go into the solution core, and when the temperature is high the pressure inside the rod, you know, also goes up.

And reorient the hydrides from the circumferential, which you see on the left side -- that's the close look at the cladding, all those, those are hydrides that are generally in the circumferential, and they kind of go similar to the

picture on my right side which is they become radial.

And Mike Billone and others had looked at this phenomena. Okay, what kind of impact does it have on the cladding integrity? And they called this radial hydrides. And he'd done some tests under de-fueled cladding that has gone through this process taking the fuel pellets out. It was a recompression test.

And he kind of showed these hydride reorientations was a possibility that the cladding may not be ductile at some temperatures. It might lose its ductility when this spent fuel is cooled and the hydrides reprecipitate in the radial direction, and of course it's sitting in the dry storage 20 years, beyond 20 years. Now you're getting ready to move this fuel, the clad temperatures that could be around that, you know, between 125, 150, at that range there is this phenomena that you might lose this ductility. And under transport condition it might not sort of maintain its integrity.

That was sort of the test. Again, this was based on a laboratory test, de-fueled cladding, not really taking into account the system as a

whole, the spent fuel, the fuel that -- fuel pellets that provides the stiffness to the entire cladding. You're just taking a section of the spent fuel rod, taking the fuel out and doing what is called a recompression test. And showing that at these low temperatures kind of, sort of it's a little bit brittle. It loses its ductility.

So this is called the DBTT phenomena. And that's what really the whole issue of the high burnup is.

I guess this next slide it sort of, I got ahead of myself. It explains what I just said, that when you move this fuel under transport condition that the fuel integrity sort of needs to be considered. Does it still maintain its integrity?

So because of that sort of issue we -- actually those research that was funded by NRC and Argonne, some of it, and some of it by DOE. And then later on was funded it at Oak Ridge taking out the real fuel, not just the clad fuel, the refuel clad, taking the entire sort of sample of the spent fuel out with fuel in it. Those are the Phase 1 tests and Phase 2 tests that the NRC is funding currently at Oak Ridge.

So about a year ago so we put out, this was kind of an issue, we put out some kind of a guidance to the applicants. Okay, how would you address if you are coming in, because they were coming in with respect to the renewal. They had high burnup fuel they had loaded in there. And they wanted to come in, get the approval for renewal. And also some of them we've got the transportation application, moving high burnup fuel. And they needed some kind of a guidance, how would they tackle this issue?

So we put out a guidance in the RIS. And basically what that RIS was, the draft RIS, I think we presented it this last summer to you. And really the main thing that is the technical basis for this RIS was the ISG-24 which sort of addressed the storage part, and ISG-11 which was both storage and transportation. And the two main NUREGs that we have published, one was based on the testing because when we started a few years ago we said, okay, what if this is really, is a real issue under these conditions?

So while we were doing testing we were pretty confident these high burnup fuels, if it's looked at as a system as a whole with fuel pellet

in there, they're really robust. But we said we've got to confirm this. We're doing testing.

At the same time we said, okay, let's do a concept message. What if, you know, things don't materialize, what we thought our theory tells us? So we both, we studied both under consequence and the testing.

So those two NUREGs were published, the consequence and the test, the Phase 1 test. And then what we are currently we are doing at Oak Ridge is the Phase 2 test. What was the Phase 1 test? It's basically taking a high burnup fuel that really hasn't gone through that dry storage transition. First establish, re-baselining that: okay, what's the behavior on that? And we tested those. I will go into detail.

Then the Phase 2 we said, okay, now let's really enter hydrides, let's apply the same test. Let's observe the mechanical property, let's observe the behavior of spent fuel rods. Kind of assimilating normal condition, vibration and even static bend test. Try to simulate a transportation condition.

So we've done, right now we are waiting for the Phase 2 test results to be completed. We

started about a week ago the first test. And we've got a few more samples to test. And eventually all these documents is going to feed into what is called a High Burnup Spent Fuel Storage and Transportation NUREG. It's going to have all the references, the information, a good story on the licensing approach, and a new approach with respect to the high burnup fuel.

And we're currently working on the High Burnup Fuel NUREG as we are getting -- because we have published most of the really the technical basis documents. I know everyone is waiting for the first test results. And we want to sort of get ahead to some extent that that way we are ready to issue the final RIS. Okay? Because we were also waiting for the 1927 SRP to be, actually to progress because one area in 1927 is the spent fuel aging management, which really touches on high burnup fuel.

So and we also wanted to wait on the retrievability. So all these three main pieces that could be consistent and go forward at the same time. That's the reason we've waited and not -- we haven't issued the final RIS yet. But when the Phase 2 tests are completed, that's the plan.

And 1927 is on its way, the final version to be issued. And retrievability also we've made good progress; we're ready to issue draft -- I mean final. We already issued a draft for public comment.

The, quickly, so what was the ISG-11 and ISG-24. ISG-11, again it was the cladding, studying the, more the criteria in terms of the cladding consideration in terms of temperature, in terms of the hoop stress, in terms of the rod internal pressure. Those are some sort of the criteria that we said in the ISG-11 about high burnup fuel.

And ISG-24 is the use of demo. Basically that is the vehicle that is used on the storage side. Okay, they're ready, and they've got their renewal for the storing high burnup fuel beyond 20 years or for worst technical basis. The demo really is the one that is the technical basis on the storage side.

So I'm going to briefly so go, I'm going to talk about this before. The NUREG-7198 was a test that was done at Oak Ridge. And the consequence analysis is the NUREG-7203. As I said, that as you can see the pictures on the upper-right

corner, those you see the actual spent fuel rod samples with the pellets in them. Because we really wanted to test the real system. We didn't want to take the cladding because this is the whole system. And the cladding provides really a lot of stiffness for the fuel rods.

And those are the Phase 1 test results. And I will go into that in the next slide. So I'm going to go into a little bit detail in these two NUREGs and provide a little bit more information.

On the consequence analysis, really the figure on the lower right is sort of a talks about all the scenarios that we looked at which I'm going to go into a little bit details on that one.

So based on test results was it -- it was that equipment that you see the picture on the right, what is called the cyclic integrated reversible-bending fatigue tester. This was the device that went into operation with the Office of Research with our senior advisor here in our division and the Oak Ridge came out with this device in order to test real spent fuel samples with the fuel in it.

And the purpose was basically, first, how does the presence of fuel, the fuel pellet

inside the clad, which is more closer to reality, impact the, you know, flexural rigidity of the fuel rods under vibration? That was really the first goal that under the normal condition of transport how does it behave.

And also the purpose was how does the presence of fuel impact the failure strain of the cladding? Again, it goes back to the ductile-to-brittle transition. Normally anything, if you saw a ductile percentage strain gauge. So that's the, that's the indication that the fuel is ductile. But if the fuel rod fails, you know, around that area, 2 percent, that was the, you know, failure criteria.

And how many cycles to failure for high burnup fuel rods? For example, in a typical transport condition the fuel will see a range of a million, million-and-a-half vibrations. And we wanted to simulate the normal condition vibration. And so we tested for failures. You know, some of them, you know, went for days to see how many cycles does it take at different G loads for this to fail.

And, of course, the last, not the least, will radial hydrides impact the bending

stiffness or fatigue, given all this stuff based on -- now, if you really have hydrides in the cladding, how does the behavior change under transport conditions?

So that's the data. We see, again, those are Phase 1 test results. Again, we presented this in details back in the summer, made a detailed presentation on that. And part about them is the number of cycles, number of vibrations. On the left is the strain amplitude. That really is related to the G loads because the G loads is converted to the strain amplitude. And I'm sure Michelle would have caught it and give you then the fuel structural engineer, they can give you the exact formula.

And we saw nicely there is a pattern, there is a trend that of course if you -- some of those strain rates I might say that those are strain rates correspond really to the middle part you're talking about, at the beginning you're talking about maybe 50 to 60 G loads. And normally normal condition of transport, the vibration is not, you know, at that load. It's really in the order of a few G loads. But we wanted to look at the entire range.

And on the low side, meaning the strain amplitude around the .1 percent, you know really correspond to 10 to 15 G loads. And some of the fuels, those are the fuels, the acronym on the right, actually the HBR is the H.B. Robinson. Those are samples that failed. We took it all the way to failure. That as you can see, went close to actually 2 million, up to 2 million vibrations, especially at the 10, 15 G loads.

And some of them did not fail at all. The H.B. Robinson, those hollow squares that even after 10 million of cycles, phase weeks, they didn't fail. And then some MOX fuels, some of those data it is not from the NRC program, it is from DOE program. DOE is continuing actually our efforts and doing the same tests on different clad types. So they're done on the MOX fuel and LMKs that Limericks the fuel. So those are the DOE funded. But of course the test results are available to us.

So again, the burnup for these samples range from 63.8 to 66.8 gigawatt-days per MTU. Certainly it was a high burnup samples.

And the Phase 1 test we, it was a total of completing four static tests. What you are

seeing, these are the -- I just put the picture for the dynamic test, the vibration. The static test basically taking the sample, you know, bending, you know, all the way and looking at these failures. Sometimes it didn't fail, it bent all the way. So it's still the behaviors show the same ductility at Phase 1, under Phase 1.

We haven't done that yet for Phase 2, rearranging the hydrides to feed the same test. We haven't done that part.

And we did a total of 16 samples. We did a vibration test on 16 samples. Basically tests that we started very recently, a week, two weeks ago. And the plan is to do a bend test on one sample, one or more if we have more samples. If we have funding, you know, we would like to get more samples. But at this point the funding that we have is only we have a total of four samples. And so we're going to use one for static and the other three for remaining dynamic tests to cut that to feed the same tests. So we're hoping in the next month or so we could complete those tests.

Now, what was the consequence of that? Those were, that's kind of a quick overview of the tests at Oak Ridge that we've been doing. So as I

said, in the meantime, a few years ago when we started that we started in parallel. Okay, let's do consequence anyway. Let's see, you know, what would be, if the fuel fails can the casks still meet all the safety requirements?

So what we defined basically three categories of reconfiguration. We defined at the three categories it was the complete cladding failures. And deformation is ranging from the contraction to the rod expansions. And as we see that appears on the right.

And we also looked at the axial alignment, that the fuel rods, especially with respect to the criticality, safety, if the fuel rods kind of are not aligned with the poisons in the cask we wanted to look at the consequence of that.

And we looked at in all four major areas in terms of consequence: criticality safety, shielding, containment and thermal. So we looked at those scenarios and the impact with respect to those disciplines.

Again, John Scapioni last summer gave a detailed presentation of the results. As a consequence these NUREGs have been issued. And so

I just put together one slide, very summary of the results what you heard back in last summer.

With respect to criticality, what did we see the analysis approach? Again, indicated that from those major, the major configuration -- we actually wanted Oak Ridge to look at the entire actual spectrum. Again, some of the scenarios in terms of the fuel failure in the -- it was very really unlikely. But we wanted to look at the entire range. But typically from the plausible scenarios or the credible scenarios in the criticality safety you would see less than 5 percent increase in the fail factor. This is what we observed with respect to criticality safety.

If you look at the reasonable and credible, you know, scenarios in terms of the all three configuration fuel failures: complete breach, bending and axial movement.

In the area of shielding, loss of the, complete loss of the fuel cladding, fuel reconfiguration, we saw that the surface dose might go up by less than three times. Normally the doses, actually these cask vendors when they design they are low. But some of them, you know, they push to the limit, for example 10 millirem. I mean

they could come in with the, you know, 9 millirem because these applications are really pushing the margins. Is there higher burnup, higher heat load, shorter cool time? So it's pushing.

So it is not unusual to see the situation that they are close to the regulator dose limits.

So this is what we saw with respect if we did a total fuel reconfiguration, what does it mean? And that assumption is we assume with the 25 percent redistribution. Of course, you know, you could do other scenarios. And we had Oak Ridge do the scenarios, like 100 percent of the fuel failure in one corner, you know. And those are the really non-credited and unreasonable scenarios. But this is, these are the numbers that you will see for credible scenarios.

In the area of containment and thermal, again allowable leakage rate and decay heat are decay-time dependent. So the consequences associated with these geometry changes may be offset by longer storage time. Which is true that the, if you see that the decay heat, for example, that kind of situation you don't hear about the cladding anymore, so what comes into play, okay,

are you still maintaining the containment seal integrity if there is a concentration of the heat source near the containment source.

But of course those can be played with because you have a really flexibility with respect to the cooling time. So with respect to allowable leakage rate, that goes back to your question in terms of we looked at the different fuel, failed fuel fraction. Oak Ridge looked at it from .03 to .10 to .15 percent. And, of course, some of these numbers, as I said that the 3 percent fuel failure under normal condition that we're assuming that's the number was historically used for low burnup fuel.

The question is, you know, are these percentages, fractions, you know, is it high? So that's what we looked at the range from 3 percent, you know, went all the way to 15 percent. And even under the accident condition even for low burnup currently what we approve, we make the applicant to assume 100 percent fuel failure with respect to containments, not with respect to shielding, criticality. Because we want to make sure in the event, unlikely event, even all your fuel crumbles, that that overpack will confine and contain the

radioactive material.

So even currently now, you know, with anything, you know, so 100 fuel failure, then use the pressures that are released from the spent fuel rod, use that as the internal pressure of the cask containment and calculate, you know, the release rate. So they still have to meet the regulatory requirements under the accident condition with 100 percent fuel failure.

Thermal: basket temperature increases. We saw that they would increase by about 130 degrees Celsius, again because of the fuel failure concentration of the fuel debris. And the temperature, the effect that it had on the temperature was around 10 degrees, you know, Celsius within the canisters, the fuel being within the canister.

And, of course, that depends on the cask design. But typically the cask design that was used for this exercise it was a generic cask. It was a 32 PWR and it was a metal system. But of course is different, you know, the casks it was a "Liporal." The heat transfer system, you know, from one design to another is different. But that will give you an idea about the range of the

changes that we saw when we did the consequence analysis.

MEMBER SKILLMAN: Meraj, is the difference between the PWR fuel and the BWR fuel the notion that for every single PWR assembly you basically have four BWR assemblies?

MR. RAHIMI: In terms of the source?

MEMBER SKILLMAN: Yes.

MR. RAHIMI: Yeah. In terms of the -- as you well know, that the uranium content, yeah, normally is generally typically one-third of the PWR content. You know, for example, you use about, you know, 170, 180 kilograms starting, the fresh BWR, versus you're talking about 450 to 500 kilogram uranium located in a single. It's kind of one to three that's what I would say.

That also when you deplete it, I would say, you know, the same things in terms of source strength. I would say, you know, three to one because, you know, looking at the uranium content, initial loading, normal PWR is two to three times more initial uranium per assembly than compared to BWR.

But, of course, you put more BWR in the cask, the same diameter cask that they use, let's

say 37 PWR, same diameter you can up to 89 assembly. Those these vendors, you know, they fit 88, 89 in an assembly.

So in terms of the source then, the overall source then is equivalent at 89 BWR versus 37 PWR.

So what is, this is the big picture what is our next step, is our goal is to issue the final RIS, you know, by the end of this calendar year because our folks are working hard. And I should acknowledge really the people that are working on this, Michelle Bales, HUDAB, you know, Ricardo, David Tang. There's a whole team, High Burnup Task Force. But they're really working hard, first, making progress on the NUREG.

Then we were at the point that we can put the drafting reg to be issued for public comment, at that time we want to issue the final RIS. And those are the dates that we have plans to issue those documents. And I think those are the same dates that Mark put up.

So that was a quick overview so in terms of high burnup. I'm sorry, maybe you wanted more details, but we will be more than happy to brief that, you know, go into, if you want, more

detailed discussion on any part of this area on the tasks we've done, on the consequence analysis. We will be more than happy to provide more information, details especially.

MEMBER SKILLMAN: Thank you.

MR. RAHIMI: And those are references that I cite throughout my presentation. Those are the acronyms.

And let's see. Oh, I had a couple back-up slides about RIS. That's what the RIS is, it's about a licensing approach flow chart. So is the other one, transportation.

And I will be more than happy to answer any questions, any more questions.

CHAIRMAN BALLINGER: Thank you.

MR. RAHIMI: Thank you.

CHAIRMAN BALLINGER: Next.

MR. CHUNG: Hello.

CHAIRMAN BALLINGER: All the way at the bottom.

MR. CHUNG: All the way at the bottom. Thank you, it's on.

CHAIRMAN BALLINGER: As long as the green light's lit.

MR. CHUNG: Yes, the green light's lit.

Thank you.

MR. RAHIMI: So where is Donald's presentation here? Let me pull up your presentation.

MR. CHUNG: All right. Wonderful.

CHAIRMAN BALLINGER: Ah. I've been waiting for this.

BUILDING A RISK FRAMEWORK FOR DRY STORAGE

MR. CHUNG: Good afternoon, everyone. My name is Donald Chung. I'm a reliability and risk analyst. I currently work for, I work for Meraj in the Office of Nuclear Material Safety and Safeguard. I'm a new player on the Storage Team. I joined the NMSS about a year ago. Prior to that I spent ten years in NRR, Division of Risk Assessment, doing significant determination process, notice of enforcement discretion, effects of regulation. And early in my career I spent a few years at TMI on the clean-up project.

Next slide.

Again, we're doing storage. And I'm going to be talking about risk-informed storage.

CHAIRMAN BALLINGER: Try to keep the paper off the little thing there.

MR. CHUNG: Oh yes. Yes. Thank you.

CHAIRMAN BALLINGER: Otherwise the court recorder will go nuts.

MR. CHUNG: Yes. Thank you. Thanks, Chief.

A little background. This is probably very obvious to most of you. The Commission has a longstanding policy on increasing use of PRA risk approach.

The risk-informed decisions extensively used in reactor oversight and licensing. And in reactors, of course, PRA modeling insights are based on core damage frequency and large early release. Of course, looking at spent fuel we don't have core damage frequency or large early release.

Next slide, please.

As mentioned earlier by Meraj, there's been two PRAs done. These were done roughly 10, 10, 14, 15 years ago. One's by NRC, the other one's by EPRI. And I will mention more on these as we go forward.

Go to the next slide.

Again, spent fuel is not the same as reactors. If you look on the right, that's a figure from NUREG-1150, Severe Accident Risk and Assessment for Five U.S. Nuclear Power Plants. And

if you look on that figure, on the top you see safety goal and then you see the bars for five plants: Surry, Peach Bottom, Sequoyah, Grand Gulf, Zion.

On the left you have the two PRAs. These are comparison of the latent cancer risks from reactors and from dry storage. As you can see, the two PRAs indicate that the latent cancer risks are roughly four orders of magnitude than for reactors. And the red dot on top, of course, it's a level of latent cancer risk that's accepted under the Commission's safety goal policy, which is 2 times E to the minus 6 cancer fatalities per year.

Next slide please.

Boss talked about the paradigm change. And basically what has changed since the last PRAs were done 10, 15 years ago, the first of course is increased storage duration for beyond 20 years. And some of the things we're aware of now is concern with aging effects, chloride-induced stress corrosion cracking. We have new information on manufacturing defects. We have data on spent fuel canister misloads that we weren't aware of or at least wasn't covered in the two earlier PRAs.

We have additional data on human error

doing cask preparation. In addition to that we also have historical data from the last 20 years. And in the last 20 years there hasn't been a known canister failure, a canister that was placed on ISFSI and had to be brought back for repair. Not a single one has failed. And there's been over 2,000 dry cask storage systems out there. So we have some historical data that we didn't have before.

Next slide, please.

Why do we want a risk-informed dry cask storage? Here's the objectives:

One is to have better focus on our regulatory efforts. Be prepared to evaluate changes in risk. We're not looking at 20 years anymore, we're looking at renewal looking at 60 years, possibly over 100 years. Things will change. There will be environmental effect, there will be aging effect.

It would be nice to have a system in place where we can evaluate changes in the risks we're facing, even though the risk right now is very low.

Again, we want to establish a decision metric. We're proposing to use confinement breach, confinement breach of the canister. If it is a

dual-purpose cask, it will be the cask.

We will look at confinement breach as comparable to what's used in reactors at core damage frequency. We will use that as a consequence measurement. That's what we're proposing.

Again, if PRA results continue to indicate very low risk, as what we're seeing right now for storage, term storage, staff will re-examine criterias for dry storage safety requirements. We'll see as we go forward.

Okay. In terms of phases of operation, you have four phases of operation. There's the cask/canister loading and preparation. This is basically typically taking the fuel, you're putting it into a canister in the pool. You take it out, you dry it, you weld it. You put it into a storage overpack. The crawler takes it out to the ISFSI. Sits out there. And then eventually you may have to transfer it.

Now, what has changed in the paradigm? What has changed, basically the last two steps, step 3 and step 4. Before when you put it on ISFSI it doesn't go anywhere, it doesn't move and no one touches it for 20 years. Well, for license renewal

things are going to be different because license renewal requires periodic inspection.

And I want to point something out to you. If you look on the figure, it shows ISFSI and the packages on there. See how close they're sitting? When you put dry cask storage units on the ISFSI, the concrete pad, where do they start putting it? They don't start from one end and go to the next end. That's not how they do it. They start from the middle. Because otherwise the ISFSI may tilt over the years; right?

So they start form the middle and they go outwards. Now, if you're going to do an inspection, which one are you going to look at? Are you going to look at the newest one out there which is on the end? No. You want to look at the one that's in the middle; right? How are you going to do that? That crawler can't pick one up that's in the middle.

So if you do inspections there's a good chance that you will have to move canister, you have to move those packages. You're going to have to lift them up. So there is risk associated with inspection.

You know, in reactors we have risk-

informed ISI, we have various things that's done in terms of risk. If you're looking at long-term storage you have risk opportunity for handling, there's opportunity for lifting. And there's risk associated with that. Setting it out there on the ISFSI and not moving it has very, very low risk. If you're lifting it, there's a chance that that cask can drop. And that's where your biggest risks are.

CHAIRMAN BALLINGER: So are you saying --

MR. CHUNG: Go ahead.

CHAIRMAN BALLINGER: -- that the risk-informed approach would avoid you having to do the inspection? Because that's the lowest risk --

MR. CHUNG: Well, what would happen --

CHAIRMAN BALLINGER: -- that you're talking about.

MR. CHUNG: Well, that's a good question. One example is what we do for reactors, risk-informed ISI; right? You could look at it and you could say, okay, now we're doing an inspection that requires moving ten casks. Now what is that buying us? Is that buying us significant safety reduction? Maybe we don't want to do it every five

years. Maybe we want to do a sample and maybe we want to do a sample every seven years.

You could do an evaluation of what you're gaining in terms of risk reduction. That's one of the considerations.

Do you have a question, sir?

MEMBER SKILLMAN: I do.

MR. CHUNG: Go ahead.

MEMBER SKILLMAN: I was waiting for Ron.

MR. CHUNG: Okay.

MEMBER SKILLMAN: Can we back up a slide?

MR. CHUNG: Sure.

MEMBER SKILLMAN: Your fourth bullet. Great. That seems like a true place for discussion. "Staff could re-examine criteria for dry storage safety requirements." For example what?

MR. CHUNG: For example, you know, we spent a lot of time talking about hydride reorientation. Is that really, in terms of storage, in terms of storage is that really important?

MEMBER SKILLMAN: Probably not.

MR. CHUNG: Yeah, probably not.

Well, what we decided on eventually. But for shipping it might be important. For transportation it might be important. But for storage it might not be.

MEMBER SKILLMAN: That seems to be a very -- that's a good answer but it's a very narrow answer.

MR. CHUNG: Yes, sir, it is.

MEMBER SKILLMAN: It seems like there are, more like there are much broader implications that this might present to industry that could be huge savings because these containers are massive, they are strong, they are passive.

MR. CHUNG: Right.

MEMBER SKILLMAN: They are happy to cool themselves. They are almost impervious to vermin. It seems that this could lead to some real benefits as long as we hold the idea that this material will remain on the ISFSI pad for a long time.

MR. CHUNG: I agree with you.

CHAIRMAN BALLINGER: Let me expand on that again.

MEMBER SKILLMAN: Sure.

CHAIRMAN BALLINGER: Right now 1927 doesn't allow for this.

MR. CHUNG: No, it doesn't.

CHAIRMAN BALLINGER: Okay. And I was asking Al what prevents a licensee from doing this in a risk-informed way to start with? What prevents a licensee from coming to you and saying, I have this ISFSI out here and I want to renew the license but I want to use probabilistic -- I want to take a risk-informed approach. Right now they can't do that.

MR. CHUNG: We're in an embryonic phase of something.

CHAIRMAN BALLINGER: Well, I'm looking at that dot there.

MR. CHUNG: Right.

CHAIRMAN BALLINGER: The third, fourth dot.

MR. CHUNG: Right.

CHAIRMAN BALLINGER: And I'm saying is that your intention --

MR. CHUNG: It's a possibility going forward.

CHAIRMAN BALLINGER: -- or is that a possibility?

MR. CHUNG: It's a possibility going forward.

CHAIRMAN BALLINGER: Okay. Possibility as opposed to intention.

MR. CHUNG: Right now we don't have the PRAs. We don't have, we don't have the data.

MR. RAHIMI: Yeah, let me add this. That the, yes, we are, our intention is not to really go one way or another. We are approaching this with an open mind. We say we've got limited resources. And this focus of resources where there's a really safety issue, you know, in terms of coming over the criteria requirement. So that is our approach.

In some areas it might be, you know, the numbers might show, oh, this is a high-risk area and we have to increase it. In some areas, in the scheme of things it might make a difference, but really we need to lower our criteria.

CHAIRMAN BALLINGER: So starting from 10 to the minus 14. So that's a number which I don't -- that's not even on my calculator. I can't even set --

MR. CHUNG: We haven't been on Earth that long; right?

MR. RAHIMI: So 10 to the minus 14, again, those actual studies that were done there was -- there wasn't really that much operating experience.

MR. CHUNG: Yeah, I will get into that. That's right.

CHAIRMAN BALLINGER: Well, but the operating experience is zero failures.

MR. RAHIMI: No, no. Twenty years, 20 years history we have.

CHAIRMAN BALLINGER: Okay.

MR. RAHIMI: The phenomena that wasn't stress corrosion cracking at that time.

CHAIRMAN BALLINGER: Well, stress corrosion cracking existed since Roman times. But --

MR. RAHIMI: I know. But in terms of with respect to the dry storage --

MR. CHUNG: Maybe it's better if we answer the question that they're asking.

MR. RAHIMI: I think so. I think so.

MR. CHUNG: Yeah.

MR. RAHIMI: But I think it's the important part that they know why we are doing this study. If we keep saying that this is 10 to the

minus 14, 10 to the minus 13, yes, those studies were done without incorporating the two main components. Aging was not a factor included when they did those numbers. And the more operating experience that we have in terms of the loading mis-loads. So that is the reason.

CHAIRMAN BALLINGER: Okay. But my question is why not do that?

MR. RAHIMI: That's what we're doing.

CHAIRMAN BALLINGER: Well, you said a possibility.

MR. CHUNG: Well, we're in the embryonic phase. We haven't got to a point where we have the funding to get labs to do research for us. We don't have, plants don't have PRAs for their ISFSIs. There's very limited information out there right now.

MR. CSONTOS: Let me -- can I distract you over here?

NUREG-1927, Rev. 1 does not preclude this. Okay? What we've done is we have to do something now.

CHAIRMAN BALLINGER: Right.

MR. CSONTOS: Okay. We have renewals that have to be done now. Okay? And we did do a

qualitative risk informing through the staff to do what we believe is reasonable.

We're not asking for inspection of all 2552 canisters that are out there. Okay? We're looking at a very small, small subset to assess whether or not there is significant degradation or not, and to assess whether or not we need to go to a full quantitative. Because it is expensive, okay. And NRC right now not, we're not doing so well in the funding arena.

CHAIRMAN BALLINGER: 2020.

MR. CSONTOS: So what we have here is we've got to do something.

CHAIRMAN BALLINGER: Well, you have your budget but they have their budget.

MR. CSONTOS: We've got to do something. And I think that's what -- I don't, 1927, Rev. 1, you'll see it tomorrow, is a learning process. Okay. It's offering a risk -- basically it's talking an operations-focused approach. Okay. We're not going to be risk-based, we're going to be risk-informed. We'll really be informed by, okay, and that's why we're not asking for everything right now. Okay? We're going to get and assess the operational experience and we'll move forward.

And how we move forward it may be a full PRA. It could be other things. All right? We're just setting the stage for what's going to happen going down the road. So I don't want to say, make points of preclusion. That wouldn't be correct. I would say that it's open to a lot of options going forward because that's why we call it an operations-focused approach.

CHAIRMAN BALLINGER: Good.

MR. LOMBARD: If I could go back also, Don referenced the fact that inspections would require lifting a system. And there is only one inspection I could think of now that would require lifting a system, that's during the inspection of the underside of the system itself to see if there is any degradation of the bottom.

So there is many, many other inspections that need -- that would be, probably be done under the aging management program, and they would not require lifting a system. So just to put that in perspective.

When we started down this path over a year ago, our intention was and still is to risk-inform the operations, storage, regulatory and oversight actually, you know, not just a regulatory

piece, not just a licensing piece, but inspection and oversight as well. So I think there still is to come up with a regulatory framework that would provide some benefits.

But as Meraj said, I mean as you go through this you might find there is or many areas that you can do less in, and there might be some areas you might want to do more in based on the qualitative risk-informed. We had intended to do PRAs or require PRAs on every single system. We don't want to put that burden on us or the industry. We are trying to come up with a qualitative approach that we could apply building this risk framework to then look at the systems and move forward and within our storage framework.

CHAIRMAN BALLINGER: Any other questions?

MR. CSONTOS: Let me just say one more thing. The risk-informed ISI inspection program for the reactor site handles certain types of cladding systems that really don't do much to safety. Okay? And if you take a look at that and you, and you try to look at CDF, okay, I bet you it's really, really low as well. Okay? And so doing a risk-informed sampling approach is the

approach we're taking there. And that's in line with what the risk-informed ISI program and the Reg Guide is all about.

Have we got to a quantitative risk-informed ISI metric yet? No. What we're doing here is we're using that same principle. That's why I'm saying it's risk-informed. What we're doing is risk-informed here.

Okay. So just please be aware of all these things that we're doing.

CHAIRMAN BALLINGER: You know, it really -- excuse me -- you look at these -- It's on.

You look at these massive things and you haven't had any failures. I mean it almost -- I'm just listening to this stuff here since I'm not a risk guy. And I'm just wondering, it almost sounds like you're doing risk because it's the vogue and the fad to do risk-informed analyses for a piece of equipment that goes nowhere, does nothing, sits there. You can't take it apart without extreme risk. And they're -- you can't look inside of them without taking them apart, which is more risk than doing nothing.

And so I just, I'm just sitting here

looking at everybody's yelling about resources and money, and it just almost seems like, I don't know, it's like when you're playing poker and you keep throwing money in. It's bad money after good.

MR. CHUNG: Good money after bad.

CHAIRMAN BALLINGER: Or good money after bad. That's good. Thank you very much. Show you how my brain's fried.

But I mean and you talk about how you have to move all these canisters around. There's ways to load a pad without having to move the oldest and grungiest, you know, container or canister that you've ever had. You don't have, so that you don't have to move anything. You just sit there and watch it, whatever it does, and if it crumples then you've got one answer, and you don't have a big -- so I, I'm just, it just kind of boggles my mind that we're really now applying PRA to something that is older than the universe.

MR. CHUNG: I totally agree with you. But let me finish the presentation. We'll finish --

CHAIRMAN BALLINGER: Oh, we're going to let you. We know you'll finish the presentation. That goes without saying. I just -- go ahead. I

just wanted to make that observation. We got going the wrong direction, so.

MR. CHUNG: Okay, doing the PRA, we'll go back to a little bit on the safety function.

Basically you have spent fuel sitting in, typically in a canister. And the safety function that's required you have basically three safety functions. One is to protect against release of radioactive material. That's the canister. The canister provides protection against release. Okay?

And by protecting against release you also protect against criticality. Because without water in the canister you will not have criticality. Okay?

And also protection against radiation exposure. Again, as long as the radioactive material spent fuel particulate isn't coming out of the canister, you're pretty well protected. You know, you have the concrete overpack that provides a lot of radiation shielding. If you don't have failure of the canister you're -- that's your greatest concern. Having that canister in place, having that canister protecting against water getting in and particles getting out, you basically

fulfill most of your safety functions.

Next. Going back to the basics, defense-in-depth. This is not a reactor. It's fairly simple. You have Level 1 is basic prevention. It's to prevent release of radioactive material, prevent criticality, limit radiation exposure. And that's being covered by C.F.R. 72, CoC, standard review plan, and MAPS.

Level 2 is mitigation. Again, there's not a whole lot to mitigate here. This is a passive system, passive nature of the material being stored. You not going to have a, you know, a lot of -- you're not going to have a core melt, you're not going to have your type accidents you can have with reactors. There's lack of a significant dispersion mechanism. Again, your storage system you have a very robust construction, dry cask storage system, as you pointed out. So Level 2 is fairly simple.

Level 3 is emergency actions. This is, again, the threat's in C.F.R. 72, adhering to emergency plan. For ISFSI if it's a general site license you have basically two levels for the emergency plan: you have alert and site only emergency.

And for ISFSI that's away from a reactor all you have is alert. There is no, there is no evacuation in the emergency plan. The reason is because you don't have the type of dispersions you have with reactors.

Since I came from the reactor world I didn't know anything about dry cask storage system. And I will share what I learned with you.

Basically there are three types. There's the vertical above-ground system. And they could be generalized into the HI-Storm 100 which is on the right. Again, that's a canister, welded stainless steel canister sitting in a concrete overpack. That's the one on the right.

On the left is a dual-purpose cask. This is a carbon steel bolted system. The lid on the hub steel cask is a double-gasket system, kind of like the reactor vessel. So it's actually monitored. They could monitor the space between the two gaskets. If there's a leak, there's a change in pressure they will know.

The welded system there is no monitoring.

Both systems are cooled by natural convection. The one on the right you see there is

an opening on top. There's also an opening on the bottom. Natural circulation cools the canister.

Okay. The PRAs that were done, NRC evaluated the HI-Storm 100, which is the concrete overpack one on the right. EPRI valuated the one on the left which is the TN, TN system.

Next slide please.

One system that's much more popular today, I guess partially because it's less costly, is the NUHOMS system which is a horizontal system. Again you have that canister.

The world of stainless steel canisters also refers to in many places a multi-purpose canister. The canister is stored horizontally into a concrete boat or concrete storage module. Again this is, it's cooled by natural circulation. You have an opening on the bottom. Air goes in and there's an air opening on top that's cooled by natural circulation. The system is, again, it's very robust. The canister is horizontal instead of vertical.

And then there's a third system. Next please. This is a HI-Storm UMAX. HI-Storm MAX and secured UMAX. This is a canister sitting in a silo that's underground. It has some advantages,

obviously. There's less of a target area for terrorists, but it has some practical issues such as it's probably more difficult to inspect. If you want to look at whether there's a corrosion of the liner, what have you, I'm not sure how you're going to do it.

Again, there hasn't been much study on these.

Go ahead again, please. Okay.

Proposed risk-informed regulatory framework. Again we're, I'm looking at this from my reactor background. You know, it doesn't matter whether it's BWR, PWR, whatever type of reactor, I'm looking at a framework that would apply to all dry cask storage systems.

Okay, next.

Okay, and I'm proposing adopting confinement breach frequency as the metric for risk. It's basically when you're looking at storage, the canister systems, that canister is your confinement. Okay, the clad, we're not giving credit to cladding. The overpack has openings for natural circulation so they don't provide any confinement. It's the canister. Okay.

The dual-purpose, of course, is hard

steel, it's one layer, 6-inch thick. It's that's one layer. So the confinement is what I propose that we use as the metric. Okay.

And also we propose to set a confinement breach frequency limit for storage in ISFSI. The two PRAs that are available right now, what they evaluate is one canister sitting out on the ISFSI. Okay. The 10 to the minus 14, that's for exactly one canister.

Now, if you go to the ISFSIs that are out there today, there are 60 ISFSIs, a lot of them have 40, 50, 60 dry cask storage units out there. And if we look at interim storage in Texas or New Mexico, you're looking at possibly a field of several thousand storage systems.

So but then if you look offsite for one of these storage areas you want to know what your risk is, regardless how many canisters that are out there. Right? If you're living five miles down the road you want to know what your risk is, not what your risk is based on the number of canisters being stored.

So I think it's good to set a limit for the entire ISFSI. Makes sense.

And then we would like to propose a

risk-informed regulatory guidance, basically a risk metric, a risk metric that will allow you to compare risk. And I will talk about all three of these things in the following slide.

CHAIRMAN BALLINGER: So confinement breach is the metric, what Al would say would be we want zero perforation of the canister. Right, Al?

MR. CSONTOS: It really depends. I mean, yes, we would like to, you know, stay in compliance with the regulations, which is the confinement function that's being maintained. Of course, you know, we'll have to see. You know, I always treat ISFSI as like a disease, you know. Let's see if we have it first before we go, go off.

If we see we have a disease, then let's go off and figure out what we're going to do about it. Whether or not, you know, there is you have some doctors say "don't do more harm." Okay. If we find out that the risk to the workers to do all this remediation work is more harmful than leaving the crack in there, okay, and that's the time to do some sort of risk analysis on this, then that's the time when we'll have to think about this.

But as of right now, the ideal, the situation is what the regulations state which is

that the confinement function needs to be maintained. And that's what we're trying to do in the aging management programs at a small level.

MR. LOMBARD: So let me just clarify. A risk analysis means in this case, as Al was alluding to, probability and consequences. So you'd know what the consequences are at the end, just to be clear.

CHAIRMAN BALLINGER: Right.

MR. CHUNG: Any other questions?

MEMBER POWERS: Can we come back a little bit. You had a discussion I didn't quite follow.

MR. CHUNG: Okay.

MEMBER POWERS: That said, okay, if I'm out in New Mexico --

MR. CHUNG: I'm sorry, you have to speak up a little bit.

MEMBER POWERS: You were out in New Mexico and you had thousands of canisters.

MR. CHUNG: Canisters. Right, you have a closed system. Right.

MEMBER POWERS: And then you said something to the effect you wanted to limit the number of canisters?

MR. CHUNG: No. We have a Commission safety goal policy. Right? And that's according to that policy it defines what's negligible risk. According to that policy, the latent cancer fatality for the general population near a nuclear facility should be no more than one-tenth of 1 percent.

MEMBER POWERS: I'm familiar with your --

MR. CHUNG: You're familiar with the policy.

MEMBER POWERS: -- productivity procedures.

MR. CHUNG: No, that policy does not state on your site whether you have one reactor, two reactors, three reactors or four reactors. Basically what I'm saying is that the same thing should apply here. Whether you have one canister or 1,000 canisters, your risk all sites should be the same.

If you live near a ISFSI, you should be exposed to negligible risk, negligible risk according to the Commission's basic policy regardless how many canisters are there. Right? Does that make sense?

MEMBER POWERS: Well, there are lots of things I can pick on here about this.

MR. CHUNG: I'm sorry, Dana, I can't hear you.

MEMBER POWERS: There are lots of things I can pick on here is policy is not law.

MR. CHUNG: Policy is what?

MEMBER POWERS: Policy is not law.

MR. CHUNG: Yes, you're right.

MEMBER POWERS: And so I can quibble with you there.

The next question that I have is have you identified mechanisms by which you would get concurrent failure of canisters?

MR. CHUNG: Yes.

MEMBER POWERS: And those are?

MR. CHUNG: Some actions that are evaluated in the PRAs they include plane crash, earthquake, toppling over, toppling canisters over. Those are not going to involve just one canister if you have a field of a thousand. It's hard to imagine a plane hitting an ISFSI with 100 casks and only strikes one. That's kind of hard to see. If you have an accident like that you're going to involve multiple canisters.

If you have an event that caused toppling, what caused one canister to topple will likely cause other canisters to topple as well.

MEMBER POWERS: But it has to fail.

MR. CHUNG: That's correct.

MR. LOMBARD: If I could be clear, some of these scenarios were looked at after 9/11. I don't know if you all were privy to any of those presentations.

MEMBER POWERS: Well, I want to stay away from the --

MR. LOMBARD: Security?

MEMBER POWERS: -- security issues right now.

MR. LOMBARD: Yes.

MEMBER POWERS: Because that's explicitly excluded from the safety policy pool, safety policy statement.

MR. LOMBARD: Right.

MEMBER POWERS: So we want to stay away from that. We're talking about an accidental plane crash or an earthquake.

MR. LOMBARD: Right.

MEMBER POWERS: Okay. So what is the probability that an earthquake topples a bunch of

canisters and the canisters fail?

MR. CHUNG: The probability of an earthquake toppling any canister is very low.

MR. LOMBARD: And the systems are actually designed against a non-mechanistic top-over. If they were to fall over they're, by design they're not to fail.

MR. CHUNG: But let me give you a scenario. There was a previous slide where I show a field of dry cask storage systems. You notice how close they fit? If you have a lift, if you have to do an inspection and you have to lift one of these things up and you accidentally drop it and it tips over, there's a good chance that it will bump into the next dry cask storage system; right?

MEMBER POWERS: Yes.

MR. CHUNG: I'm not saying that you're going to have a domino effect, but potentially you can have multiple canisters impacted.

MEMBER POWERS: But it's not evidence that it causes the canister to fail.

MR. CHUNG: Well, let me go on and we can talk about the question, sir. Because I think I'm going to address some of that in the presentation.

MEMBER POWERS: Well, at least I know what you're saying. And that's all I really wanted to do.

MR. CSONTOS: You know, we're not, the inspections that we're looking at, okay, that EPRI is doing a really phenomenal job at creating these robots and stuff like that to go in, very small robots and such just to look, they would require no movement of canisters or casks. And so they would just -- what would happen is little robots, which we tried out at Palo Verde I think -- you know, you're going to be talking about it, right, Keith?

MR. WALDROP: Yes.

MR. CSONTOS: So those are, you know, they'll be autonomous -- not be autonomous but they'll have cables in it, but there, that would mean you don't have to move them around. Because every operation involves risk. So you have to evaluate risk of movement, risk of any of these other operations to what's the information you're going to gain out of it and what you're doing to the workers.

So we have to be cognizant of that. And that's what we've done in our, in our team in that qualitative risk-informed kind of approach

that we're doing here.

So FYI. I don't want to frame them, I just want to make clear.

MR. CHUNG: Yes, thank you. That's very good, Al.

And technology's evolving. There may be ways to do inspection without lifting. But right now I can only tell you based on what we have right now.

MR. RAHIMI: Yes. I think I need to qualify what Donald is saying that at all times in the system that we approve and they have to withstand a design-basis accident at all times. We approve them for 20 years, at any time during 20 years. If we renew them another 40 years, let's say up to 40 years.

So tip-over, drop, at all times they have to meet.

So even given any possible degradation, I mean that's what we're going to evaluate, will they continue to meet a design-basis accident and safety requirements. So if it is, I mean not the lift and drop because those are given that at all times these systems during their life sitting on the pads up to 60 years at this point, they should

meet their confinement requirement given the design-basis accident. And they do. At this point at least for what we have approved, we have looked at it, and that's where the whole renewal, whole aging management comes into play that they continue to assure that the casks meet the design-basis accident.

MR. CHUNG: Let me just kind of bring us back a little bit. The purpose of this presentation is to talk about the risk-informed framework that we're building. You know, we're going beyond building this framework. You know, we're in the embryonic stage. We're not looking at actually how is this going to be applied? Not so much. But right now I'm bringing my knowledge from NRR how risk-informed is used. And I'm looking at the spent fuel storage and I'm saying, okay, how that knowledge could be applied here. And we're developing a process for risk informing.

In terms of going forward, I think that there's a lot of work to be done.

MEMBER POWERS: What I'm hearing is this is a conceptual approach. This is not cast in concrete.

MR. CHUNG: No, it's not.

MEMBER POWERS: This is embryonic thinking.

MR. CHUNG: Yep.

MEMBER POWERS: And this is, at least at this point in time the general direction that you're heading. And this is subject to change, it's subject to challenge, but at least this is a place to start.

MR. CHUNG: Yes, sir.

MEMBER POWERS: Is that correct?

MR. CHUNG: You're absolutely right.

MEMBER POWERS: Thank you.

MR. CHUNG: Any other questions?

MEMBER RICCARDELLA: This is Pete Riccardella. Am I online?

MR. CHUNG: You are.

MEMBER RICCARDELLA: A question on this confinement breach frequency. Is that per operating year? I'm trying to draw the analogy to a CDF, core damage frequency.

MR. CHUNG: Yes, it's per year.

MEMBER RICCARDELLA: Per year.

MR. CHUNG: Right.

MEMBER RICCARDELLA: Could that, we usually talk in terms of per reactor-year; right?

MR. CHUNG: Right.

MEMBER RICCARDELLA: And if you have multiple reactors at a site, --

MR. CHUNG: Yes.

MEMBER RICCARDELLA: -- I'm getting back to this multiple-cask issue that you discussed.

MR. CHUNG: Right. When you say per reactor-year, you don't take a site with three reactors and divide it by three, you treat it as if there's only one reactor. And basically it's per site.

So with confinement breach frequency what I am proposing is that we have it the same way, we have it per site.

MEMBER RICCARDELLA: Okay. So it's directly comparable then.

MR. CHUNG: Yes.

MEMBER RICCARDELLA: Okay.

MR. CHUNG: Think of the person living five miles off from the ISFSI. Are they going to be living with greater risk when you have more dry cask storage systems on the site? They should be living with the same risk regardless how many storage systems you have.

MEMBER RICCARDELLA: I understand.

MR. CHUNG: Right. Okay. Ready to go forward?

MEMBER REMPE: Yes.

MR. CHUNG: Okay. I presented the three concepts. And I'm going to go through the first one. This is confinement breach, why I'm proposing confinement breach. The metrics were reconformed.

The reasons are the following: one is the precursor to release of radionuclides; two, when you talk about risk from storage, the risk is really to workers, these people on site. Also, when you talk about risk, you're really also concerned about risk of environment or contamination. Okay. That's, that's my justification for selecting confinement breach.

Next slide, please.

This is just kind of a brief presentation on how the PRAs were done. Basically they have initiating events. They have, you know, this is an event tree. You have an initiating event. In this case it's a drop, you have the confinement, the split fraction for confinement breach.

You also have split fraction for fuel cladding. And the two PRAs, any time you have a mechanical impact it assumes that the fuel cladding would fail. Okay, if you have a drop, the fuel cladding it would fail.

So if you look in confinement breach, basically the frequency of initiating event times the probability of canister failure times the probability of fuel cladding failure, in most cases the probability of fuel failure is one.

One exception to this is here is when you have a fire, it's recognized that because you have such a robust system, even if you, even if you damage the canister the cladding may not go. That's our only exception.

This is how it's done in the PRA. I'm not defending it. I'm not -- I'm just presenting what is there.

MEMBER POWERS: Is it the form you're using confinement breach frequency, doesn't that fail to recognize that the potential source term is vastly small compared to the reactor?

MR. CHUNG: Dana, you brought up a very good point. This is very different from a reactor, as I point out in the very, very early slide.

Okay. In the reactors if you have an accident, it doesn't matter if it's a new reactor or a 45-year-old reactor, your source term is going to be pretty much the same.

Here the spent fuel decays with time. Right? So if you want to look at a consequence, if you want to look at the consequence where the spent fuel is less radioactive over time, so this gets very complicated if you want to look at consequence.

So, again, going to that next slide --

MEMBER POWERS: What is the potential source term?

MR. CHUNG: I'm sorry. What?

MEMBER POWERS: What is the potential source term?

MR. CHUNG: What's the potential source term? I have a very -- I have a slide at the very end of the presentation. Do you want me to answer that question now or can I answer later?

MEMBER POWERS: I'm perfectly willing to wait.

MR. CHUNG: Okay. Let's do that at the end of the presentation. Appreciate that.

MEMBER SKILLMAN: I would like to ask

this question before you proceed.

MR. CHUNG: Sure.

MEMBER SKILLMAN: In this conceptual PRA --

MR. CHUNG: This is not a conceptual PRA. This is how the PRA EPRI, NRC PRA 1864, this is basically what they do in terms of modeling consequence.

MEMBER SKILLMAN: Okay. Well, what I'm stuck on is the definition of what's confinement. As I see it, there are at least three confinements. You've got the canister, the fuel clad, but you also have the overpack confinement.

MR. CHUNG: The overpack is not a confinement because it's open on the bottom and top.

MR. RAHIMI: Yeah, in some systems, in most of the systems the vented system overpack is not your containment, because it's vented, very cool vented. But the metal system, yes.

MEMBER SKILLMAN: The metal, so I'm thinking particularly of the metal system where it acts as a shield, and then you have the canister and then you have the fuel clad. So it seems like this, this model is acceptable --

MR. RAHIMI: Yeah, this is the NR -- right, this is the NRC model.

MEMBER SKILLMAN: -- for all, for all except the steel overpack --

MR. RAHIMI: Yes.

MEMBER SKILLMAN: -- design.

MR. RAHIMI: Yes.

MEMBER SKILLMAN: Okay, I'm clear now. Just making sure.

MR. CHUNG: Good question.

Move forward. Okay. Again, the typical initiating event, this is in the standard review plan where they evaluate the mechanical events and they also have thermal events. And this is typically what's evaluated for, for accidents of drops, tip-over, seismic, water currents during a flood, strike from a heavy object, shock waves from nearby explosion; thermal event of course, you know, vent blockage, lightning, fire from aircraft fuel.

And so the way the PRA is done, basically they have all these -- this is just some of the event trees that are there. They basically have all these event trees and they combine them for each facility basically adding the cuts

together and that gives you the confinement breach frequency. You know, all these events they have initiating frequencies, you have the breach frequency and so forth.

Going forward.

Now, as we mentioned earlier in previous presentations, there is a concern with aging effect, chloride-induced stress corrosion cracking. One way that could be addressed is to have event trees that basically instead of having a split fraction of yes and no, you have ones that basically have the different wall sites, different through-wall crack sites.

Eventually you're going to be doing inspections. You know, you're going to look at a canister and the canister is 60 years old and you say, oh, there is a small crack here. But then do you have to take the canister back to the pool somewhere and repackage? Well, hopefully you don't have to do that. Hopefully you will be able to use risk-informed and look at it and say, okay, now given that there's a 10 percent through-wall, what is the probability of that canister failing? A 20 percent through-wall, what is the cut there, what's the probability of it failing?

And you can evaluate it here so that you don't have to repackage the canister for every single little flaw that you find.

Go ahead.

CHAIRMAN BALLINGER: Well, what if you can't tell?

MR. CHUNG: Well, that's a, that's a different problem. I guess you have to, then you may have to do whatever you have to do.

I mean you're familiar with aircrafts, you're familiar with reactors. The way things were done, years ago I worked in crash mechanics. And for airplanes they have cracks, what they do is they put a yellow line there and they basically look at the rate of crack growth. And they look at what's the critical size of that crack and they decide whether they can still fly the plane or not. Right? Same kind of concept to be applied here.

CHAIRMAN BALLINGER: What I'm asking you is what if --

MEMBER RICCARDELLA: Excuse me. This is Pete. But we do that same thing in reactors.

MR. CHUNG: Yes.

MEMBER RICCARDELLA: You don't need PRA to do that.

MR. CHUNG: Yes.

MEMBER RICCARDELLA: We do an in-service inspection. If we find a crack --

MR. CHUNG: Right.

MEMBER RICCARDELLA: -- we do a deterministic evaluation.

MR. CHUNG: Right. And what happens, that could be applied here.

CHAIRMAN BALLINGER: Doing this for 50 years, you may very likely see some canister with flaws.

THE OPERATOR: Please pardon the interruption. The conference contains less than three participants at this time. If you would like to continue press Star One now, or the conference will be terminated.

CHAIRMAN BALLINGER: My point is, what if you can't ever decide that it's 10, 20, 30 or 40 percent through-wall? What if you can see only -- what if the only thing you can see with any inspection technique that's reasonable --

MR. CHUNG: Right.

CHAIRMAN BALLINGER: -- is something that gives you an idea that there may be something going on?

MR. CHUNG: Right.

CHAIRMAN BALLINGER: Now what?

MR. CHUNG: This is hypothetical.

CHAIRMAN BALLINGER: Well, mine's hypothetical as well.

MR. CHUNG: Yes.

CHAIRMAN BALLINGER: But I think it's more less hypothetical than this is.

MR. CHUNG: Yeah, okay.

MR. CSONTOS: I don't want to take away Chief's thunder but there are techniques that they show that the Palo Verde demo that can look at 50 percent through-wall. So you may even have just a simple 50 percent through-wall go/no go type of thing that can see how deep cracks are with phased-array eddy current systems they have which is -- it was on the back of that robot.

All I'm saying is that this is nice. What Pete said is actually is what we're trying to do in the code right now. Pete was mentioning that we have a deterministic process, and we're trying to mimic what Pete just talked about in terms of what the reactors are doing to what we're doing this side of the house for, you know, looking at cracks, how much of an area do you need to look at,

where do you need to look at? And then if you can find out, if you can get this determination of what size crack it is then, you know, we can figure it out.

But first is first. Let's see if we have a disease. Then we move on to the next thing.

CHAIRMAN BALLINGER: But the 50 percent through-wall was already there. You knew it was there and you were trying to size it; right? At Palo Verde.

MR. CSONTOS: Well, it was a sample that was made by somebody else. The other individual it was something of a surprise. We didn't expect 50 percent through-wall ourselves, that we could be able to see that. We were surprised.

So let me ask from an operational perspective, if you find cracks can you characterize them? If you can characterize the cracks you put it in the corrective action program and then you do your assessment as a licensee.

MEMBER BROWN: Why do I care if there's a crack?

MR. CHUNG: I'm sorry?

MEMBER BROWN: Why do I care if there's

a crack? Just let's get down to through-wall 10 percent, 20 percent, even if it goes all the way through if it's not circumferential and the whole thing is going to tip over?

MR. CHUNG: Okay, why -- Okay, go to the next slide, please, Meraj.

Why do you care with these? What happens is that when you look at the PRA, when you look at things that could happen, you have basically all these things.

MEMBER BROWN: Let me, I don't want to look at a PR -- why do I care if there's a crack, I mean all the way through? What is the physical manifestation of a through-wall crack that probably does not go straight through but meanders around and all this other kind of stuff?

MR. CHUNG: The robustness of that container is compromised. So if you have a tip-over or a drop, there's a greater likelihood that you will have confinement breach. There's a greater likelihood that --

MEMBER BROWN: Maybe you ought to pack them closer together so they don't fall over.

MR. CHUNG: Well, if they're sitting there, they're sitting and you're not moving it,

you know, you don't have to worry. But the thing is if you, if you look at storage, long-term storage, you will be lifting, you will be doing inspection, and there's a chance that you may have a drop or some kind of accident that causes that crack to lead to a confinement breach.

MEMBER BROWN: Can the crack start on the inside and work from the inside out?

MR. CHUNG: We don't believe so. The type of crack that we're looking at is chloride-induced stress corrosion cracking, and there's no salt inside.

MR. CSONTOS: The inside is inerted, of the canister, so if you have an inerted environment, just like I said earlier about the fuel doesn't have any aging mechanisms, that we have asked for --

MR. CHUNG: Well, we don't know of any mechanism that causes a crack from the inside.

MEMBER BROWN: So you're going to go eddy current test thousand -- I'm going to take your thousand test field.

MR. CHUNG: No. No, you do a sampling.

MEMBER BROWN: I have a term for that that I won't use on the public airways.

MR. CHUNG: Okay.

MEMBER BROWN: I hear you.

MR. WALDROP: I'll talk a little bit about that in my presentation of a way to get a good -- to determine which ones you want to inspect.

And also on your question about why do we care, I guess there's a few ways to answer that. One, I mean you're leading towards the full consequence analysis. What's the dose really if you do have a through-wall crack? That's a good question.

We did an analysis at EPRI looking at what is the flaw tolerance? In these systems, the most likely crack that you'll get in the direction that it goes, these systems are very flaw-tolerant. And I don't remember the exact details. It was done by one of my co-workers.

But basically you remember, Al? Like close to, you know, 80 percent --

MR. CSONTOS: It's in the meters. It's in the meters --

MR. WALDROP: Yeah.

MR. CSONTOS: -- for critical flaw side. So it's very flaw-tolerant.

MR. WALDROP: A huge flaw that you need before you have an issue.

Trying to, I guess what he's looking at as far as the probability part, what's your starting condition and what event do you have occur? So I guess he's concerned about it from that point as an input parameter.

MR. CHUNG: Well, what you said, Keith, is very important because if you're talking about risk-informed and you know what's the probability of, looking at the canister, okay, if you know, if you know that, okay, up to a certain crack size you don't have a problem for the type of lift height that you're going to be dealing with, you can justify not taking that canister back and repackaging it.

But you don't want to open these canisters and repackage if you can help it. That's why it's important to know what your crack size is. And that's why you want to have a probabilistic approach to this here so you can say, okay, we have, we did testing and we know that there's a flaw in this canister here. For our process we're going to limit the lift height because if we have a drop with this type of flaw

size, as long as we don't see a certain height we're not going to have a breach.

MEMBER BROWN: You can always slip another sleeve around it.

MR. CHUNG: Not that simple. You're talking about very heavy lifting here.

MEMBER BROWN: I didn't say move it. I said bring another sleeve in and put it over the top.

MR. CSONTOS: Pete's company does weld overlays too.

MR. CHUNG: We could be very creative on --

MEMBER RICCARDELLA: Excuse me. This is Pete. Can you hear me?

CHAIRMAN BALLINGER: Yes.

MEMBER RICCARDELLA: You know, I heard a lot of talk about ruptures and dropping and cracks and critical flaw length, but if one of these through-wall cracks -- if one of these cracks that's 40 percent through-wall, grows to through-wall, even if very small, isn't that a confinement breach?

MR. CHUNG: Yes, that is. But what happens, when you have a confinement breach without

-- what happens, if you have a through-wall crack, the crack in itself doesn't lead to release of particulate. You know, some of these cracks, if you think stress-corrosion cracks they were very small. And as long as it's sitting in place --

MEMBER RICCARDELLA: Right.

MR. CHUNG: -- and you're not moving it there's no, there's no driving force for material get out unless you drop a canister or you tip it over, you know, you really don't have a major concern. You probably won't even be able to detect any release from that canister.

But the thing is that if you're sitting out there and you're going to have to move the canister, then you have a concern. You need to, you know, you need to deal with, okay, what is the critical qualify for the list that I have to do?

MR. CSONTOS: But as Pete said, I think -- Kris, do you want to talk about that?

MS. BANOVAC: And I think along those lines so the, I guess the licensing basis or design basis for most, if not all I guess, of our ACC and dry storage system is that to meet the confinement safety functions that it is an impassively-tight barrier.

Now, we do have the dose limits in Part 72, the 72.104 dose limits. It is possible if, you know, a licensee or a CoC holder, you know, wanted to show that, okay, I can have this happen to my canister or my system. I could have this many quals to wade through. And, oh by the way, I still meet the dose limit. They could go down that path if they wanted to. That's something we would review.

But I think it's fair to say -- and please, anybody in the audience if I'm wrong, correct me if I'm wrong -- I think it's fair to say that most, if not all, of our systems are -- currently how they meet the confinement function is that it is a impassively-tight barrier for storage.

So I think if -- yeah, but it doesn't preclude if someone wants to go down the other path to show, hey, I could have, you know, this many cracks, this many through-wall cracks. And, oh, by the way, I still meet, you know, the dose limits; that's something we would review and consider, but currently no one is doing that.

MR. CUMMINGS: Kris, this is Kris Cummings from NEI. That's not entirely true.

MS. BANOVAC: Okay.

MR. CUMMINGS: The earlier generations of the welded casks were not tested to leak type because they were tested a little bit differently. The closure weld was tested with a helium sniffer test. And so you run into some issues with getting down to that sensitivity with the natural helium in the background.

The point being is that the licensing basis of the cask is that there is a design basis leak rate based on what they tested it to. It tended to be around 5 times 10 to the minus 6. There were some of the even older casks in that that were 1 times 10 to the minus 4.

So they, as part of their licensing they calculate what their dose consequences are at the site boundary, and they have to show with the number of casks that were loaded to that CMN limit, that lower leakage rate, that they still meet the 25 millirem. And so that gives us a good indication when we are talking about consequences that you can have 10, 20, 30, 40 casks out there with a lower-than-leak-type basis and still meet the regulatory requirements for normal conditions, 25 millirem per year.

25 millirem per year is nothing. That

is a tiny, minuscule amount of radiation. We can still meet that.

MEMBER RICCARDELLA: I understand. The numbers you were quoting, those are leak rates in what units?

MR. CUMMINGS: Atmosphere CCs per second.

MEMBER RICCARDELLA: Okay. Thank you.

CHAIRMAN BALLINGER: But that leak could be in theory from a crack.

MR. CUMMINGS: Right. I mean in the cases of those casks they're --

CHAIRMAN BALLINGER: In theory. I don't know what the leak rate would be but it could be in theory from a crack.

MR. CUMMINGS: Right. In those, in the cases of those casks they're at leak tight as any other. They just couldn't be tested down to that sensitivity at the time, and that was 10, 10 to 15 years ago.

CHAIRMAN BALLINGER: So that in effect would put a floor on what would be allowed --

MR. CUMMINGS: Sure.

CHAIRMAN BALLINGER: -- if you had a leak.

MR. CUMMINGS: Sure. It's a good data point that we have, understanding that you can have certain flaws that would lead to a certain leakage and you could still meet at least the normal conditions. But a confinement, a loss of confinement integrity I don't think would be a normal or off-normal condition. It would be in regard to an accident condition.

And so those older tests did look at loss of confinement boundary integrity and showed with large amounts of damage to the fuel that they could meet the accident condition requirements which are much higher.

CHAIRMAN BALLINGER: But that leak could come from a chloride stress corrosion crack.

MR. CUMMINGS: It could. It could. Yes.

CHAIRMAN BALLINGER: I mean nobody says where the leak would come from, it's just there.

MR. CUMMINGS: Right. Correct.

CHAIRMAN BALLINGER: Right.

MR. CUMMINGS: Correct.

MEMBER RICCARDELLA: Yeah, presumably that crack could get big enough that it would constitute, --

CHAIRMAN BALLINGER: Yeah

MEMBER RICCARDELLA: -- even without dropping and rupturing it would constitute a containment -- a confinement breach.

MR. CUMMINGS: Right. Correct.

MR. CHUNG: Again this is a, we're in embryonic stage. This is just some proposed concept going forward. So I don't think we need to spend a lot of time dwelling on this unless you really want to.

Any other questions?

(No response.)

MR. CHUNG: All right, next slide.

Again, you know, based on the Commission Safety Goal, you know, you'd have what's defined as negligible risk. And then also the Nuclear Material Safety Safeguard has this Quantitative Health Guideline. And that defines negligible risk to 2 times E to the minus latent cancer per year as the, as negligible risk.

And so for confinement breach, based on the Quantitative Health Guideline -- this again, this is based on NUREG-1864, based on their calculation -- that number would come out to something like 5.5E to the minus 3 per year,

confinement breach per ISFSI.

Okay. Again, I think going forward, more study may, consequence study may be needed. They only looked at one type of fuel, not high burnup fuel. You know, you may want to consider what would happen if you had MOX fuel and what have you. But, you know, that's, that's the number that's currently out there.

Next slide, please.

And decision metrics, again decision metrics would support evaluation of quantitative changes in risk and provide basis for assessing acceptable change in risk.

Next slide, please.

Now, again this comes right from the NRR. And I think a lot of you are familiar with Reg. Guide 1.174. And we're basically looking at the counts in 1.174. And basically the requirements, you know, what is acceptable numerical risk. And the specific requirement may be relaxed if the initial risk is, it's already low and the incremental increases from the change, from a change are also small.

Example is at inspection, okay. If you look at the risk where the risk is 10 to the minus

12, and if you don't do inspection every five years, you do it every 10 years, what is the increase in risk? If it's also very low you might say, well, that's fine. Okay.

Go to the next figure, please.

And this is a figure from Reg Guide 1.174. I think a lot of you are familiar with it. For reactors you have this figure. You have Region I, Region II, Region III. You know, 10 to the minus 5 versus bigger 10 to the minus 6. Then 10 to the minus 4 is greater than 10 to the minus 5. So if you're in Region I you're in a higher risk and you're not allowed to have an increase in risk.

If you're in Region III you're allowed to have up to 10 to the minus 6 increase in risk. If you're below 10 to the minus 6, you can have up to 10 to the minus 5 increase in risk.

In other words, if your ISFSI planning has a confinement breach frequency of 10 to the minus 6 and you want to eliminate some of the inspections, you may be allowed to increase your risk by 10 to the minus 5.

It's a, you know, it's a concept from reactors, if you're familiar with how, how we do it with reactors.

MR. CSONTOS: One thing about that, the risk-informed ISI SRP for NRR talks about how you can do risk-informed ISI. But if there are augmented inspection requirements for, at the time it was IGSCC, PWSC, things like that, those are not subject to the risk-informed ISI. So we're trying to do something that's kind of combining these two right now.

So just FYI, just you know, we had to make sure that we're for normal kinds of fatigue and other things, those were fine to go ahead and risk inform. But for things that were, that we found that the cracking disease, that they were, that had different augmented requirements at NRC.

MR. CHUNG: Right.

MR. CSONTOS: Those were not subject to the risk-informed ISI.

MR. CHUNG: Right. Thank you, Al. You brought up a very good point. The word here is risk-informed, not risk-based. Right? If you're here with Reg Guide 1.174, risk-informed has a number of other requirements. Right? It has to meet regulations. It has to maintain defense-in-depth. It has to maintain safety margin. It has to be monitored.

You know, there's other requirements, risk-informed just provide one additional piece to your decision making. It's not risk-based. Okay. So just because you're low risk and you're asking for a slight increase in risk, it may or may not be granted. That's the way risk-informed is defined in caucus of Nuclear Reactor Regulations.

MEMBER SKILLMAN: Don, back up a slide, please.

MR. CHUNG: Yes, sir.

MEMBER SKILLMAN: Do the owners have tools that are sufficient to enable them to justify their CVF and their delta CVF?

MR. CHUNG: Currently the owners doesn't have anything. Currently the owners do not have PRAs. For reactors every -- you know, they do a risk analysis and they come to us and we have our staff core model. We run our model. We confirm their values and we say, okay, yeah, we agree with their evaluation.

For ISFSIs we don't have PRAs for the licensees.

MEMBER SKILLMAN: Okay. So this proposal presumes that somewhere along the line --

MR. CHUNG: Right.

MEMBER SKILLMAN: -- these tools will become available?

MR. CHUNG: Yes, sir.

MEMBER SKILLMAN: Thank you. I'm good.

MR. RAHIMI: Let me qualify that. I mean at this point our approach is coming there with method and applying to our criteria and looking at our requirements, you know, we see where we are, you know, in the risk area given that 10, 15 years ago we did a couple of PRAs that didn't have aging management, didn't have operating experience. So that's the approach really, at this point the goal, you know, is not to, you know, create a requirement, you know, for the licensee to go and --

MEMBER SKILLMAN: The PRAs, right.

MR. RAHIMI: -- do these things.

Now, we are coming up with a method, an approach and we're applying it and looking at from the generic basis where are we after 15, 20 years? Last time we did a PRA study with this, you know, aging manual with some operating experience that we've got. How has that, how has the numbers changed from 10 to the minus 13, 10 to the minus 14? That's what the goal is at this point.

MR. CHUNG: To kind of follow up with what Meraj just said, we talk about, talk PRAs. The PRAs you know, if I'm assuming that every ISFSI has to have a PRA, you know you can have kind of a collaborative effort for sites that are similar.

They can -- because there are only so many different types of dry cask storage systems, they can work together and develop a generic PRA for similar sites, similar environments, similar storage systems. So you may, you don't necessarily have that 60 PRAs out there. You may have a dozen or half dozen PRAs that capture all the different environments and storage systems.

Again, we're in the early stage. And there are lots to be developed as we go forward.

Okay, information needed for risk-informed decisions. Some of the stuff that we need going forward, we need to have more information on aging effect during storage. There's a lot of talk about chloride-induced stress corrosion but, you know, there really -- as far as impact on canisters there hasn't been any failures. We have, you know, we don't have a whole lot of information available.

And we need to have more information on canister failure probability for accidents. This

is probabilistic mechanics. If you have -- stainless steel is very ductile. So you have a crack in there you're not going to have brittle failure. You know, dropping it, you know, what is the probability of having a through-wall breach if you have a 50 percent or 60 percent, 70 percent through-wall crack? We need to have some information on that.

We need to do some more Level 3 PRA evaluation of consequences. Right now we're no longer looking at one type of fuel, the high burnup fuel. There's MOX fuel.

There needs to be some consideration of common cause failure. Dr. Power kind of touched on that point.

And also, the PRAs that were done, they were point estimates. And we need to probably do some uncertainty evaluation. You know, we know that there are manufacturing flaws in some of these canisters, there are weld flaws and so forth.

Options going forward. One is to develop the required PRA information to support risk-informed framework.

The other one, again, because the low risk we might consider adopting a deterministic

framework since there isn't very high risk.

That's all I have. And, Dana, I indicated that there's a slide -- please go to the end. Keep going. Keep going. Keep going.

Here it is. You asked me about a consequence. Okay, if you have a 35-year-old fuel assembly and it's sitting probably in the back of the room I guess from where I'm sitting, about 35 feet away, what is the dose rates, about 30 rem per hour. Okay. That's kind of spent fuel 35 years old.

MEMBER POWERS: You know what I'm more interested in is suppose that I drop the canister hard. I crack it.

MR. CHUNG: Okay.

MEMBER POWERS: The insides are scrambled, completely scrambled, --

MR. CHUNG: Okay.

MEMBER POWERS: -- I mean it's rendered into debris. What kind of the source term am I likely to get?

Now, in the case of melting down a reactor core I know what it is.

MR. CHUNG: Right.

MEMBER POWERS: Here it's not so

obvious.

MR. CHUNG: No, sir, it's not. It depends on the age of the fuel. And most of your impact, again as I mentioned earlier on an earlier slide, the impact is really the worker and environmental contamination. You know, you don't have to store energy. You don't have the driving force to get it off site. You know, you're basically looking at having a net or wherever you dropped it, whether it's on the ISFSI, whether it's on the road. And --

MEMBER POWERS: Let's drop it, scramble the inside. In the course of dropping it it hits a truck, it busts the gas tank and we've got a ferocious fire under it. Okay?

MR. CHUNG: Okay.

MEMBER POWERS: So it heats up. So now we've got a driving force. We're pushing things out.

MR. CHUNG: If the truck is moving it it's sitting in overpack.

MR. RAHIMI: I think the context of it has to be determined. If we're talking about dry storage --

MEMBER POWERS: Probabilistic gas tank.

I'm going to put a fire under this some way.

MR. CHUNG: Yep. Okay.

MEMBER POWERS: Because I want to get a driving force. Okay. So now I've got a driving force pushing stuff out.

MR. CHUNG: Right.

MEMBER POWERS: How much is it going to push out?

MR. CHUNG: Good question.

MEMBER POWERS: I just did a back of the envelope calculation.

MR. CHUNG: Okay.

MEMBER POWERS: Obviously I'm trying to be as conservative as possible here, but basically because I can use all round numbers.

MR. CHUNG: Okay.

MEMBER POWERS: Come out with 100 curies per day. That's not a whole hell of a lot?

MR. CHUNG: Well, again, the impact would be basically to the workers; right? People that are near where that accident occurred. There's going to be environmental contamination.

MEMBER POWERS: What I'm saying is that it's not evident to me that I can draw a complete analogy between CDF for reactors and containment

breach frequency just because the CDF was accepted because everybody knew it doesn't really matter whether you have a BWR or a PWR --

MR. CHUNG: Right.

MEMBER POWERS: -- once you melt down the core you're going to have a hell of a source term.

MR. CHUNG: Right.

MEMBER POWERS: Here the source term is so much smaller, --

MR. CHUNG: I totally agree.

MEMBER POWERS: -- so microscopically small that I don't think you can draw the analogy completely. I think you've got to put a calibration factor in there someplace. It says, yeah, even if I bust the hell out of these things, I do the most grievous thing I can think of, and I bust 100 of them, I'm still dealing with an event that, as you properly characterized, is completely local.

MR. CHUNG: You have environmental contamination. You have lots of environmental contamination. The ground's --

MEMBER POWERS: Well, not very much. I mean it is pretty small.

MR. CHUNG: It gets to be very complicated because --

MEMBER POWERS: I mean Fukushima we released, what, 2 million --

MR. CHUNG: Well good, I'm glad you brought up Fukushima.

MEMBER POWERS: -- curies?

MR. CHUNG: Well, I'm glad you brought up Fukushima because very few people died from radiation, offsite population died from radiation. It's zero? I'm not sure whether it's zero or not.

MEMBER POWERS: I was going to say, I thought it was zero.

MR. CHUNG: Well, there is some cancer cases. So I don't, I don't really know. But the biggest concern there is the environmental contamination. You know, if they -- if you have a canister failure --

MEMBER POWERS: You're trying to say Fukushima is like one of these sites. And I'm telling you I can do 100 of them and I release 1 curie. Fukushima was 2 million curies of cesium. Cesium is what you're worried about.

MR. CHUNG: Yes.

MEMBER POWERS: All the rest of the

stuff is crap. Okay.

And so what I'm saying is right there I've been as conservative as I possibly can be. I mean just because I can do the numbers as factors of 10 and don't have to do very hard arithmetic here.

MR. CHUNG: Right.

MEMBER POWERS: And I come up with 100 curies. And so I say let's do 100 canisters, you know. Something really bad happening, there's 100 canisters, each one of them released. I get 1 curie versus 2 million. It seems to me that I would be very careful about using CDF criteria and standards in evaluating. I'd be very careful about that because it's, I mean it's six orders of magnitude difference in consequence here.

MR. CHUNG: Well, we're not using this to regulate. We're using this as a yardstick so that we can be better risk-informed. Right?

MEMBER POWERS: What I'm telling you is you're using a micrometer as a yardstick here.

MR. CHUNG: Well, --

MEMBER POWERS: You've got much more, you've got huge margins here --

MR. CHUNG: Yes. Yes, we do.

MEMBER POWERS: -- before you get into public consequences. You know, you --

MR. CHUNG: Right.

MEMBER POWERS: -- are probably not going to be real popular with the Oil, Chemical and Atomic Workers but as far as public dose you're talking about a very small number.

MR. CHUNG: Well, we recognize that in the very beginning; right? We were talking about this. If you have a mechanism to measure the risk it offers you opportunity to revisit our regulations. This is just a -- having a micrometer is better than having no measurements; right? If you're doing deterministic --

MEMBER POWERS: I'm not sure I'm willing to make that argument.

MR. CHUNG: Okay.

MR. LOMBARD: Dr. Powers, we get your message loud and clear and understand it. And we'll take that back.

MR. CHUNG: We're open to better ideas.

MEMBER POWERS: Well, all I'm showing you is that I think, I think you need to go a step further. You mentioned maybe we have to do something --

MR. CHUNG: Right.

MEMBER POWERS: -- in the nature of Level 3 kind of analysis. And I'm telling you, yeah, I think you really do because the threat here under the worst -- I mean, what did I have to do, I had to put a fire under it, I had to bust them, I had to bust a bunch of them. And you won't believe how bad I was on assuming the size of aerosol particles. You get no vaporization really because your temperature is not going to get hot enough to vaporize things.

To get any kind of release you pretty well have to do at least a crude kind of Level 3 analysis.

MR. CHUNG: Well, that's one of the -- that's the last slide, that's one of the things that's proposed, we need to do more Level 3 PRAs to have a better appreciation for the consequence.

MEMBER POWERS: You know, I don't know that you need to do anything comparable to what was done for reactors. But you need to at least get order of magnitude feel for the amount of radioactivity you're going to release here and do your scaling not only by the frequency of initiating event but also the magnitude of the

source term.

Now if I can come back, you made the point throughout your presentation of your experience at NRR.

MR. CHUNG: Uh-huh.

MEMBER POWERS: In the course of discussing the various types of canisters you mentioned one below grade underground canister.

MR. CHUNG: Yes. Yes, I can go back to that.

MEMBER POWERS: In your experience at NRR you are of course well aware that we have problems at a lot of sites of flooding --

MR. CHUNG: Yes.

MEMBER POWERS: -- cable chases, things like that.

MR. CHUNG: Yes.

MEMBER POWERS: Does that cause you pause on these underground things?

MR. CHUNG: I have a lot of problem with underground things. Underground things are out of sight, out of mind. You can't inspect as easily.

MR. LOMBARD: I would add --

MEMBER POWERS: There's not much

problem in New Mexico let me assure you.

MR. CHUNG: You don't have flash floods in New Mexico?

MEMBER POWERS: Yeah, we've got a lot of flash floods but, boy, we've got a lot of drying mechanisms too.

MR. CHUNG: Okay. I just remember running a -- I went to Albuquerque and I noticed there was a canal, right, there's a mountain range, there's a canal -- I'm not sure it was a canal. It's a dry trough.

MEMBER POWERS: They're called arroyos and they criss-cross the cities. And, yeah, they flood like crazy.

MR. CHUNG: Right, right.

MEMBER POWERS: About twice a year.

MR. CHUNG: Twice a year, okay. Twice a year could be a problem.

MEMBER POWERS: It won't stay long. They're bone dry the next day.

MR. CHUNG: Except when you're in a silo and the water gets in there, the silo is not going to be dry the next day; right?

CHAIRMAN BALLINGER: We're getting a little bit far afield here. A little bit far

afield and we have to try to keep on some reasonable schedule.

MR. CHUNG: Yep. Anyhow, that's all I have. Any other questions?

(No response.)

MR. CHUNG: Well, thank you very much. I enjoyed this opportunity presenting to you. And feel free to contact me if you have questions for us.

MEMBER POWERS: That was a nice presentation. I enjoyed it.

MR. CHUNG: Well thank you, sir. Thank you very much.

CHAIRMAN BALLINGER: We're maybe 10, 10 or 15 minutes behind, so it's not a big deal I don't think.

MR. WALDROP: So the pressure's off.

CHAIRMAN BALLINGER: No, no, no, no.

MR. WALDROP: So I'm here to present on the industry perspective of research in the areas of storage and transportation. The work that we have going on in EPRI. So I'm going to provide kind of an overview of some of the R&D and focus areas and then get into a little bit of the detail of some of the work that we're doing.

So if you think about the total spent fuel management picture, you've got first the area of storage, both wet and dry, then transportation and eventually disposal.

So starting with wet storage, although this isn't the focus here I just want to remind everybody storage begins with wet. And we do have some active research going on in these areas looking at spent fuel pool criticality, leading to full burnup credit, and then neutron absorber material performance where we're focusing mostly on BORAL these days.

In the dry storage areas we've talked about, we're relying on these systems to last much longer than originally intended. So we've got to be sure that they're going to be able to maintain their safety functions for those periods of time.

We've got a lot of good experience so far with them. They're performing well but we've got to look forward. So one of the first things that we did back in 2009 was to establish or develop an extended storage collaboration program. And it has grown a great deal over the years. It fosters good global collaborative research. And it helps us look at what areas that we need to work

on.

In that program we are able to look at the entire big picture collectively and then kind of cypher up or split apart the pieces of the pie that different people need to work on. So that's been a big success.

Next we've got the area of aging management. And there we're focused on the susceptibility of stainless steel canisters, the CISCC that we've talked about.

We've got high burnup fuel performance. And we talked about the data collection project that we have going on there. I'll get into a little bit more detail.

And then we went on to transportation where we're looking at the properties of advanced claddings for long-term storage, both in the hypothetical accident and normal conditions of transport.

Also, although not a lot of work going on these days, but full burnup credit in transportation.

And then, lastly, in the area of disposal, we've got little to no involvement at this time. We're just kind of keeping tabs on

what's going on, both DOE and internationally.

So as I mentioned, since these systems are being relied on for longer than originally intended or licensed, so we need to be sure that we know, understand and can manage the aging effects of these systems. So starting, to get us started we took the initial steps of a literature review and a failure modes and effects analysis.

And the results of the failure modes and effects analysis showed us that this CISCC is the most likely potential active degradation mechanism that could lead to through-wall penetration. While we haven't seen CISCC on any dry storage components, it has been observed on the reactor side on stainless steel components when we have the classic of these three elements present, both elevated stress, susceptible material, and a corrosive environment.

For CISCC that corrosive environment gets a little more complicated. You've got to have chlorides transported to the surface of the canister through the air. Then you have to have sufficient humidity such that those chlorides will deliquesce, create a concentrated brine and give you a corrosive environment.

So to address things, EPRI has a multi-year project looking at two things, both developing ageing management guidelines for specific to CISCC, and develop and demonstrate the inspection capability.

So developing the aging management guidelines we take the results from a literature survey and failures modes and effects analysis, as well as I referenced earlier, a flaw growth and tolerance assessment that we performed. And out of that we got a crack growth model that we were using.

And that led us to a susceptibility assessment criteria, I think something that is probably of interest. We poked around the corners of this in some of the discussions today. And it can help us define what are the site conditions in the canister parameters for each canister that are important to CISCC. Then we can take that information and allow ourselves to rank what canisters are more susceptible than others and what sites are more susceptible than others to help us prioritize what our inspections might be.

CHAIRMAN BALLINGER: I have a question. Now, I can see where you could fairly easily decide

which sites are the most at risk. But now I'm wondering how to decide which canister within that site would be the one that's the most at risk. Because I presume you're sampling a small population of the overall canisters.

MR. WALDROP: Uh-huh.

CHAIRMAN BALLINGER: So given what we know about especially older canisters where the welding fractures and things like that was let's just say a little bit less rigorous for inspections and things like that, so since this weld heat affected stresses and, in particular, weld repairs and things like that which may not -- may be unknown in canisters, how do you decide which canisters to inspect?

MR. WALDROP: You bring up a good point. So really the primary factor is driven on what's the decay heat? It's that what's going to get it into that deliquescent range where the site is going to determine whether or not there's chlorides there. The canister's going to determine what temperature range you're in, whether or not you're getting deliquescence.

Other factors that you do want to consider, if you have that information as put in

the report, are things like was there local repair done on that? That might be some information to help you further differentiate between I'd say canisters that are equally ranked.

CHAIRMAN BALLINGER: Yeah, I could see easily I guess where you could construct a population of canisters where you get the right temperature range where you get deliquescence. That's, so that narrows it down a little bit. I don't know how far it narrows it down.

But then within that population you won't, sometimes you won't know whether there was a weld repair made. So does that mean you have to inspect all of those canisters within that population?

MR. WALDROP: No. And forgive me for the -- the susceptibility criteria assessment report has got a lot of those details in them. I won't remember the exact details off the top of my head. But basically you work to what are your, you know, what's the highest rank. And then you want to inspect within numbers and also understand the fidelity of what went into that. It's not perfect, you know, it's kind of this way. But it's something.

So certainly one of the factors is canisters within a rank, if you find something, now you want to start expanding that inspection to canisters within the same rank of two because we don't know it that well.

MR. CSONTOS: Just to say a few things. I think for -- you need to look at the global perspectives. The environment is one that's not going to be different really between different canisters at a site that it is or is not, does or not have chlorides. The what you just said is a thermal decay heat, what's the temperature of the surface of the canister.

And another part to it is deposition rate of chlorides that would be there as a function of the age of a system. So, you know, when you, when a licensee comes forward, and we're going to get an application here, we just had a PREOP meeting, what, a couple days ago looking at how the licensee is now saying this is why we selected these canisters, okay, for inspection.

And so one of them, you know, I think a couple of them you have to think about the temperature but you also have to think about the, about the chlorides that could be present. So that

would include the deposition rate which would then be relevant to age. How old is this canister and how long has it been on the pad?

So those that have the lowest temperature on the pad I think would be the ones that you would want to go after.

CHAIRMAN BALLINGER: Okay. Okay.

MR. WALDROP: So let's back up.

So then the next step in our process is a probabilistic confinement integrity assessment. And what that does is it takes and looks at a cumulative probability of canister leakage due to CISCC over time. Looks at it compared to a base case that we set a value equal to one. And then what you're able to do is go in very different parameters, particularly looking at different inspection regimes of how you might go about inspecting it and see what effect does that have on our ability to detect -- on the probability of leakage rather.

So say for example, if I inspect every 20 years versus every ten years or five years, am I seeing a big reduction in that canister leakage probability?

And there it also does some sensitivity

analysis looking at the base case on what are some of the assumptions going in there. Kind of just a sanity check to see that the model's working right and what are the important parameters.

And all this finally will lead into the integration of all these pieces into aging management guidelines for CISCC.

I'll also point out I think in one of the earlier presentations talking about the ASME efforts that these aging management guidelines and our steps along the way I think are going to be key references into the work that's going on right now on the development of an ASME code case for in-service inspection criteria.

So this just summarizes the different steps that we've taken along the way and lists what the EPRI report numbers are. And I'd point out the last two that are expected to be out later this year, the aging management guidelines.

And then the very last one is really our first look at doing a scoping study on the consequence side. So we're going to take a stab at that by the end of the year.

So with the guidelines talking about inspections, we certainly understand that those are

going to be needed. So also we're looking at developing that capability. EPRI is focused on four main areas in developing the inspection capability:

Collaborations. We want to be able to get the biggest bang for the buck, and working together to do that;

Working on finding and developing mock-ups. The non-destructive evaluation technology, what are we going to use to be able to inspect that?

The EPRI efforts right now are focused on looking at eddy current array, guided wave and acoustic emission.

And then, lastly, let's not forget the delivery system. AS has been alluded to, not necessarily to have to move these systems, but to be able to use these two examples here of a robot kind of car thing that will be able to go inside these systems and get your technology to the location it needs to.

So backing up to mock-ups, there's a couple efforts there. One, a mock-up with flaws embedded in it to be able to test your technology. And another mock-up of a full-blown canister and

overpack system to be able to test your delivery techniques. With the goal that we'll be able to demonstrate these techniques in the 2017 time frame.

So moving on to cladding behavior in high burnup fuel. The high burnup R&D project that we've talked about and then performance of advanced cladding materials.

So we've talked about this some, but from a different perspective, a little background on low burnup versus high burnup. We've talked about this a little bit, but the technical basis for low burnup fuel has been provided mainly through a demonstration program that was done taking actual low burnup fuel, loading it in a cask, opening it up 14 years later and examining to find out that there was little evidence if degradation, and testing some of the properties, still significant creep life left.

For the high burnup side we haven't done that. We have a technical basis but it's based primarily on lab testing at this point. And as we've talked about, it showed that the hydrides can reorient, leading to a loss of ductility, which is really more of a problem for transportation than

it is for storage. You've got to have a load applied to this to worry about it.

But what that did do was it allowed -- we used bounding conditions and allowed guidance to be developed such that we could go forward with licensing high burnup fuel. So it was a success in that aspect. So ISG-11, Rev 3, basically gave us a limiting peak clad temperature of 400 degrees C. So that was good for storage and for up to 20 years.

Now we're to the point of needing to extend those. And for transportation licenses, actually ISG-11, Rev 3, says it doesn't apply. So the transport licenses on high burnup fuel that we have are very limited and restricted.

So what we have is a lack of data on high burnup fuel under the actual dry storage conditions. And we want to go and repeat those earlier low burnup demonstrations using high burnup fuel. It will give us the ability to look at the behavior of multiple types of cladding under typical dry storage conditions. So the plan at the North Anna site is to use four different clad types. So we're going in with this trying to develop a really good demonstration project.

It will, another key aspect is it will provide data for benchmarking fuel performance models so that we can best understand that and be able to model things.

In addition, it supports a need for, that we have for data in existing renewed licenses. Calvert Cliffs and Prairie Island both have tollgates to look at data coming out of this project. And as Mark talked about, there's a bow wave coming by 2020 of several more license renewals coming due.

As well as it's going to support the need for data to support transportation in the future, both with U.S. plans for consolidated storage and internationally. Certainly Spain it's a big issue with Spain and transport of high burnup fuel.

So giving just kind of a high level picture of what are the major steps in the project that we have going on, well, first we developed and we are now implementing a final test plan. Final design is completed. The storage license application has been submitted to NRC and is currently under review.

Next is we've identified, extracted and

shipped some of these sister rods that are going to be able to give us these baseline characteristics to Oak Ridge National Lab to be able to begin that non-destructive and destructive exam. So just to make sure we're on the same page, so these sister rods were carefully identified, have the same characteristics as some rods uniquely identified that are going to be in the cask.

So we went and looked at the operating histories and everything that we could to identify these rods compared to rods that are actually going to be in the cask.

The next steps are to modify the cask lid. We're going to have penetrations in the lid to be able to insert the instrumentation after the fuel is loaded. Fabricate that instrumentation. Then pending NRC review and approval, get the storage license. Dominion will perform the dry runs and load the cask and immediately begin to collect the data coming out of this, being temperatures and we'll take gas samples in, certainly in the initial period while it's in the fuel building.

Then looking forward, so now the project gets going and we've started collecting

data. So where do we go from here? Nominally the idea is to store the cask for about 10 years. That's not a magic number, it may change. And then ship the cask to a fuel examination facility, basically a large hot cell. And we need to do that because we don't want to put this back in a pool and open it, we could re-quench the fuel and possibly affect the properties that we're actually trying to measure.

So the fuel examination facility, which is yet to be identified or be, well, I'd say, yeah, just identified at this point. Then once it's there we can open the cask and examine the fuel and perform those same destructive and non-destructive exams on those rods that we've identified as sisters to the ones that are being tested earlier, and identify what's the difference between these two rods. So what is the effect of dry storage on this high burnup fuel?

And if we want this for extended storage, certainly the option is to re-close it and let it store longer with the option to open it again later. There's no reason to stop this.

So that's on the high burnup demonstration project. So moving on to the

performance of advanced cladding materials.

The issue here being that data on these advanced clads, Zirlo, Optimized Zirlo, M5, AXIOM, those materials that were developed specifically for high burnup, we need data on that to understand the performance to be sure that we're meeting the regulatory requirements applicable to dry storage and transport. And the reason for that is that the guidance in ISG-11, a lot of that is based on testing done on Zircaloy-4 fuel.

As well as for transportation, while we've got ISG-11 for storage, we don't have similar generically-accepted guidance on transportation.

CHAIRMAN BALLINGER: I have a question. I think I know what AXIOM is but I'm not exactly sure. Is that -- what is AXIOM?

MR. WALDROP: It's another advanced cladding type that --

CHAIRMAN BALLINGER: From who?

MR. WALDROP: I don't know.

CHAIRMAN BALLINGER: Does anybody know?

MR. CUMMINGS: It's a Westinghouse. It's a Westinghouse advanced. It's niobium.

CHAIRMAN BALLINGER: That's the latest one?

MR. CUMMINGS: Yes. Yes.

CHAIRMAN BALLINGER: Okay.

MR. CUMMINGS: It's not, it's not in full use yet. It's still in LTA.

MEMBER POWERS: What kind of an alloy is it?

MR. CUMMINGS: It's a zirc 1 percent niobium with some changes in the minor aspects.

MEMBER POWERS: Thank you.

MR. WALDROP: So lastly, the steps we have going in this project are we're participating in collecting some of this post-irradiation data. It's very expensive to collect this data. We're talking nuclear and we're talking spent fuel, so it's very expensive in hot cells.

So what we do is we participate where we can to collect things like thermal creep, hydride reorientation, DBTT, and even delayed hydride cracking. Then we take that data and we're feeding it into our fuel performance models to be able to try to come up with good models to predict the performance.

And a lot of the things that we're learning here is also helping provide guidance in the high burnup demonstration program, with the

goal of being able to resolve the regulatory issues of extending dry storage licenses beyond 20 years, and eventually transportability of the high burnup fuel.

MR. LOMBARD: So if I may add a fun fact about the demonstration project. For me it's fun because thermal couples will be active from T equals zero. So we'll be able to, we, collective we, will be able to track the temperature inside the system from the time it's loaded to the vacuum drawing process and it goes on the pad.

So that's going to tell us a lot and I know the industry a lot as well as we go forward with that.

MR. WALDROP: Yeah, and I didn't get into, yeah, too much detail on some of it. But if you're interested in more of the high burnup demo, I can talk about the science part but not anything to do with licensing. It's under review right now.

CHAIRMAN BALLINGER: Questions?

MEMBER POWERS: You certainly showed pictures of hydrides, both in the laminar and in the radial direction and the reorientation of this stuff. Do we still with these high burnup fuels have difficulties with hydride blisters?

MR. WALDROP: Not my area of -- I believe that's more of a BWR thing. And I don't believe it is but I can certainly, I 'll be glad to take that back to my --

MEMBER POWERS: Well, if you find some information on it, it would sure be interesting to me because they've always been a conundrum in what to think about them.

CHAIRMAN BALLINGER: Other questions?

We've gone over quite a bit. Can we take a, can we take a 15-minute break.

MEMBER POWERS: Another quick thing to point out. You show some what I think to be clad pictures up there but you're not confronting the issue of fuel adherence to that clad when you get to high burnup complete picture. And that, that's an issue.

MR. WALDROP: That was one of the big things that came out of the surf testing that they found was, particularly in high burnup fuel, the bonding effect that you get between the fuel and the clad is really helping you.

MEMBER POWERS: That's right.

CHAIRMAN BALLINGER: So we'll take a 15-minute break, back just before quarter of.

(Whereupon, the above-entitled matter went off the record at 3:29 p.m. and resumed at 3:46 p.m.)

MR. CUMMINGS: So I'm Kristopher Cummings. I'm a Senior Project Manager at NEI. It seems like I sometimes try to get out of the used fuel area, but I keep getting dragged back to it, so but, it's good, we can --

MEMBER POWERS: You made the mistake of claiming some knowledge in this area, which nobody understands.

MR. CUMMINGS: Somebody maybe claimed that for me.

CHAIRMAN BALLINGER: Somebody dropped the dime on you.

(Laughter)

MR. CUMMINGS: Exactly. Exactly. But, we've had a lot of discussions with the NRC over the last two-and-a-half years, at least, when I've been with NEI and we've made some --

(Off microphone comment)

MR. CUMMINGS: I think we've made some real good progress working collaboratively with the NRC, to ensure that we bring our perspectives from the Industry and operational perspective, and then,

of course, tried to understand the NRC's perspective, as the regulator.

So what I wanted to try to do is, was give a little bit of the perspective of the Industry on the overall dry storage framework, because we think there are some opportunities to make larger achievements, with regard to, you know, how dry storage casks are regulated and some of the technical issues associated with it.

Next slot. So before I get into that, just a very broad overview. We have about 2,250 casks loaded, as of January this year. We load about 200 of them per year. We've gotten to the point where we know how to do it. We do it very safely.

Just as point of reference, about 36 percent of the fuel that's out there now is, currently, in dry cask storage. It's a very robust and competitive industry.

I think that's one of the things that really lends a lot of the innovation in the dry cask storage arena, the vendors are always figuring out new ways to, either, put more fuel assemblies into the casks, or increase the cask load, or introduce materials --

MEMBER POWERS: Are we getting casks too big to go into repositories?

MR. CUMMINGS: That's a good question. We've, EPRI, EPRI has done studies to show that the large casks can go into the repository, obviously, the repository is envisioned at Yucca Mountain had a very low heat load, 12 Kilowatts, for the individual packages, but as we go on with longer and longer times not having a repository, those canisters --

(Off microphone comments)

MR. CUMMINGS: -- go down in heat. So, you know, if there were a silver lining, maybe, with a delay of a repository, maybe, you can --

MEMBER POWERS: The internal optimist, always looking for the good side here.

(Simultaneous speaking.)

MR. CUMMINGS: I'm looking for the up side, exactly. Exactly. So --

MEMBER POWERS: Well, I mean, that's a, that's a problem, because --

MR. CUMMINGS: But you can design a repository with a higher heat load capacity.

MEMBER POWERS: Well no, what I'm more, I mean, what you don't want is to repackage.

MR. CUMMINGS: Right. Correct, and --

MEMBER POWERS: -- and you don't have to worry about shipping them.

MR. CUMMINGS: Right.

MEMBER POWERS: Okay, but you, what you really don't want to do is repackage, because if --

MR. CUMMINGS: Correct.

MEMBER POWERS: -- we have to repackage that's, that's just an operational nightmare.

MR. CUMMINGS: Well, and if you need to repackage into smaller packages, then, then all those 2,200 that are loaded would now become 5,000, or 10,000 and DOE has looked at, you know, the studies of four PWRs and nine BWRs and other, other combinations. But, yes, it certainly, it certainly adds to the scope of the issue of designing and building a repository, so --

MEMBER POWERS: Okay.

MR. CUMMINGS: Next slide. High burnup fuel. I wanted to give you just some, kind of, rough numbers and these are rough, how people characterize high burnup fuel, about 45,000, depends, to some extent, on how you include the uncertainties and how you determine your burnup from reactor records. But, there's about 600 casks

have, at least, one fuel assembly of high burnup fuel in them. That's about a quarter of the casks out there.

But it's about 9,500 assembly, so it's not super prevalent, at this point, but we understand, as you can see from this graph that, the amount of high burnup fuel that's going into dry storage is increasing with time, simply because, they've taken a lot of the low burnup fuel and put it into storage already, or they're simply managing their fuel effectively and mixing some of the high burnup fuel with the low burnup fuel, so that they can manage their heat load inventory and be able to continue to load dry cask storage. Next slide.

So in terms of improving the regulatory framework, we've had, you know, sometimes the perspective comes that we don't have a lot of experience with dry cask storage. I think, from the Industry perspective, we have a lot of experience, we have 30 years, I think, the oldest ISFSI is 1985.

You know, we've got a lot of casks out there, we're learning more about them, obviously, as we do inspections we're going to learn even

more. But we have a lot of experience from the reactor side that's completely applicable.

Concrete and steel are used in the power plants and they're also used in dry cask storage. There's not many unique materials in the dry cask storage arena that are different than what's used in the dry cask storage.

But we believe that we can gain efficiencies, especially, in the consideration of the relatively low risk of dry cask storage and making sure that it's appropriately recognized.

So specifically, NEI, in 2012, had proposed rulemaking to the NRC, to define the certificate of compliance in tech spec contents, along with a safety criteria similar to what's in 5036., specifically, tying the criteria to safety goals, essentially, and then, also, an explicit recognition of defense-in-depth aspects.

And one of the final things was also looking, when we get into a little bit more of the detail, is where are there areas that we think the review of dry cask storage applications can be more focused, especially, when you look at risk considerations.

So the two that I put in here,

specifically, are shielding and radiation protection evaluation. There's a tremendous amount of detail that goes into the chapter for shielding calculations and then you calculate what your total occupational dose is going to be, as you load that cask and put it out on the ISFSI.

There's, those are done been a very bounding perspective and from our perspective there's not a lot of value there, because you end up going out and making a measurement on those casks anyway.

Now you still need some sort of shielding analysis, but whether you need some of the detailed review of that analysis, as been done in the past, is questionable in a risk-informed environment. Next slide.

MEMBER BROWN: Can I ask you a question?

MR. CUMMINGS: Sure.

MEMBER BROWN: If you go back to slide, the one with the graph. Thank you. So we've been operating our plants, since when?

MR. CUMMINGS: Sixty something.

MEMBER BROWN: When did the first one start at the, when was the first Naval Nuclear one,

what year, do you remember that?

MR. CUMMINGS: I don't know.

(Simultaneous speaking.)

MEMBER BROWN: -- shipping port.

(Off microphone discussion)

MR. CUMMINGS: I was born, maybe, a year or two after, no --

MEMBER BROWN: '57, '58, or, '58 or '59, I thought, somewhere in that ballpark. Okay. And then we built more and more and more, so for 50 plus years, 56 years, is that right? Sixty plus 60 --

(Off microphone comments)

MEMBER BROWN: We've uploaded and put fuel into casks, we've got 600 casks today, you say?

MR. CUMMINGS: Well, no, this is just the high burnup, we've got 2,258 --

MEMBER BROWN: High burnup?

MR. CUMMINGS: -- of 2,268, as of January --

MEMBER BROWN: Okay that's, I like that number, too.

MR. CUMMINGS: Yes.

MEMBER BROWN: That's good, I like

that.

MR. CUMMINGS: Yes.

MEMBER BROWN: Let me use that one, 2,268 in 56 years. We're projecting 3,200 casks, and how many, at 76 sites, or roughly --

MR. CUMMINGS: Just about everywhere.

MEMBER BROWN: Yes, but how many, let's see, how many per site? Because that's, that's ten, 50 per site, or something --

MR. CUMMINGS: Yes.

MEMBER BROWN: -- like that?

MR. CUMMINGS: Right. Some, some have more, others have less, depending on when they started loading.

MEMBER BROWN: All right. So I'm just trying to calibrate this to the discussion from the last presentation about hundreds of casks that could then cascade and have ginormous problems --

(Off microphone comment)

MEMBER POWERS: You're talking about an interim storage facility there.

MEMBER BROWN: I'm, well, I'm just talking about all these little --

MR. CUMMINGS: Right.

MEMBER BROWN: -- ISFSIs, okay?

MR. CUMMINGS: So --

MEMBER BROWN: They're interim storage.

MEMBER POWERS: But, no, the interim would accumulate all these.

MEMBER BROWN: Well, we've got 76 sites, right now, I mean, if you just kept --

MR. CUMMINGS: Sixty-eight sites.

MEMBER POWERS: DOE's proposal is to have, have specialized sites where they would bring all these nuclear --

MR. CUMMINGS: Right.

MEMBER BROWN: Well that's a bad idea. But I'm just --

MEMBER POWERS: I know, it's a stupid idea, but --

MEMBER BROWN: I'm just wondering on, if we don't do it --

MEMBER POWERS: We're talking about DOE, Charles.

MEMBER BROWN: Yes, I understand, but nobody's done anything. I mean, there's no repository, there is, you know, no other specialized site that's in place, and if, I can just foresee that we're going to continue business, as usual, for another 50 years. So we get up to

6,400 casks, I'm going out to 2020, at 70 or 80 sites, which may be 20, 25, 30, maybe, 50, maybe, 100 casks. It's not like we have these sites with huge populations, which generate great risks. I just wanted to make a point.

MR. CUMMINGS: I was looking for the question there and, you know, there's no self-identifying --

MEMBER BROWN: There is no question. I'm working for the point. That point being is that we're looking at, if everything continues, as usual, you will have still 75, maybe more, sites, with 50 or 60 casks, maybe more, a few more, but not huge sites with forests full of casks sitting around --

MEMBER POWERS: So you're, that's the DOE's intention.

MEMBER BROWN: Well, I know, but the intent, you know, the world is fraught with good intentions, which rarely ever come to fruition, so particularly, you know you don't --

MEMBER POWERS: I mean, if you're going to project, you got to project on the best knowledge you have and --

MEMBER BROWN: No, I --

MEMBER POWERS: -- that's --

MEMBER BROWN: -- the best knowledge is that nothing's going to happen, other than additional ISFSIs.

MR. CUMMINGS: Yes.

MEMBER BROWN: Little --

MR. CUMMINGS: Right.

MEMBER BROWN: Little --

MR. CUMMINGS: Right.

MEMBER BROWN: -- little storage sites.

MR. CUMMINGS: And we've loaded, we've loaded fuel into direct cask storage at just about every site, I mean, between now and --

MEMBER BROWN: No, I'm good --

MR. CUMMINGS: -- and 2020 --

MEMBER BROWN: I'm just trying to put the risk in perspective --

MR. CUMMINGS: Right, right.

MEMBER BROWN: -- based on the projections of doing risk informed analyses of non-existent locations with non-existent numbers of casks that are, create problems --

MR. CUMMINGS: Well let's --

MEMBER BROWN: -- that's all.

MR. CUMMINGS: Let's hold that thought

--

MEMBER BROWN: In my own --

MR. CUMMINGS: -- because --

MEMBER BROWN: In my own mind that's all.

MR. CUMMINGS: Because I think, I think, from our perspective, we can develop that framework to mitigate and manage that risk in an appropriate manner with appropriate programs.

MEMBER BROWN: I --

MR. CUMMINGS: So that, that's --

MEMBER BROWN: I'm not questioning you --

MR. CUMMINGS: -- what I'm going to get into --

MEMBER BROWN: We've been doing it now for --

MR. CUMMINGS: Exactly, 30 years.

MEMBER BROWN: -- many, many years --

MR. CUMMINGS: Yes.

MEMBER BROWN: -- and so -- decades.

MR. CUMMINGS: Right.

MEMBER BROWN: All right, thank you. I appreciate just --

MR. CUMMINGS: No problem. Next slide.

MEMBER SKILLMAN: Kris, I wanted to ask you about your slide -- looking for a number here -- number 4.

MEMBER POWERS: You're going backwards, Kris.

(Laughter.)

MR. CUMMINGS: It'll never get done.

MEMBER SKILLMAN: I was listening to what you were saying and I was trying to understand the meaning of what you were saying. For the last, the third bullet, the last item under the third bullet, guidance for risk appropriate level for review of shielding, are you suggesting that there should be a de minimis, or no effort, to review shielding?

MR. CUMMINGS: Well, I think there should be, there's a minimis, because, I mean, this is one of those things where you do these computer calculations to determine what is your dose from your cask, so that you can show that the cask would meet the 10 CFR 72.104 and 106 shielding requirements, dose requirements, at the site boundary.

However, with something like shielding, you end up going out and making a measurement of

that cask. I mean, when the cask, when the canister and the transfer cask gets pulled out of the spent fuel pool, you got RP people right there making measurements.

When you transferred them into the storage over-pack, there are certificate of compliance requirements and tech spec requirements to make a measurement, to ensure that the dose is less than a certain amount.

So this is an area where, putting a lot of effort into the review of the accuracy of shielding analysis that goes into, like, a certificate of compliance, which is done with very bounding considerations, and so you may calculate on the surface of your casks a 100 millirems per hour, when you actually go out and measurement, measure it, it's like two millirems per hour, so is there a lot of, is there a lot of benefit?

And that's where we think, we wanted to give a specific example where we felt like you could risk inform the review of the individual applications and, and we see here that this may be an opportunity to increase the efficiency, by bringing in a risk informed perspective.

MEMBER SKILLMAN: Yes, but it seems

like the, the other side of the argument is one that you should be, that we should be sensitive to, and that is, supposing being calculated, it was supposed to be two MR an hour, and it turns out to be 100 MR an hour. There is good reason to have good shielding calcs.

MR. CUMMINGS: Sure.

MEMBER SKILLMAN: So I'm hoping that you are not suggesting --

MR. CUMMINGS: No.

MEMBER SKILLMAN: -- that such activities should not be undertaken?

MR. CUMMINGS: No. I'm not suggesting that those would not be undertaken.

MEMBER SKILLMAN: All right.

MR. CUMMINGS: But that, you would still do a shielding analysis, but when, when we look at, maybe, some of the aspects where we get REIs on, well, what's the impact of the dose right around a bolt, because there's, maybe, some neutron streaming through that? Well, that has no impact on what the dose is at the site boundary, and so that's, really, where we're trying to provide some recommendation on --

MEMBER SKILLMAN: Okay, I can

understand --

MR. CUMMINGS: Right.

MEMBER SKILLMAN: -- that feature, if you are specific in communicating that is the problem --

MR. CUMMINGS: Understood.

MEMBER SKILLMAN: -- you would like solved.

MR. CUMMINGS: Right.

MEMBER SKILLMAN: But, I think, at an overall level, it's mighty important to understand how thoroughly shielded those casks are, just --

MR. CUMMINGS: Absolutely.

MEMBER SKILLMAN: -- case in point.

MR. CUMMINGS: Right.

MEMBER SKILLMAN: We've all loaded one at TMI, its contact there was 250,000 R, per hour.

MR. CUMMINGS: Yes.

MEMBER SKILLMAN: And when we settled it in its transfer cask, we had calculated 10 MR an hour on the outside of the cask. And most of us, who looked at that calc, said there's no way.

MR. CUMMINGS: Yes.

MEMBER SKILLMAN: I mean, it's going to be hundreds and --

MR. CUMMINGS: Yes, right, right.

MEMBER SKILLMAN: -- it was 8 MR an hour.

MR. CUMMINGS: Yes, yes.

MEMBER SKILLMAN: And so there is value in that, that was the Rockwell Codes and we were fortunate --

MR. CUMMINGS: I agree.

MEMBER SKILLMAN: -- to have had the precision and the ability to calculate, as we did, but there's value in --

MR. CUMMINGS: Yes, I'm --

MEMBER SKILLMAN: -- in having calculations really guide you in the right direction.

MR. CUMMINGS: -- not questioning the value of doing the calculation, I'm questioning, to some extent, doing a super detailed review, especially, in the context of some of the REIs we've seen on impacts of some of the minor features of the --

MEMBER SKILLMAN: No, I understand.

MR. CUMMINGS: -- casks on the --

MEMBER SKILLMAN: Okay. Thank you, Kris.

MR. CUMMINGS: -- on the shielding right now --

MEMBER SKILLMAN: Okay, thanks.

MR. CUMMINGS: -- currently. So in terms of the proposed rulemaking, the vision here was to standardize the dry storage licenses, themselves, and, specifically, the certificate of compliance.

Looking through some of the certificate of compliances that are out there, they're more detailed, they're more lengthy than the reactor licenses. One, I think the largest certificate of compliance is something like 280 pages long and has tremendous amounts of details on loading specifications that, in some respects, are redundant to other requirements that are in the certificate.

So level of detail and then, also, that was consistent with the Commission policy statement on improved tech specs. And we had some other things in that proposed rulemaking, such as the appropriate risk prioritization in dry storage licensing, placing more information under licensee control, i.e., the 7248 process.

Currently, the Part 72 does not extend

the Back-fit Rule to CoC holders, so there is, sometimes, a disconnect between the general licensees having application of the Back-fit Rule, but not the CoC holders, where invariably that effects the general licensees anyway, if you make changes to the cask design and there's no application to the Back-fit Rule. And then we had some other minor changes to the rule, to improve its efficiency. Next slide.

So the keys to ensuring safety, with more information under licensee control, first, of course, is having a robust and mutually agreeable 7248 change process that, both, the Industry and the NRC has a high confidence in, and we've had some discussions, recently, with --

OPERATOR: Please, pardon the interruption. Your conference contains less than three participants, at this time. If you would like to continue --

MR. CUMMINGS: I was hoping a fourth would call in, at some point, today.

OPERATOR: -- press star one now.

MEMBER POWERS: Nobody wants to listen to you, Kris.

(Laughter.)

MR. CUMMINGS: Well -- I'm going to let that one go.

(Laughter.)

MR. CUMMINGS: A second with, especially, with license renewal having robust Aging Management Programs in place. And, again, this is, I think, a good, a place where we've had good discussions with the NRC and been able to understand both, both perspectives on both sides.

And then, the final one is a reliance on the NRC Inspection Programs. Within the Industry, we see the NRC as one NRC, we don't see the regional inspectors as separate and the headquarters here, in Rockville, as something different.

We see that all as, collectively, part of the regulatory oversight of our plants, of our dry cask storage, our systems, of our general licensees, of our cask vendors, we see that as one organization and we need to leverage the different parts of that organization, even if they're in different branches, or offices, so that we have a holistic view of how we're managing the safety of spent fuel storage. Next slide.

So specific improvements to that

regulatory framework that we've been working with the NRC on, and an Industry, submitted in 2012, a 72.48 guidance and, really, that was, currently, the guidance on 72.48 processes contained in any I90-607, which was on the 50.59 process for making changes to the plant.

There's an appendix in there, Appendix Bravo, which was, kind of, not the best fit in the world. It had the Part 50 perspective applied to Part 72, so we decided that we'd write a guidance document that would be really more reflective of the Parts 72.48 process.

Now there's a lot of simulators there, but there are some nuances. A meeting that we recently had with the NRC, I think, we reached a good consensus, or are reaching consensus on some of the fundamental issues of concerns. So we're making good process there on reaching that consensus on the 72.48 process that I talked about earlier.

Sorry about that. Second, and we'll talk a little bit more about his tomorrow, is NEI-1403, those are the guidance the Industry put together on implementing a dry cask storage operations based to aging management process, and

also, on the format and content for licensees to submit their license renewal application.

And so there's four, what I'm calling fundamental cornerstones that are included in that, the first is ensuring that we know that we're submitting good, quality applications to the NRC and there's a consistent format and content, so that's that we're providing the information to the NRC that they're expecting. That goes hand-in-hand with NUREG- 1927.

Second, is an operations-based aging management, through learning age and management programs that was discussed a little bit earlier, by the NRC, in that we need to have the flexibility of the Aging Management Programs that we develop, as part of the license renewal application, have the ability to be modified flexible, based on things we learn through operating experience.

So that goes to the third cornerstone, which is sharing of that operating experience across the Industry, amongst the cask vendors, amongst the different utilities.

So we've worked with the four cask, the four major cask vendors, Holtec and AC International, Areva TN and Energy Solutions.

Through info, they're developing a database where they can start putting the operating experience that we get, through age and management inspections, into this database that is now fully searchable by the utilities, by the vendors, and we'll have some ability to share that information with the NRC, either on their request, or on a regular basis.

And the fourth cornerstone is, kind of, a regular toll gate safety assessments where we go back on a periodic basis and look at what we've learned, determine whether the Aging Management Programs that were developed, as part of the license renewal application, are still the appropriate Aging Management Programs, is there something else we need to look for, is there something that we now have new evidence on that says, well, maybe, we don't have to look at that particular issue on as frequent of a basis, as we first thought, in the Aging Management Programs and stuff. I'll go into more detail on that tomorrow. Next slide.

So I want to touch on high burnup fuel cladding integrity. And the last time we talked about this, with the risk, again, I put this up

here. And, I think, we talked a little bit about the operational safety problems that was in the retrievability ISG, and, I think, this is where maybe that wording came from.

When we look at this part of the Regulation, I focus on the things that I've highlighted here. One, you know, protecting the fuel against mechanisms that lead to gross ruptures. I think that's very important.

And, second, such that the degradation would pose operational safety problems. And, I think, those two are key things to keep in mind and exactly how the Regulations are written. Next slide.

So if I take a risk-informed perspective on fuel cladding, it sits in the dry storage environment, it's been inerted, it's got a helium environment in there, there's no significant stresses on the fuel, in storage, whether it's under normal, off normal, or accident conditions.

The casks are designed to prevent the canister from losing its confinement integrity, and also, protect the fuel, during the various accident and normal/off normal conditions that are required to be analyzed by the NRC, to ensure safety. Going

back to the PRAs that were conducted, previously. We've talked about those, they show very, very low risks.

EPRI gave a presentation at our Used Fuel Management Conference, last year, which said, you know, kind of, looked at this holistically, the high burnup fuel issue, and came up, and I put a couple of the conclusions in there that high burnup fuel is likely not brittle.

We're seeing now that the temperatures are not getting up into the 400 degrees C-range, or even in the 320 degree C-range, where you get a significant amount of high dried re-orientation.

And so I go down to the second EPRI results, best estimate, little or no re-orientation should be expected, during dry storage. And so not only is the fuel maintained within the cask, but we're seeing that these mechanisms that were found in some of the ring compression testing, may not actually be occurring to the extent that they would at 400 degrees C.

And then, finally, the fuel and cask internals, which is also particular to the fuel geometric rearrangement, which is important for criticality, that it's unlikely, even for accident

conditions that you're going to get any significant fuel reconfiguration.

And even if you do get fuel reconfiguration, you have that confinement boundary in place, and so there are no consequences and if a confinement boundary remains in place, then you don't, one, you don't have radionuclides leaking out, but then you, also, don't have the water getting in that you would need to sustain a nuclear criticality reaction. Next slide.

The other point I wanted to make is there's still significant research ongoing, certainly, the NRC, the surf testing, you know, I think, was a very good piece of research, in terms of that it actually looked at the entire fuel pellet, the fuel rod with the pellet, and the interaction between the cladding and the pellet, holistically, rather than with some of the ring compression testing, which was just looking at the material properties of the cladding, itself.

There's some ongoing studies by Sandia, they've already done on the road, vibration tests of an instrument assembly. That was on a road. They're now going to be doing one with a full size

cask on a railcar, so there's some of those that are going to be going on.

Obviously, there's the DOE EPRI Demonstration Program that's going to provide some additional verification of the behavior of high burnup fuel with storage times. And, I mentioned before, the Oak Ridge Energy Sponsored Fatigue Testing of high burnup fuel. Next slide.

MEMBER POWERS: I can't help but note that there is no ISFSI in New Mexico. And so knowing about its roads, which are terrible, I mean that is probably not a useful thing.

MR. CUMMINGS: Right. Well, there's no ISFSI there now, and there has been a proposed one there, in Texas, and those are very similar, so --

MEMBER POWERS: But do not confuse New Mexico with Texas.

(Laughter)

MEMBER POWERS: You'll piss off the Texans.

MR. CUMMINGS: Yes, I have a sister-in-law who is Texan, and I would never dare make that mistake to confuse those two. Next slide. So I think another point is the link to

retrievability, you know, it's funny, because I want to call this back, there and back again, going back. If you go back and actually look at ISG-2 Revision O, it was, maybe, two paragraphs, and it really said retrievability can be defined, as the ability to go get the cask, put it in a transport cask, and take it off. And now, you know, 15 years later, we've been -- it's 15, or five pages, excuse me.

Well, but still, we're going back to where we were when we first designed these casks, which was, as long as we can show that we can go get that canister, get that cask, prepare for transportation, be able to ship it and get it to a facility where, maybe, you would be able to do something more with it, then that meets the definition of retrievability.

And we're, certainly, very, are complimentary of the NRC to take on that effort, to go back and look at this again, after having made the decision to go to individual fuel-based retrievability.

And just, the last thing is that, you know, even if something happens to the fuel, even

if it's minor, we have the ability to handle fuel with gross ruptures, small ruptures, I mean, I go back to, you know, when I first started working for Holtec, they loaded the Trojan Fuel into dry cask storage and included in with some of that fuel were fuel debris cans with pallets and fuel assemblies that had broken off rods.

And it is perfectly viable for the Industry to be able to go in and take fuel that's not in a pristine condition, put it into dry cask storage, leave it there, and be able to, either, analyze it for potential realistic configurations, or to ensure that that fuel remains in a safe configuration going forward. Next slide.

So I want to talk a little bit about PRA Metrics. We met with the NRC, I think, it was in February of last year, where they were talking about updating the previous PRA study that was done before. And so this is just is, pretty much, a copy of one of my slides from there.

And at that point, we said, look, we still think latent cancer, or prompt fatality metric, it is one good way to go, because it does allow you to do a direct comparison of the risks,

which include consequences, as part to the reactor-related risks, and we had some discussions about that.

MEMBER POWERS: Why go to, to fatalities and not just go ahead and stick with dose?

MR. CUMMINGS: That's a good question, and we have come back and said, you know what, dose, dose might be another way to do it. But, I think, the most --

MEMBER POWERS: I think dose is just so much, there's one step in there that's controversial that you avoid, by going with dose.

MR. CUMMINGS: Sure. Sure.

MEMBER POWERS: And, especially, here. I mean, the fatality metric is, is just extremely small --

MR. CUMMINGS: Yes. Right.

MEMBER POWERS: -- here, whereas dose, at least, gives you a number that's comprehensible.

MR. CUMMINGS: Right, right. Yes. And we're certainly open to that. What I think is very important and I had a chance to look at Donald's slides before today, and, you know, I think, what's

missed by confinement breach, is the consequence part.

MEMBER POWERS: Yes, I, I mean, it, I --

MR. CUMMINGS: Because, other ways --

MEMBER POWERS: -- I just don't see --

MR. CUMMINGS: -- other ways, you know, --

MEMBER POWERS: -- that you use the --

MR. CUMMINGS: You get this illusion that confinement breach then --

MEMBER POWERS: Yes.

MR. CUMMINGS: -- is this massively consequential, can't have it --

MEMBER POWERS: Consequence.

MR. CUMMINGS: -- horrible result, when you really look, and in my previous life, I've done those consequence analysis, using very sophisticated codes, MAX II, I've done it very simplicity, in accordance with ISG-5, you always get back to, hey look, the consequences are really, really small.

Because, realistically, what's going to happen if you have a loss of confinement, with a

through wall crack, the noble gases out, and that's even if you have cladding deformations.

If you don't have any cladding deformations, you've got all intact fuel, most of the fuel is intact. And even the stuff that's not intact, most of the fuel rods are intact.

It may have one leaking fuel rod in one of the rods of a single fuel assembly, you're really only going to get the noble gases to come out. Those aren't very reactive with, with much of anything.

That's, there are no gases --

MEMBER POWERS: No more --

MR. CUMMINGS: Right. Exactly. Exactly.

MEMBER POWERS: But --

MR. CUMMINGS: So --

MEMBER POWERS: But more importantly, their dose consequence --

MR. CUMMINGS: Right.

MEMBER POWERS: -- numbers are low.

MR. CUMMINGS: Right. Right. So Keith mentioned this that EPRI will be doing some consequence analysis and I've been trying to assist

them with getting some of the previous work that, either, I, or other people, have done, so that they know, kind of, some of the approaches that can be taken.

CHAIRMAN BALLINGER: Well, one wonders, why the consequence analysis shouldn't have been first?

MR. CUMMINGS: Well, I would actually say that the consequence analysis is out there. I mean, it's been done before. It's just, from my perspective, the consequence is so low that nobody's ever come back to it again, because, well why do I need to calculate 1 x 10 - 14?

MEMBER POWERS: But what are the problems that you, you truthfully had in this, to be completely fair? Because, I agree with you, many, many of your scenarios are going to result in just a noble gas release.

MR. CUMMINGS: Right. Right.

MEMBER POWERS: But you cannot discount the more extreme scenarios --

MR. CUMMINGS: Right.

MEMBER POWERS: -- where you will get a particular release.

MR. CUMMINGS: Sure.

MEMBER POWERS: And we are in poor stead --

MR. CUMMINGS: Yes.

MEMBER POWERS: -- on estimating what those particles look like.

MR. CUMMINGS: Right.

MEMBER POWERS: Okay that complicates the consequence analysis. Is it insurmountable, absolutely not.

MR. CUMMINGS: Right. Right.

MEMBER POWERS: It just hasn't gotten the attention.

MR. CUMMINGS: Right.

MEMBER POWERS: But, I think, without looking at the consequences, at least, dose, I don't think you need to go to, to actual fatalities and --

MR. CUMMINGS: Right.

MEMBER POWERS: -- and I think there are complications in doing that in this context. But, to look at the actual releases, the only way to put it in perspective, the fact that you're not talking about a three million, a three billion

curie source --

MR. CUMMINGS: Right. Correct.

MEMBER POWERS: -- on the front end of this accident scenario.

MR. CUMMINGS: Correct.

MEMBER POWERS: And so when you make those reactor analogies, you're inherently implying that three billion curie source --

MR. CUMMINGS: Right. Correct.

MEMBER POWERS: -- and that's just not --

MR. CUMMINGS: Correct.

MEMBER POWERS: -- nothing here.

MR. CUMMINGS: Right. Right.

MEMBER POWERS: I don't care how you do it, --

MR. CUMMINGS: Right.

MEMBER POWERS: -- you cannot get to those kinds of potential releases.

MR. CUMMINGS: Yes, the path for release of the particular finds, the volatiles, the gases, the aerosols, are a very small percentage of what is actually even in the cask contained in the cladding. You really have to have some of these

severe, I would call them, somewhat unrealistic scenarios, with massive damage to the fuel, to even get enough of a source term in the cask cavity --

MEMBER POWERS: I mean, we're --

MR. CUMMINGS: -- that would even be available for release.

MEMBER POWERS: -- we're worried about, or rare events, and rare events with, I mean, the hypothesis of an airplane crash effecting multiple cancers was raised here, or effecting multiple canisters, I can't call that zero. And so you need to, at least, give a pass and consideration, but --

MR. CUMMINGS: Right.

MEMBER POWERS: But, I think, you have to go to consequences to get any kind of comparison --

MR. CUMMINGS: I agree.

CHAIRMAN BALLINGER: But, for the most probable scenario, even if it is probable, once you depressurize the canister, once the pressure's equal across it, the event is over.

MR. CUMMINGS: Right. So --

CHAIRMAN BALLINGER: Of course, the whole --

MR. CUMMINGS: You might have a little bit of --

MEMBER POWERS: Oh I --

MR. CUMMINGS: -- breathing of the cask and --

MEMBER POWERS: -- I don't think that's true.

CHAIRMAN BALLINGER: No?

MEMBER POWERS: Because the rod's pressured.

CHAIRMAN BALLINGER: Oh, so you have to get the rods, as well?

MEMBER POWERS: Yes, you have to crack the canister, then you fill the rod --

CHAIRMAN BALLINGER: Okay.

MEMBER POWERS: And then you get a burst release. And so I don't think the action's over just because you've --

MR. CSONTOS: And, also, I think one of the things to think about is that, when we do see these types of this mechanism, on the reactor side, it's usually not just one crack, it's usually many cracks, okay. It may go through a wall, and then, another one and then another one, but if that's,

that's what we've seen on the reactor side, in terms of piping systems and other types of locations.

Now, there will be a limited extent, still, but, there's breathing and other things, these are all things that I was telling you about before that, if we start going down this path of consequence analysis, there's lots of stuff we need to start thinking about, and lots of stuff cost a lot of money to start evaluating. And, at this point in time, we may not be in that place to be able to handle that in our resource department.

MR. LOMBARD: I think that's why defining the balance of the analysis and the input assumptions, though, are very critical --

MR. CUMMINGS: They are critical.

MR. LOMBARD: -- moving forward with the consequence analysis.

MR. CUMMINGS: Correct.

MR. LOMBARD: Make them realistic, maybe, do some type of sensitivity analysis, some sensitivity study, as part of it, but to keep them as realistic, as possible, based on the data that we have.

MR. CUMMINGS: Well, and I think that's important to, not only look at, maybe, some of the bounding scenarios, but also to look at the realistic scenarios, so that you have a feel for what that is, and, and, you know, I think it's also, to add another complexity to it, you know, you've also got the fact that, what we talked about earlier that, the social term is decreasing with time, and so you've got something with, like, CISCC, which takes decades to occur.

And so as time goes on that source term is decreasing and the potential impacts of what could happen to the fuel, if you do have loss of confinement, you know, reduced with time, also, because the temperature's decreasing.

And so I mean, you're getting into a lot, you know, you could make this really, really complex. Typically, we try to simplify it and either do it in a bounding manner, but, I think, again, we've had good discussions with the NRC to, don't just go out and try to do the most bounding thing that you can, to try to, you know, bless it away, maybe, do that and then look at some of these sensitivities of what might be more realistic, so

that you have a good feel for, kind of, the more probable and the what if. Next slide.

So in summary, having an efficient dry storage licensing process is essential for managing the dry cask storage systems that are out there. Like I said, there's 2,200 systems plus. It will simply grow. I think our projections are by 2021, or 2022, we're going to have about half of the fuel in dry cask storage.

We have achieved some success with the NRC in applying a risk-informed framework in some focused areas, specifically, retrievability is one of those, having a common understanding of the 72.48 process, I think, we've had some good progress, especially, recently on that.

And then, certainly, NUREG-1927 and 1403, and how we develop the Aging Management Programs and how we allow those programs to be flexible and considerate of the fact that we're going to learn stuff, especially, in the next five or ten years, as we go forward.

But we would certainly like to see the NRC pick up 72-7 and implement that, the principles that are in there, so that we can reduce the level

of detail that's in the certificates, and allow more flexibility to the CoC holders, to make changes, especially, to the contents.

You know, just case in point, if you want to add a new fuel assembly that's, pretty much, identical to the ones that have already been licensed for the casks, you have to go back to the NRC for a licensed member request for that.

Reactor side, they're able to make fuel design changes, under 50.59, especially, if you're going from one to another. There's some nuances in the licensing process that are a little bit different on both sides, but the level of detail in our certificates for dry cask storage is, I would say, in order of magnitude, higher than what's on the reactor side and we would like to bring that, at a minimum, in line with the reactor level of detail.

MEMBER SKILLMAN: Kris, I'm not sure that's completely accurate. When you change fuel, you have to submit your COLR, your Core Operating Limits Report, in which you embed all of your analysis for that new fuel. So you actually do, upon your COLR --

MR. CUMMINGS: You do, but --

MEMBER SKILLMAN: -- licensing of what will be, if you will your reload, plus your LTAs, or whatever you're going to load.

MR. CUMMINGS: Sure, if you make a change from one vendor to another, then you, typically, have to a license member request. However, if you switch from, say, an RFA-1 to an RFA-2, some of that and, especially, large parts of a scope of that, could be done under 50.59, with maybe just the things that needed to be changed in the tech spec.

But the methods, you know, would not have been changed, you would've used the methods that were already in the COLR. So yes, I recognize that there are a little bit of nuance differences in the licensing regime there.

MEMBER SKILLMAN: Have we seen PRM 72-7? Have you all seen it? So the only reason I raise the issue is just for my own understanding of what you are asking for.

MR. CUMMINGS: Okay.

MEMBER SKILLMAN: And I don't think the members have seen PRM 72-7. That might be

something that would be --

MR. CUMMINGS: Specifically.

MEMBER SKILLMAN: Okay, thank you.

MR. CUMMINGS: I mean, just very quickly, to summarize, it's essentially, in 50.36 there are criteria for what you include in the tech specs, we're simply saying, let's take those criteria and have, either, those criteria, or something very similar that's applicable to dry cask storage. That's the biggest thing that's in that, in that proposed rulemaking.

MR. LOMBARD: If you look at 72-7, I'd ask you to keep in mind our current environment in the rulemaking space and how that rulemaking would score. How it would have scored, even a year ago, and how it would score in the future --

MEMBER POWERS: Fortunately --

MR. LOMBARD: -- pertaining with the rulemaking.

MEMBER POWERS: -- we are blessed with a proscription of, against managing the agency.

(Laughter)

MR. LOMBARD: I understand that and our plan is to achieve some of the goals, as many as

possible, if any, through SRP development and the risk-informing framework that we're putting together, and we can have another discussion on that, in future, after you get your eyes on 72-7.

MEMBER POWERS: Kris, let me ask you a question that's totally unfair, but I'll ask it anyway.

MR. CUMMINGS: That's fine, I wouldn't expect anything less from you.

(Laughter)

MEMBER POWERS: I just wondered if NEI had any particular view on deep boreholes?

MR. CUMMINGS: Oh jeez.

(Laughter)

(Simultaneous speaking.)

MR. CUMMINGS: I'm trying, I'm just, I'm pausing, because I'm trying to think of what is -- Rod, do you want to -- I'm trying to make sure I don't say something different than what we said before. I'm going to defer to my boss, to make sure he gets it right.

(Laughter.)

MR. McCULLEN: Yes, we haven't, in our used fuel position, we haven't staked out a

particular position on deep boreholes, but we do know, and I think DOE has come to realization, as well, that it's very unlikely that it will be any kind of a foreseeable future solution for used fuel. It would be more likely for smaller sources. I think that's one of the reasons DOE is splitting, you know, they're considering splitting the repository, because -- and they're, DOE is not, the answers that DOE is not, currently, not looking at deep boreholes for commercial used fuel and I think we're in agreement with, if you're going to, if you're going to look at boreholes that's probably a good distinction to make.

MEMBER POWERS: Yes, I think the -- I really, honestly, don't know where they stand, but at one point they were contemplating the test on it, but not, not for commercial fuel, for DOE-type waste.

MR. CUMMINGS: Yes. Yes.

MR. McCULLEN: By the way, for the record, I was Rod McCullen, at NEI.

MR. CUMMINGS: I knew I brought him for something. Thank you. And now --

(Simultaneous speaking.)

MR. CUMMINGS: My arm's twisted --

MR. McCULLEN: Just trying to make you look good, Kris, that's all I'm doing, I'm playing the straight guy here.

(Laughter.)

MR. CUMMINGS: Okay, last, but not least.

MR. LOMBARD: I have three pages of closing comments. No. I really don't. I, you know, there were many things that we've talked about today, again, we really appreciate the Subcommittee's time to be able to bring these, these topics to you and give you an idea of the overall environment that we deal in, as well as, these specific technical topics and some not so technical topics that we brought before you today.

I don't think it's a big benefit to rehash those topics, and we had great discussion and, I think, through those discussions that we did state what our, kind of, where we're coming from, in each one of those technical topics.

So I'd rather just leave it open for, for feedback from you all, if there's any other questions that you didn't ask earlier, on the

technical topics, and also, leave time for public comments, which is on your agenda.

CHAIRMAN BALLINGER: Thank you. Thank, everybody. I think we now, are there people in the audience that would like to make a comment, while we're getting the line open? Pete, are you still there?

(No response.)

CHAIRMAN BALLINGER: Apparently not. They, apparently, got four feet of snow. And he sent us a picture. Put a real crimp on his style, he was teaching skiing out in Denver.

MEMBER RICCARDELLA: I'm sorry.

(Laughter.)

MEMBER RICCARDELLA: I'm still here, I didn't take off, as much as I was tempted to.

CHAIRMAN BALLINGER: Do you have any comments, Pete?

MEMBER RICCARDELLA: Nope, nope, I --

CHAIRMAN BALLINGER: Because we've got to go around the table, then.

MEMBER RICCARDELLA: -- thought it was very, very informative.

CHAIRMAN BALLINGER: It sounds like

something's open. Are there any folks out on the public line that would like to make a comment?

MS. GILMORE: Yes, this is Donna Gilmore. There was mention about having a lot of experience with these canisters, so we probably have, but since we haven't been able to inspect any of them for cracks, we have no idea how many cracks they have, or how deep the cracks are, so --

And then, something that wasn't addressed is the fact that the, in Japan, they determined that the aluminum may last longer than 60 years and, I think, there needs to be an assessment of, you know, of that issue and does it affect our aluminum?

And there's also a March Sandia Report, March 2015, that, due to the, it was stating that due to the higher temperatures of our canisters, those cracks could go through the wall in five years, or less.

I don't know if you're familiar with that, I'm, I could share documents for what I'm talking about here. I have a lot of other comments, but I think I might take an hour or so I'll just, I'll stop at this point.

CHAIRMAN BALLINGER: Thank you, very much. Is there anybody else out there that would like to make a comment?

MR. LEWIS: My name is Marvin Lewis, member of the public.

CHAIRMAN BALLINGER: Yes, Marvin.

MR. LEWIS: All right, look, back when WIPP, Waste Isolation Pilot Project, was starting, we're going to get the same problem, as they do in the Ukraine.

And, nothing's going to burn down there, we're going to have all this waste packed in bentonite and a, an inorganic. Well, a few months ago, sure enough, things started burning at WIPP and, sure enough, the waste was not packed in bentonite, it was packed in a wood waste.

And I'm wondering, just how many assumptions and how many promises will be kept with these high-level spent fuel, I mean, highly enriched spent fuel casks and how many assumptions will be right? And I'm wondering, also, is this, are the fires still burning at WIPP? Thank you.

CHAIRMAN BALLINGER: Thank you. Anybody else that would like to make a comment out

there?

(No response.)

CHAIRMAN BALLINGER: Hearing none, we can close the line. We can go around the table for member comments. Dick?

MEMBER SKILLMAN: No, I made my comments earlier and I appreciate all of the presenters today. This has been a good solid set of presentations that have really, in my view, identified a number of action items that we, in the ACRS need to take, but it's also made us aware of a lot of action in the Agency that we had not been aware of, and also NEI. So thank you, for today's presentations and, thank you.

CHAIRMAN BALLINGER: Dr. Powers?

MEMBER POWERS: Well, to be sure, these were, these was one of the best sequences of presentations that we've had in a long time and I thank the Chairman for bringing us together, to enjoy this. This was terrific.

CHAIRMAN BALLINGER: Pathological liar.

MEMBER POWERS: Despite his obvious failings in other respects. Technically --

CHAIRMAN BALLINGER: Now he's not

lying.

MEMBER POWERS: Technically, I think there are just a couple of points that I'd like to make. One is, I reiterate that, yes, we need to think, not in terms of crack, or containment failure, frequencies alone, but we do need to do, go to some sort of level three kinds of analysis.

I don't think it merits the kinds of detail we do for the reactors, because I think we know that the source term is just not, as big, but we need to have some feeling for how much radioactivity we're, we can potentially expose to the public here, just to put things into a proper context.

The other one is, I'd like to remind the Committee, in thinking on this subject that, we are prescribed, by Charter, for managing the Agency with whatever charge we're giving the Commission technical advice, whether they can take it out, because the resources are not, is not our responsibility.

CHAIRMAN BALLINGER: Thank you. Right. I'm looking at Charlie.

MEMBER BROWN: You're looking at me in

trepidation. No, I made my only real comments, I'll make earlier is, is I voiced a couple of times, but I do appreciate the presentations.

I agree with Dan and Dick that, it was well-organized and well put together and, I think, there was a lot of good ongoing back and forth and discussion that was very open and very positive, so I thank you. I've learned a good bit and it clarified a number of questions that I had in preparing for it, so thank you.

CHAIRMAN BALLINGER: And I'd like to thank you, all the presenters, everybody. It was really an outstanding, long day, but outstanding. Regarding what Dick's comment was on action items, I've got, at least, three that we need to think about, we have, we was going to pick up tomorrow morning and talk about 1927, but the issues that we have to think about are 1927 and a meeting with the full Committee, related to that.

ISG-2, there's been a suggestion that, that the staff could go and make the word changes that we've suggested, but that, once that is made, that does not rise to level of coming to the full Committee, or anything like, so that's another

thing to discuss, maybe, at the end of the day, tomorrow.

And, third, we have been challenged by the staff to participate in a brainstorming session, a closed brainstorming session of the Subcommittee and other members, related to risk-informing and the whole, that whole issue, and so Kris is taking that up.

And we're trying to, we actually had a time slot in May, which we had gave up, but now we're trying to get it back. So there's another thing that's on our, on our plate.

And, I think, we had some discussions, amongst ourselves, earlier, and I think Dick talked with John Stetkar, as well, so I think we're all, in generally, very much in favor of something like that.

So those were the three things that -- was there any other action item that you thought we had to deal with?

(No response.)

CHAIRMAN BALLINGER: Okay. Then, thank you, very, very much for participating in this and coming before us and, again, it was really an

outstanding day.

MR. CUMMINGS: Thank you.

CHAIRMAN BALLINGER: And we look forward to another outstanding half day.

(Laughter.)

CHAIRMAN BALLINGER: We are now adjourned.

(Whereupon, the meeting in the above-entitled matter was concluded at 4:42 p.m.)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Overview of the Spent Fuel World

Mark Lombard, Director
Division of Spent Fuel Management

Meeting with Advisory Committee on Reactor Safeguards
Subcommittee on Metallurgy & Reactor Fuels
Framework for Storage and Transportation of Spent Fuel
March 23, 2016

NMSS
Division of Spent Fuel Management

Agenda

- Roles and Responsibilities
- Part 71
- Part 72
- The New Paradigm
- Interim Consolidate Storage
- The Perfect Storm
- ACRS Topics
- Successes

Roles and Responsibilities

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Licensing, Certification, and Inspection
  - Part 71
    - Spent fuel transportation packages
    - Radioactive material transportation packages
  - Part 72
    - Spent fuel storage facilities
    - Spent fuel dry cask storage systems
  - Vendor, QA, and ISFSI inspections
- Coordination with:
  - State and federal agencies (most notable DOT and DOE, but also EPA)
  - Foreign and international regulatory agencies
  - Native American tribes
- Public outreach

NMSS
Division of Spent Fuel Management

Division Branches

- Confinement, structural, thermal (CSTB)
- Criticality, shielding, dose, risk (CSRAB)
- Materials, renewals (RMB)
- Project managers (SFLB)
- QA, inspection, oversight, rulemaking (IOB)

Transportation of Radioactive Material, Part 71

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

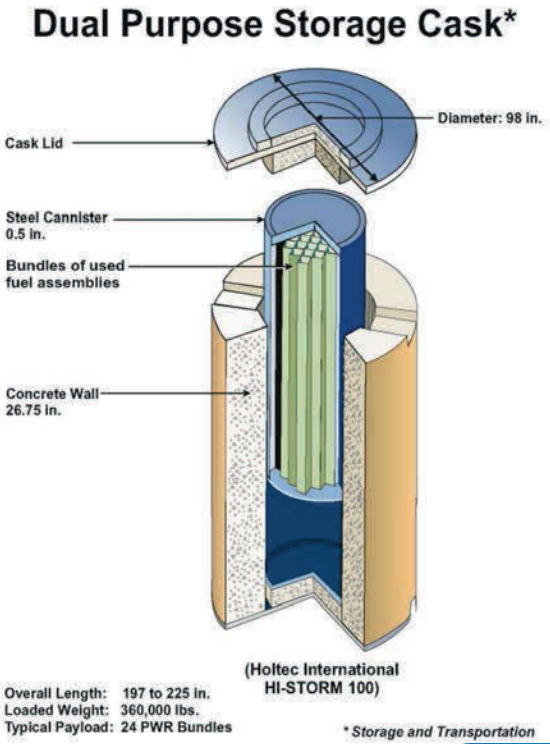
- Approximately 100 active Certificates of Compliance (CoCs)
- 50-70 transportation cases each year
- Support transport of nuclear materials used for:
  - Spent fuel
  - Medical and industrial applications
  - Power and research reactors
  - Fuel cycle facilities
- Work closely with DOT in both domestic and international transportation
- Also coordinate with DOE, States, and IAEA

NMSS
Division of Spent Fuel Management

Dry Cask Storage, Certificates of Compliance, Part 72

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Approximately 12 active storage CoCs
- 20-30 storage cases each year
- Coordination with DOE project planning and research organizations
- Significant engagement with stakeholders



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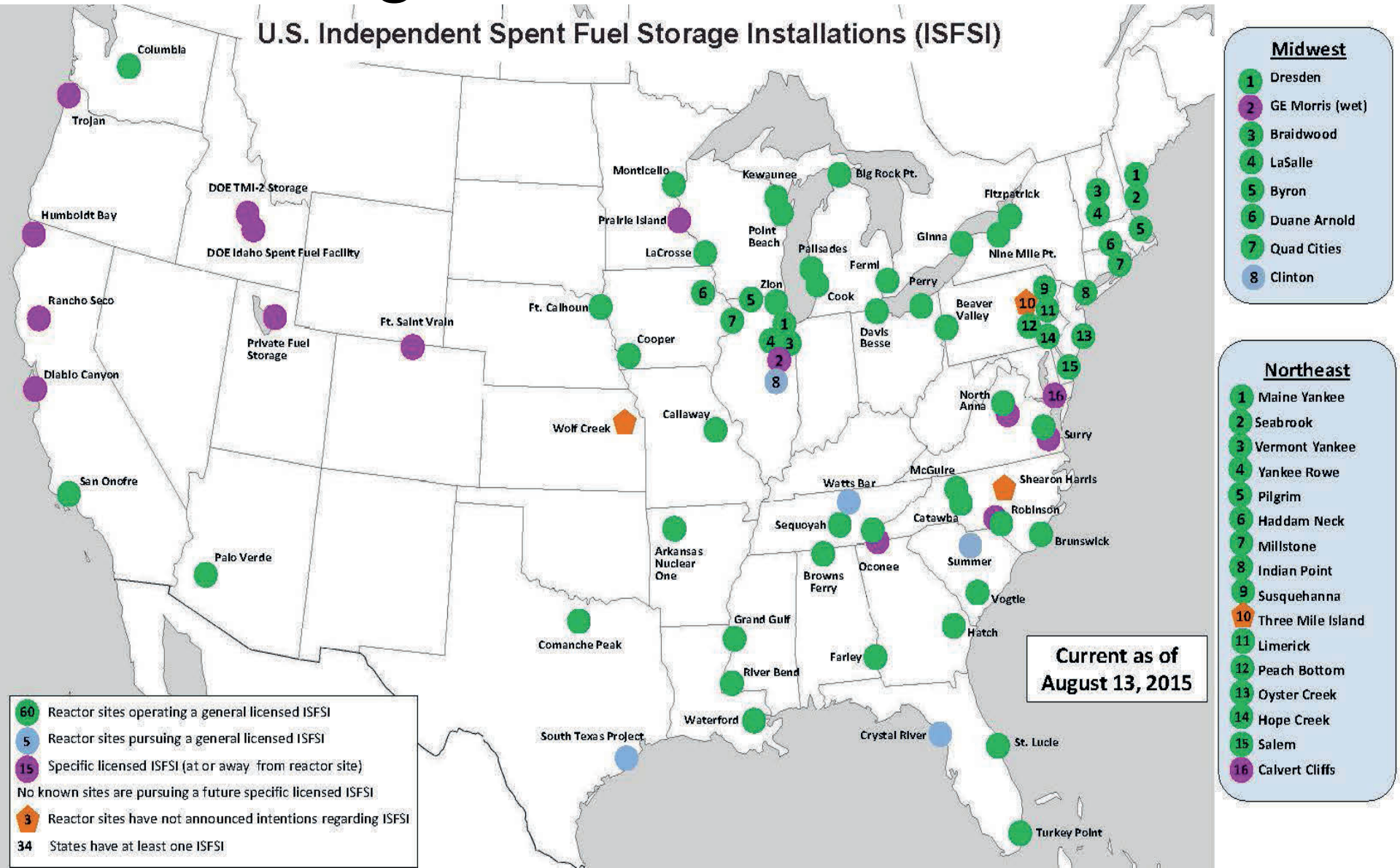
Status of Independent Spent Fuel Storage Installations

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment



The New Paradigm

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Uncertainty regarding backend of the fuel cycle
- New paradigm
  - Longer storage periods
  - 72-71-72
- Interim Consolidated Storage
- DOE TSAR

NMSS
Division of Spent Fuel Management

Interim Consolidated Storage

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

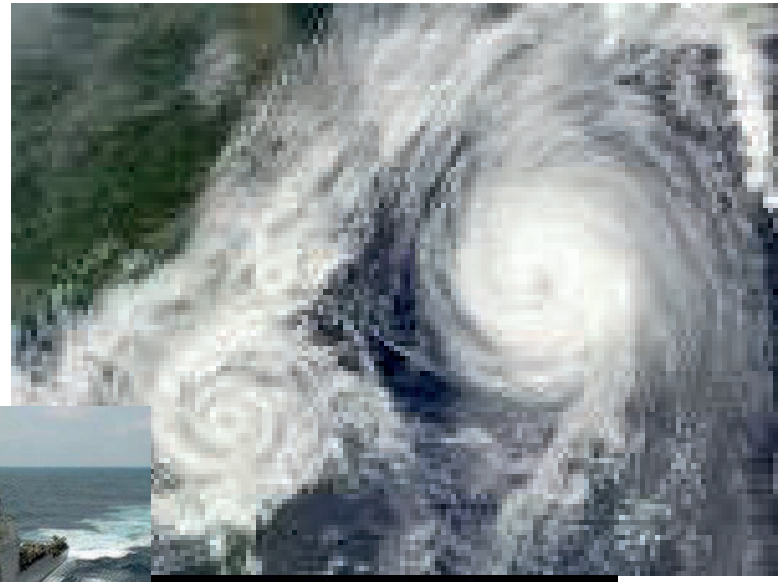
- Received letters of intent from Waste Control Specialists and Holtec/Eddy Lea Alliance to submit applications in 2016
- Potential DOE TSAR
- Part 72 is adequate for storage and packaging
- Continue to monitor and coordinate, as appropriate, with DOE and industry

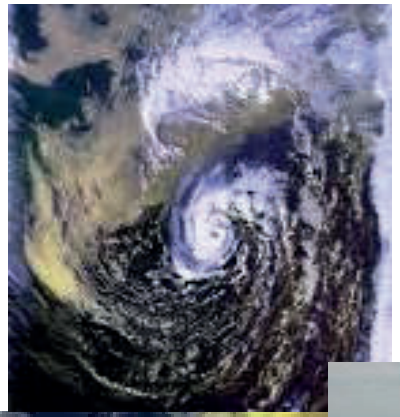
NMSS
Division of Spent Fuel Management

FY16 – FY20
The Perfect Storm

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

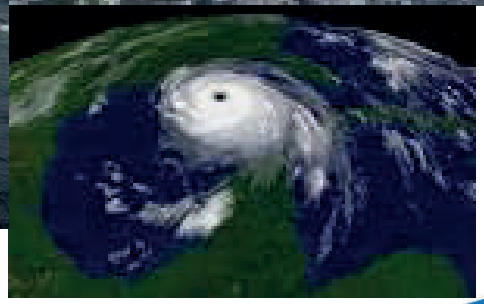
WCS and Holtec





Normal workload

DOE TSAR



CoC and ISFSI Renewals

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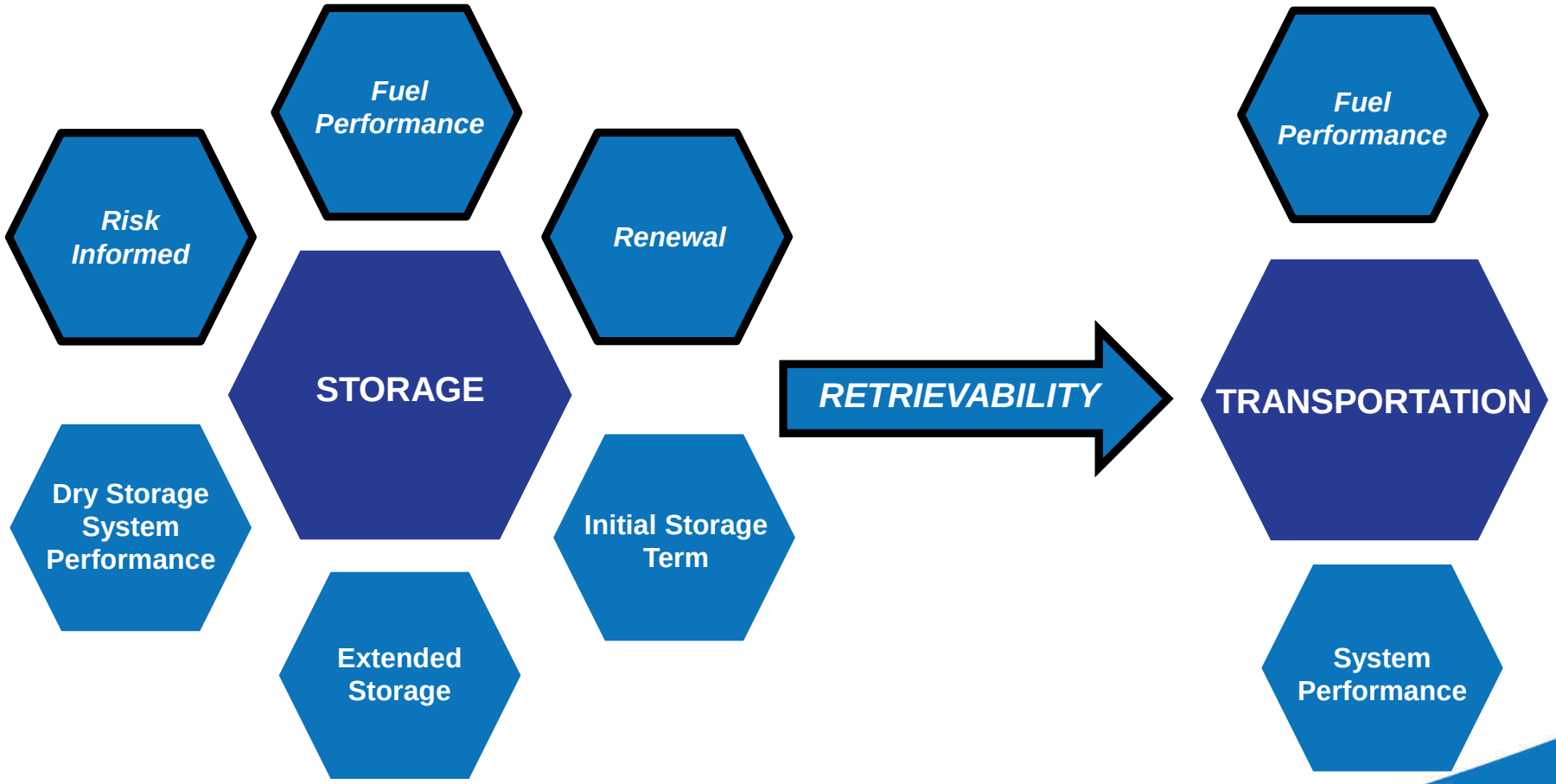
ACRS Meeting Topics



Renewals

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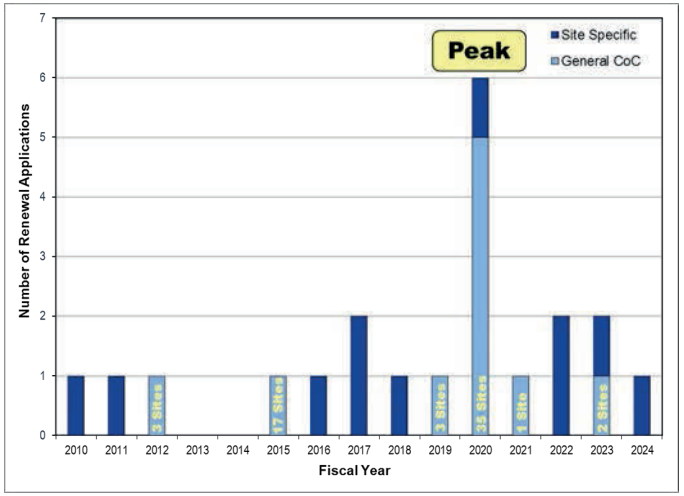

- Aging Management
  - Time-limited aging analyses
  - Aging management programs
- In-service Inspections
  - Operations-based
  - Appropriate monitoring and inspection techniques and timeframes
  - Assessment of monitoring data and inspection findings
  - Reporting, aggregating, and trending of operating experience
  - Learning aspect

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Fuel Performance

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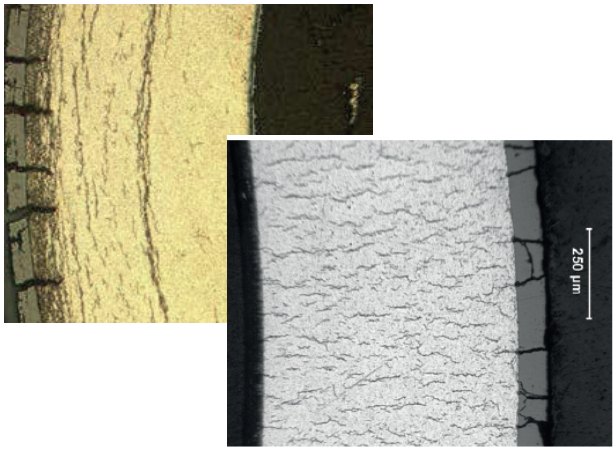
- Demonstration Project
  - Long-term demonstration program to provide the confirmation of continued safe storage of HBU fuel
  - The NRC is closely monitoring
  - Currently reviewing the North Anna License Amendment for the HBU Demo cask
- ORNL Testing
  - Research activities of high burnup spent fuel rods specifically focused on the effect of hydride reorientation on structural response of spent fuel rods (cladding and fuel pellets) to conditions experienced under 10 CFR Part 71



Microscopic Views of Fuel Clad Hydrides

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Risk-Informed Regulatory Framework

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- To better enable the staff to focus its spent fuel storage regulatory efforts, improve guidance, streamline casework activities, help assess 10 CFR 72.48 changes, and evaluate requests for exemptions to the storage regulations while maintaining appropriate margins of safety and security.
- Currently developing risk framework to quantify the impact of changes associated with components important to safety on the overall risk of spent fuel storage systems.

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Retrievability

- In 2001, NMSS defined retrievability on a fuel assembly basis
- Impractical in the New Paradigm
- Refined and broadened definition in ISG-2
- Allow options to approach

Future documents for possible coordination with ACRS

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- NUREG-1536/1567 – Consolidation of Storage Standard Review Plans (SRPs)
  - September 2016 (proposed final)
- High-Burnup Fuel Regulatory Issue Summary
  - December 2016 (proposed final)
- Managing Aging Processes in Storage (MAPS) NUREG Report
  - January 2017 (proposed final)
- NUREG-1609/1617 – Consolidation of Transportation SRPs
  - May 2017 (proposed final)
- High-Burnup Fuel Technical Basis NUREG
  - July 2017 (proposed final)

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Successes

- NUREG-1927, Revision 1
- ISG-2, Revision 2
- ORNL testing
- ICSF review strategy
- Risk informed framework status
  - Defense in depth
  - Safety goals
- Licensing process changes

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Spent Fuel Storage Renewal Framework

Kristina Banovac
NMSS/DSFM/RMB

Meeting with Advisory Committee on Reactor Safeguards
Subcommittee on Metallurgy & Reactor Fuels

Framework for Storage and Transportation of Spent Fuel
March 23, 2016

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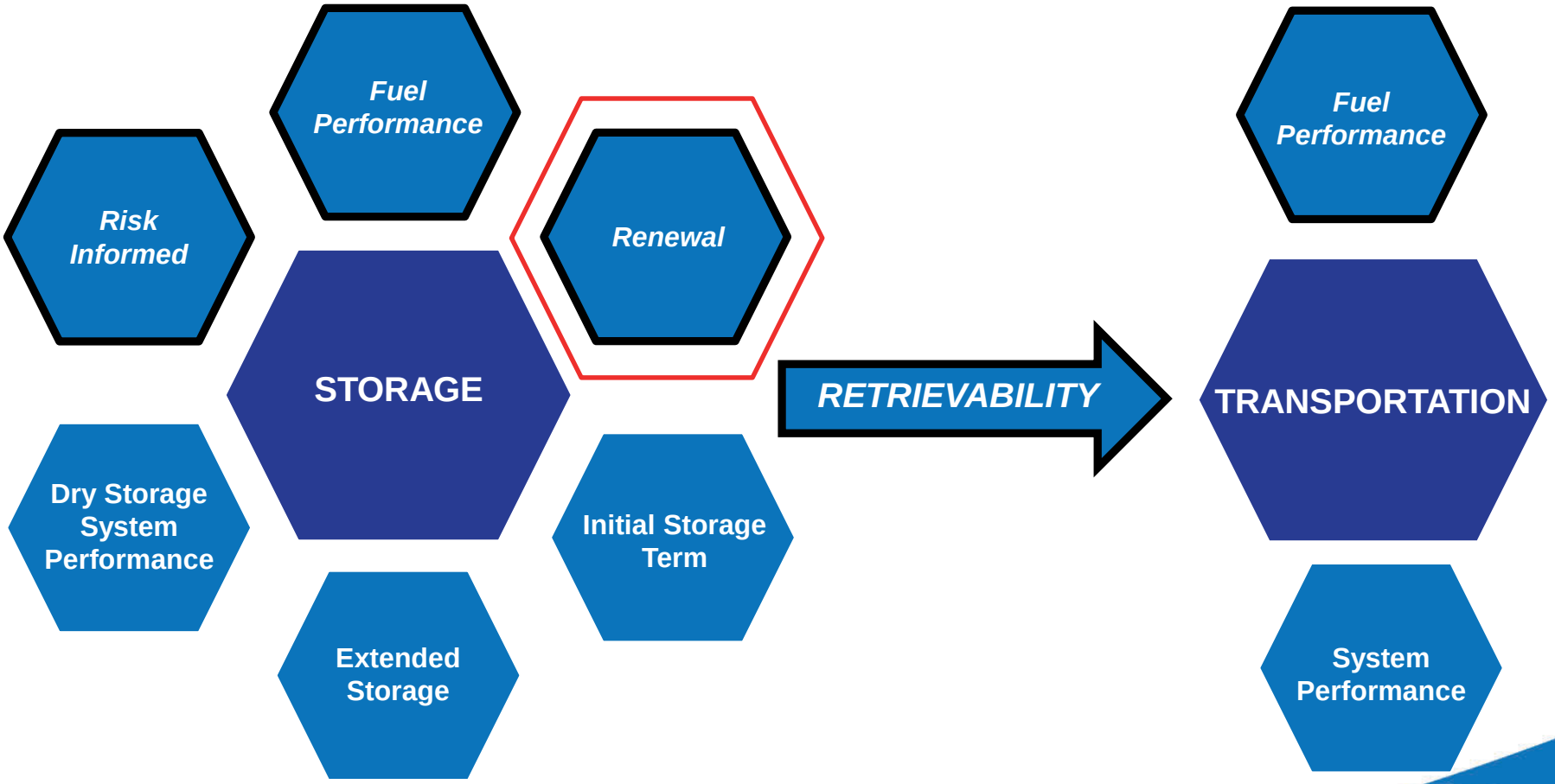
Fuel Performance
Risk Informed
Renewal
STORAGE
Dry Storage System Performance
Initial Storage Term
Extended Storage
RETRIEVABILITY
Fuel Performance
TRANSPORTATION
System Performance

Outline

- Background
  - Requirements for spent fuel storage renewals
  - NRC effort to identify needs for the storage renewal framework
- NRC guidance development
- External infrastructure development

Background – Storage Renewal Requirements

- Renewal of Independent Spent Fuel Storage Installation specific licenses and Certificates of Compliance for dry storage system designs, for a period not to exceed 40 years
- Maintain intended functions in the period of extended operation
  - Time-limited aging analyses
  - Aging management programs (AMPs)

Background – Effort to Identify Needs

- NRC staff experience with storage renewal reviews indicated a need for expanded guidance
- NRC team assessed current regulatory framework to determine what changes were needed
- Extensive stakeholder engagement and valuable input received from stakeholders

Background – Needs

- Operations-focused approach to storage renewals
  - Learning, proactive and responsive
- Sustainable regulatory framework for storage renewals
- NRC guidance development and external infrastructure development

Infrastructure for Updated Storage Renewal Framework

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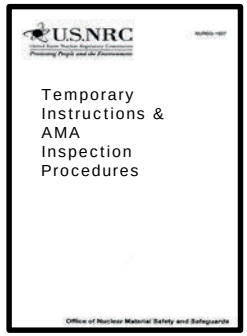
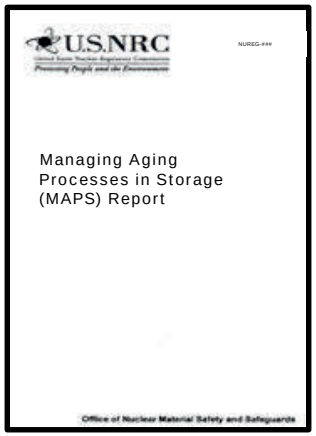
TI / IP Inspections



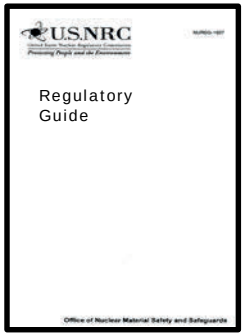
SRP 1927R1

Staff consideration of Stakeholder inputs

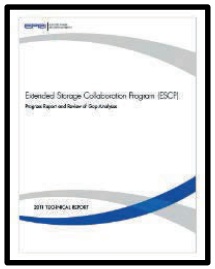
MAPS



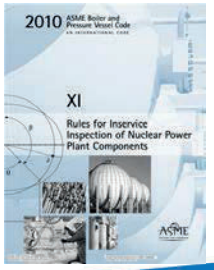
RG



Technical Issue Resolution



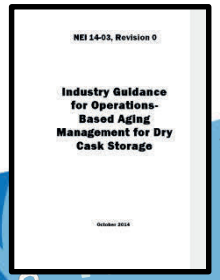
Consensus Codes



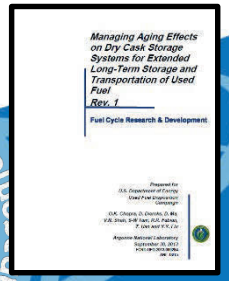
Storage/ Reactor OpE

SRP NUREG-1927R0

NEI 14-03



DOE/ANL Report



NRC Guidance Development

- NUREG-1927, Rev. 1 (Standard Review Plan for storage renewals)
- Managing Aging Processes in Storage (MAPS) Report
- Guidance for NRC inspections of licensees' aging management activities
- Regulatory Guide

NUREG-1927, Rev. 1

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- Revisions and updates made throughout Rev. 1
- Includes example AMPs
- Draft guidance published for public comment in July 2015
- Staff has considered public comments and has developed proposed final guidance for coordination with ACRS
- Path forward:
  - engage with ACRS in March/April 2016
  - Publish final guidance in summer 2016

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MAPS Report

- Provide an acceptable generic approach to aging management for dry storage systems
- Comparable to NUREG-1801 for reactor renewals
- Increase efficiency of preparation and review of storage renewal applications
- Path forward:
  - Engage with stakeholders and ACRS
  - Publish draft guidance for public comment (summer 2016)
  - Publish final guidance (summer 2017)

NRC Inspection Guidance

- Guidance for NRC inspections of licensees' aging management activities
  - Verify that licensees are effectively implementing AMPs by:
    - maintaining effective procedures for AMP implementation
    - conducting proper inspections and monitoring
    - completing timely and effective corrective actions
  - Temporary Instruction, Inspection Procedure
  - Under development

Regulatory Guide

- Regulatory Guide that discusses storage renewal guidance framework
  - Vehicle for potential endorsement of industry guidance in NEI 14-03
  - Future development, pending NEI 14-03 review and MAPS development

External Infrastructure Development

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- Consensus American Society of Mechanical Engineers Boiler and Pressure Vessel Code Section XI Code Case for inservice inspection of dry storage canisters
- Consensus American Concrete Institute Guide for inservice inspection of concrete overpacks

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External Infrastructure Development (cont.)

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- NEI 14-03, Rev. 1, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management
- In-situ nondestructive examination capabilities
- International Atomic Energy Agency guidance on development of AMPs for dry storage systems

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Sustainable Renewal Framework

- Informed by review experience, operating experience, and research
- “Learning” – aging management programs consider and respond to operating experience
- “Living” – guidance will be updated over time, as needed
- Applicable to first and subsequent renewal periods

References

- Draft NUREG-1927, Rev. 1, Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel

  http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1927/r1/

- Proposed Final NUREG-1927, Rev. 1 and responses to public comments (for ACRS coordination)

  ADAMS Accession No. ML16053A199

- NUREG-1801, Generic Aging Lessons Learned (GALL) Report

  http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1801/

- NEI 14-03, Rev. 1, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management

  ADAMS Accession No. ML15272A329

Acronyms

- ACRS – Advisory Committee on Reactor Safeguards
- AMP – aging management program
- DSFM – Division of Spent Fuel Management
- MAPS – Managing Aging Processes in Storage
- NEI – Nuclear Energy Institute
- NMSS – Office of Nuclear Material Safety and Safeguards
- RMB – Renewals and Materials Branch

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Spent Fuel Retrievability

Emma Wong
Division of Spent Fuel Management

Meeting with Advisory Committee on Reactor Safeguards
Subcommittee on Metallurgy & Reactor Fuels
Framework for Storage and Transportation of Spent Fuel
March 23, 2016

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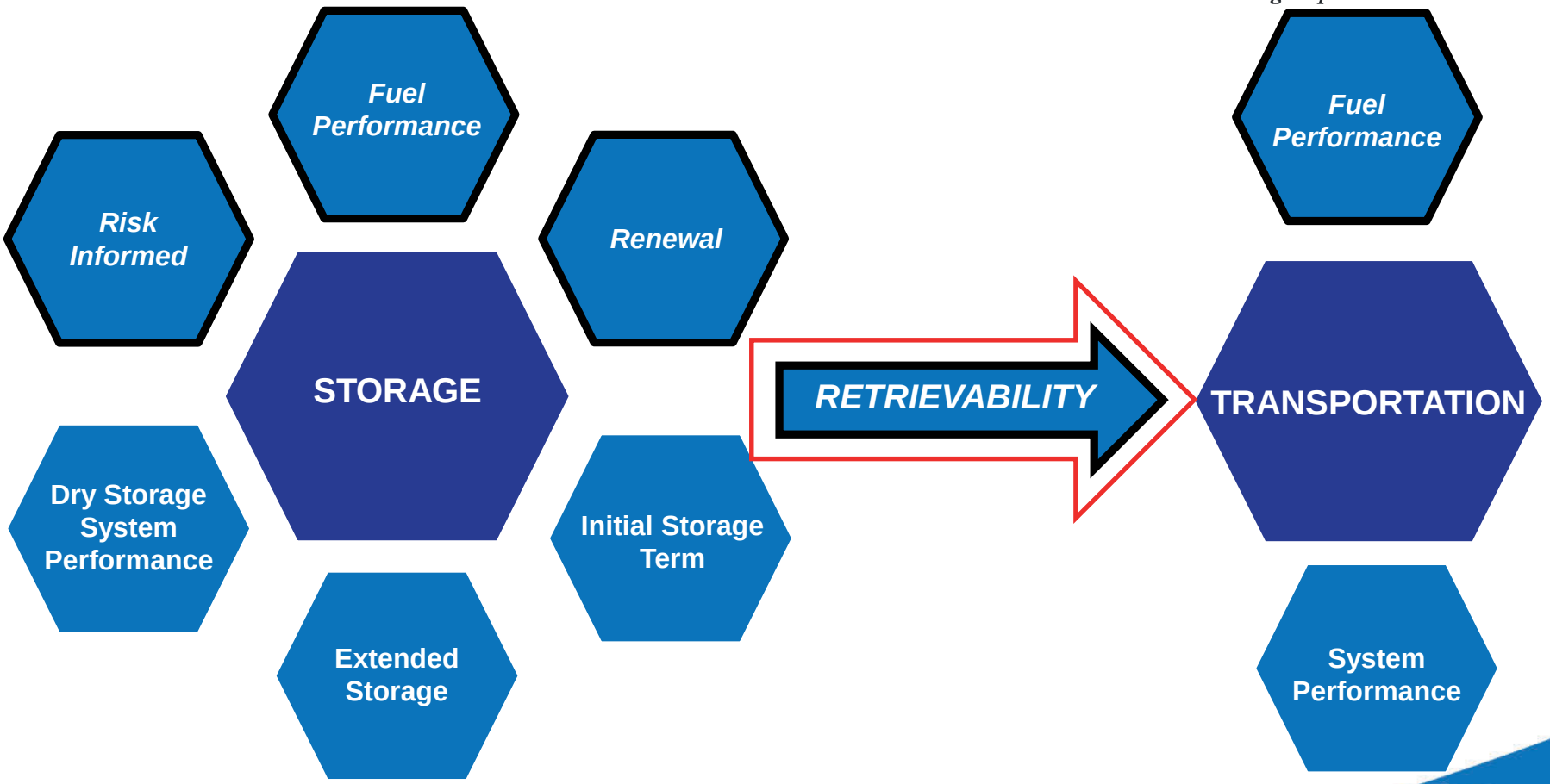
Fuel Performance
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Outline

- History
- Regulations
- Retrievability
- Guidance
- Paradigm Shift
- Proposed Guidance
- ISG-2
- Updating Guidance

Regulatory History

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1982 Nuclear Waste Policy Act Section 141(b)(1)(C)

1988 Final Rulemaking 10 CFR 72.122(l)

1990 Final Rulemaking 10 CFR 72.236(m)

- NWPA Section 141(b)(1)(C) as amended

  "to provide for the ready retrieval of such spent fuel and waste for further processing and disposal"
- Codified in 1988 rulemaking to add 10 CFR 72.122(l)
- 1990 rulemaking added 10 CFR 72.236(m) for CoCs to consider design consideration of retrievability

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Applicable Regulations

- 10 CFR 72.122(l) - Retrievability

  "Storage systems must be designed to allow ready retrieval of spent fuel, high level radioactive waste, and reactor-related GTCC waste for further processing or disposal"

- Applies to general and specific licensed ISFSIs

Applicable Regulations(con't)

- 10 CFR 72.236(m)

  "To the extent practicable in the design of storage casks, consideration should be given to compatibility with removal of the stored spent fuel from the reactor site, transportation, and ultimate disposition by the Department of Energy."

- Applies to storage CoCs

Retrievability

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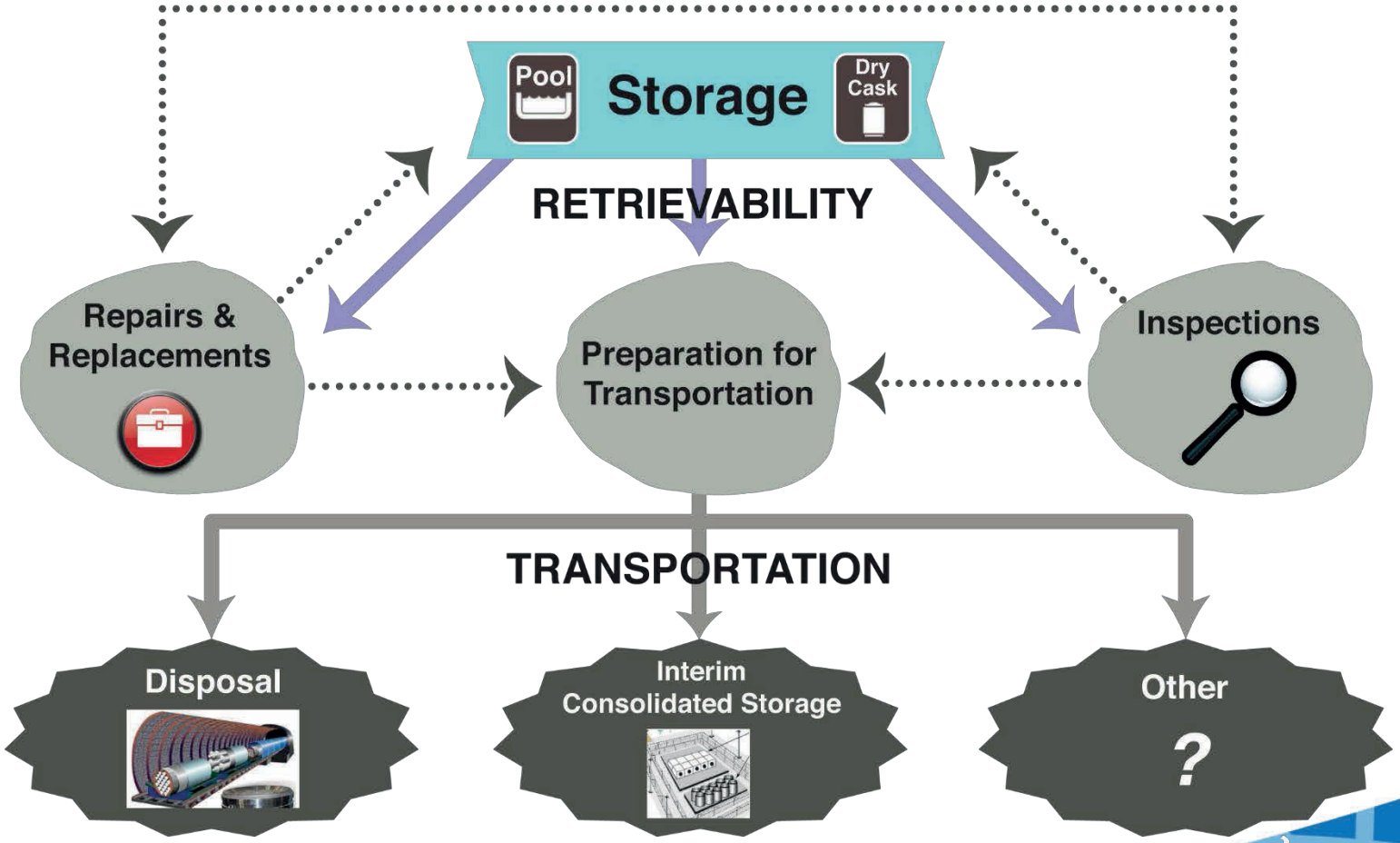

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Guidance

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1998 ISG-2 Rev. 0
Fuel Retrievability

2001 SECY-01-0076
Retrievability of Spent Fuel from Dry Storage Casks

2010 ISG-2 Rev. 1
Fuel Retrievability

- "…the ability to move a canister containing spent fuel to either a transportation package or to a location where the spent fuel can be removed. Ready retrieval also means maintaining the ability to handle individual or canned spent fuel assemblies by the use of normal means." (ISG-2, Rev. 1)
- Reflected a time of a near term repository

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Paradigm Shift

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2010 COMSECY-10-0007 Project Plan → 2011 & 2012 Public Meetings Licensing and Inspection Enhancements → 2013 Request for Public Comments on Retrievability

- Long term performance of aging internal components
  - Ongoing agency and industry research
- Unintended consequences of current guidance
  - Difficulties in assessing internals may lead to opening the cask/canister
  - May increase worker dose & degrade/eliminate the confinement boundary

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Proposed Guidance

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2015 July Public Meeting
Retrievability of Spent Fuel

2015 FRN & Draft ISG-2 Rev. 2
Fuel Retrievability

2015 October Public Meeting
Draft ISG-2 Rev. 2

- Interactions with the public
- Draft ISG-2, Rev. 2
  - Continue to protect public health and safety
  - Ensure spent fuel can be retrieved from storage safely for further processing or disposal
  - Provide guidance to the NRC staff on licensing reviews

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ISG-2

- Current revision 1
  - Ability to move a canister containing spent fuel to either a transportation package or to a location where the spent fuel can be removed and
  - Ability to handle individual or canned spent fuel assemblies by the use of normal means
- Draft revision 2
  - Focuses on safety and design bases to allow maximum flexibility to maintain safety for an undefined storage duration

Ready Retrieval

The ability to safely remove, with no operational safety problems, the spent fuel from storage for further processing or disposal.

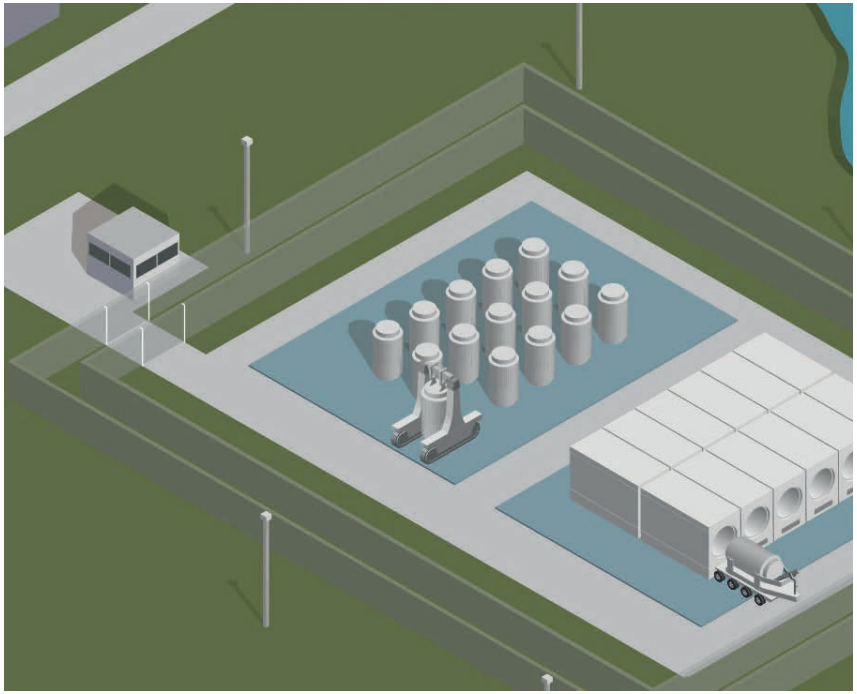
Ready Retrieval (con't)

Ability to do at least one of the following options:

A. remove individual or canned spent fuel assemblies from wet or dry storage,
B. remove a canister loaded with spent fuel assemblies from a storage cask/overpack,
C. remove a cask loaded with spent fuel assemblies from the storage location.

Ready Retrieval: Option A and Option B/C

- Currently at all sites
- Fuel assembly removal
- Canister/cask removal
- No operational safety problems



Ready Retrieval: Option A

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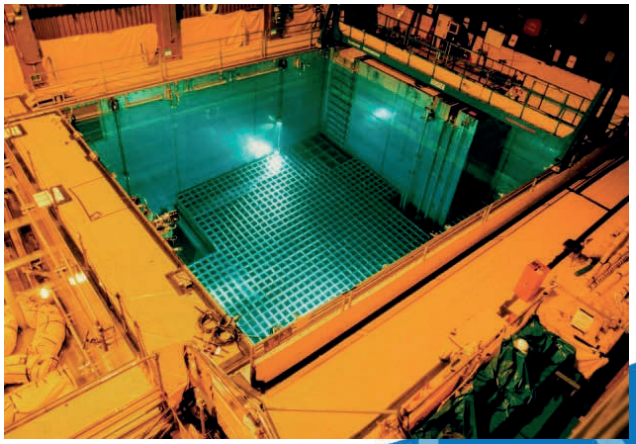
- Wet and dry storage design
- Fuel assembly removal
  - Assure that the fuel will not exhibit gross degradation
  - Or the fuel is placed inside a secondary container
- No operational safety problems



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Ready Retrieval: Option B/C

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- Canister/cask removal
  - Include technical specifications (TS) to maintain ready retrieval
  - May have program to identify, monitor, and mitigate possible degradation
  - Complies with 10 CFR Part 72 requirements
- No operational safety problems

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Licensing Applications

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- Initial and amendments
  - System designed for retrievability
  - Identified important SSCs & subcomponents
  - TS ensure retrievability capability is maintained
- For example: Maintain as-loaded condition according to the TS
  - Known loaded fuel condition and configuration
  - Dry and inert environment
  - Maximum fuel clad temperature limits
  - Thermal cycling is limited

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Licensing Applications (con't)

- Renewals
  - Ensure design bases is maintained
  - Review AMPs and TLAAs
  - Review operating experience
    - Inspections and analyses of SSCs and subcomponents
  - For more information refer to NUREG-1927, Rev. 1

Certificate of Compliance

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- Initial application
  - Not required to meet 10 CFR 72.122(l), retrievability
  - Meet 10 CFR 72.236(m) to the extent practicable
  - If included, evaluate the retrievability aspects and that other 10 CFR Part 72 requirements are met
- General licensees
  - Required to meet 10 CFR 72.122(l), retrievability
  - Load in accordance with a CoC
  - Demonstrate that the canister/casks meet the fabrication, loading, and preparation for storage requirements

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Certificate of Compliance (con't)

- Amendments
  - General licensees can voluntarily adopt a later CoC amendment
  - Must be adopted in its entirety
- Revisions
  - Supersedes the CoC amendment being revised
  - General licensees using the CoC amendment being revised must comply with the revision
  - Subject to backfit review

Updating Guidance

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2016 February Updated Draft ISG-2 & Responded to Comments → 2016 March/April ACRS Meetings → 2016 Summer Issuance of Final ISG-2, Rev. 2

- 70 comments received and NRC responses drafted
- Clarified and updated draft ISG-2, Rev. 2
- ACRS meetings
  - March 23, subcommittee overview
  - April 7, full committee (if needed)
- Issue final guidance

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Questions/Comments

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References

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- 42 U.S. Code §10101 et seq. Nuclear Waste Policy Act (NWPA) of 1982, as amended.
- 53 FR 31651 1988 Final Rulemaking "Licensing Requirements for the Independent Spent Fuel Storage of Spent Nuclear Fuel and High-Level Radioactive Waste."
- 78 FR 3853; July 17, 2013. "Retrievability, Cladding Integrity and Safe Handling of Spent Fuel at an Independent Spent Fuel Storage Installation and During Transportation."
- COMSECY-10-0007 "Project Plan for the Regulatory Program Review to Support Extended Storage and Transportation of Spent Nuclear Fuel," ML101390216.
- Draft ISG-2, Revision 2, "Fuel Retrievability in Spent Fuel Storage Applications," ML15239A695.
- Final draft ISG-2, Revision 2, "Fuel Retrievability in Spent Fuel Storage Applications," ML16019A128.
- FRN requesting public comment (78 FR 3853) & comments, ML15110A370.
- ISG-2, Revision 1, "Fuel Retrievability," ML100550861.
- ISG-2, Revision 0, "Fuel Retrievability"

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References

- NUREG-1536, Revision 1, “Standard Review Plan for Spent Fuel Dry Cask Storage Systems at a General Facility,” ML091060180.
- NUREG-1567, Revision 0, “Standard Review Plan for Spent Fuel Dry Storage Facilities,” ML003686776.
- NUREG-1927, Revision 0, “Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel,” ML111020115.
- NUREG/CR-7198, “Mechanical Fatigue Testing of High-Burnup Fuel for Transportation Applications,” ML15139A389.
- Response to Stakeholder Comments on the Final Draft of ISG-2, Rev. 2, ML16019A134.
- SECY-01-0076, “Retrievability of Spent Fuel from Dry Storage Casks.”
- Summary of Public Meeting on July 27, 2011: “Enhancements to Licensing and Inspection Programs,” ML113000303.

References

- Summary of Public Meeting on August 16, 2012: “Meeting to Obtain Stakeholder Feedback on Enhancements to the Licensing and Inspection Programs for Spent Fuel Storage and Transportation,” ML12261A069.
- Summary of Public Meeting on July 29, 2015: “Public Meeting on Retrievability of Spent Fuel at an Independent Spent Fuel Installation,” ML15216A272.
- Summary of Public Meeting on October 29, 2015: “Public Meeting on the Draft Interim Staff Guidance (ISG) 2, Revision 2: Fuel Retrievability Under 10 CFR Part 72,” ML15317A259.

Abbreviations

- ACRS – Advisory Committee on Reactor Safeguards
- AMP – Aging Management Program
- CFR – Code of Federal Regulations
- CoC – Certificate of Compliance
- FRN – Federal Register Notice
- GTCC – Greater than Class C
- ISFSI – Independent Spent Fuel Storage Installation
- ISG – Interim Staff Guidance
- NWPA – Nuclear Waste Policy Act
- SSC – Structures, Systems, and Components
- TLAA – Time Limited Aging Analysis
- TS – Technical Specification

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STORAGE AND TRANSPORTATION OF HIGH BURNUP SPENT FUEL

Meraj Rahimi
Chief of Criticality, Shielding, & Risk Assessment Branch

Meeting with Advisory Committee on Reactor Safeguards
Subcommittee on Metallurgy & Reactor Fuels
Framework for Storage and Transportation of Spent Fuel
March 23, 2016

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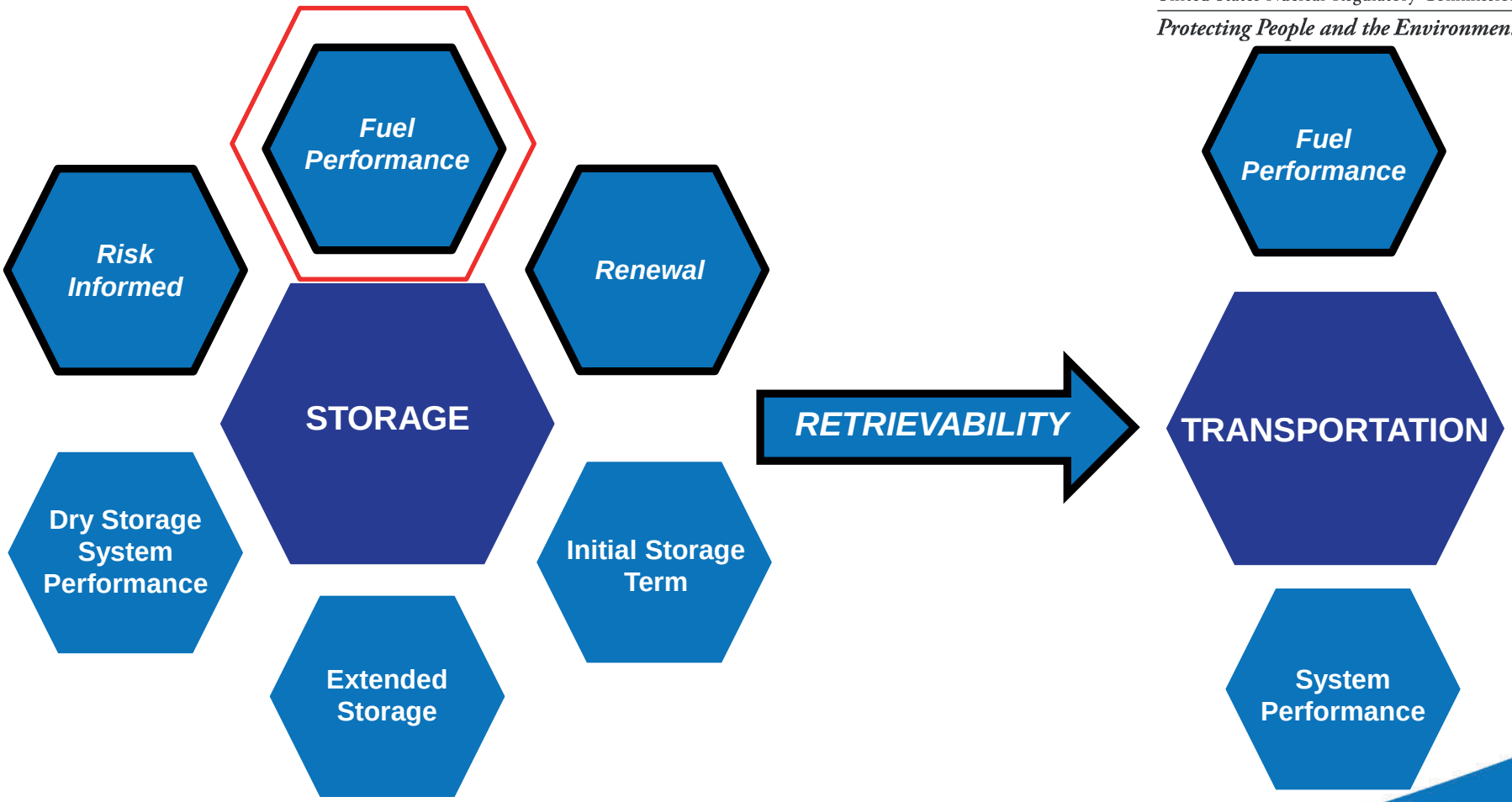
Fuel Performance
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System Performance

Background

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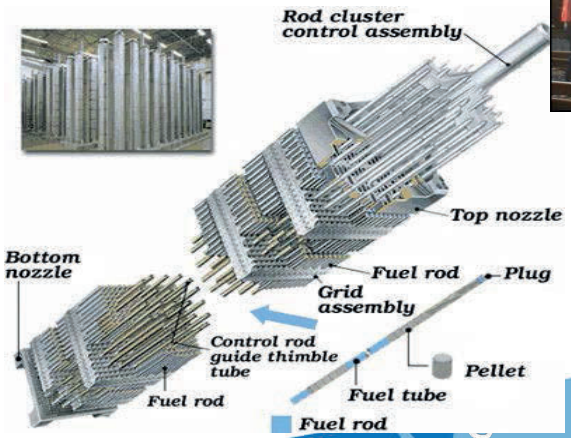
- Historically, safety analyses for design of storage casks and transportation packages have generally relied on spent fuel cladding confining fuel in as-loaded geometry inside casks and packages under normal and accident conditions



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Requirements for Storage (10 CFR 72)

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- Normal/Off Normal/Accident Conditions
  - Dynamic and thermal loads from normal fuel loading into casks, draining, drying, transfer to pad, and extreme ambient conditions
  - Human errors, out-of-tolerance equipment, equipment failure, instrumentation failure, vent blockage
  - Cask drop and tipover, flood, tornado, earthquake

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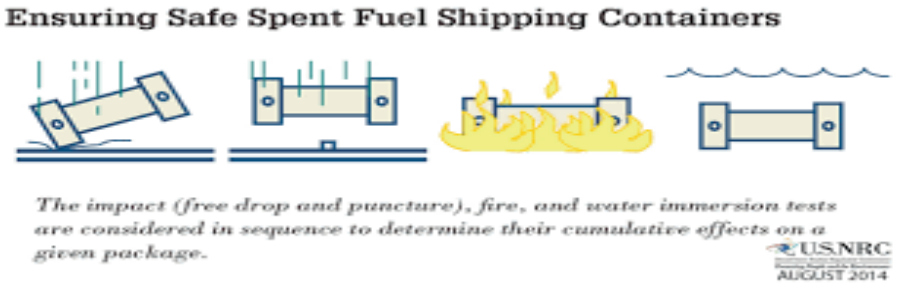
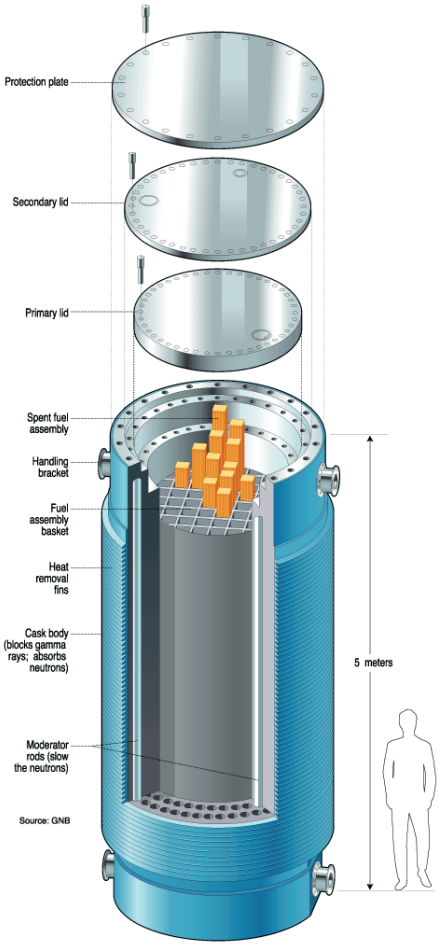
Requirements for Transportation (10 CFR 71)

- Normal/Accident Conditions
  - Dynamic and thermal loads from normal transport vibration, one-foot cask drop, and extreme ambient conditions (e.g., -40 ^{o}C)
  - 30-foot free drop, puncture, fire, and 50-foot immersion under transport accident conditions



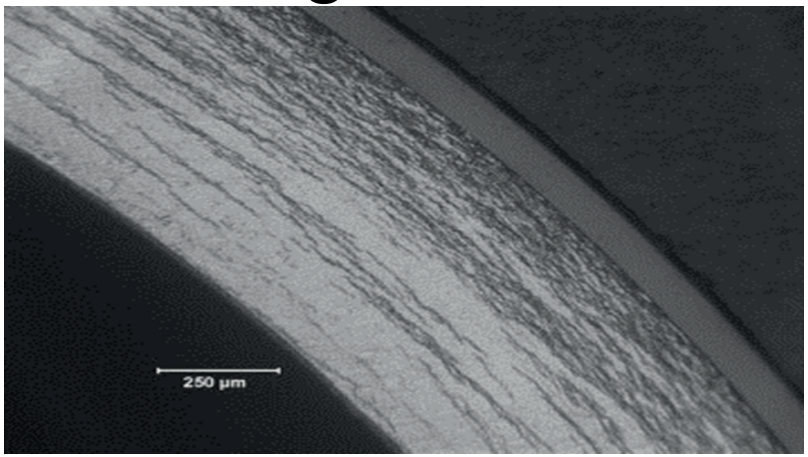
Spent Fuel Cladding Mechanical Prop.

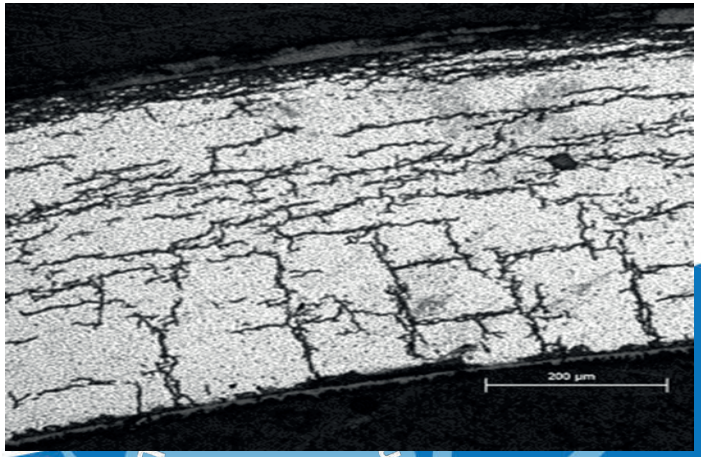
- Research (e.g., M.C. Billone, etl.) has indicated possibility of changes in high burnup (i.e.,>45 GWd/MTU) spent fuel cladding mechanical properties when subjected to cask loading conditions and subsequent long period of storage.



Hydride Reorientation

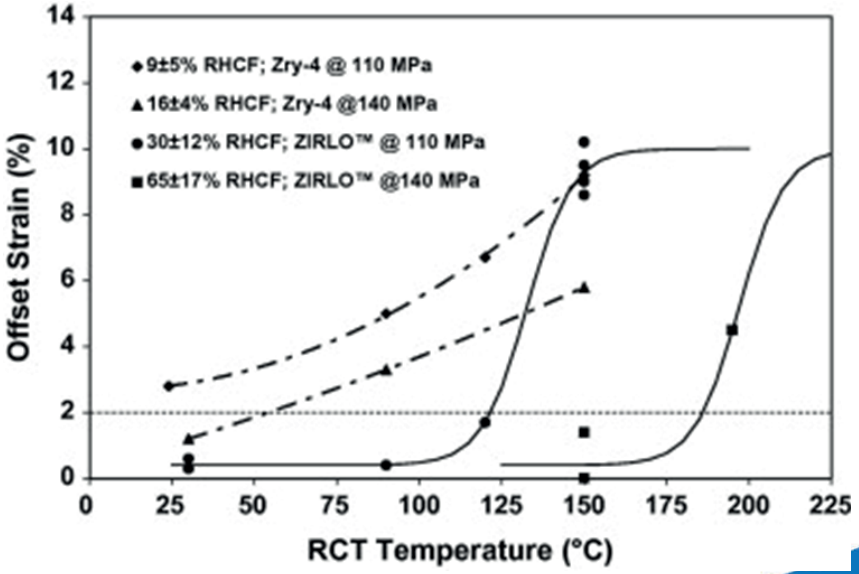
- During cask draining and drying, fuel temperature and fuel rod internal pressure increases causing hydrides in cladding to go into solution form and reorient from circumferential to radial directions during storage





Ductile To Brittle Transition Temperature (DBTT)

- Hydride reorientation results in a less ductile and more brittle of the cladding when the cladding temperature falls below a certain value after a long period in storage



Design-Basis Loads

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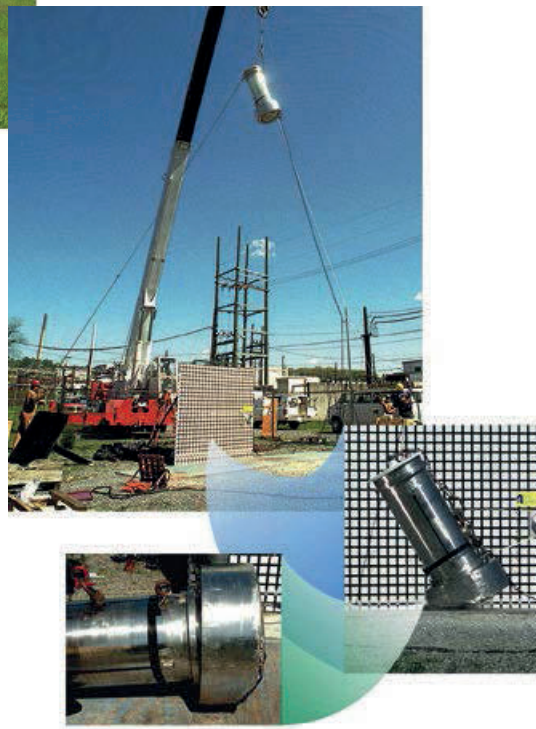
- Due to aging of high burnup fuel in storage and potential of design-bases loads during transportation (e.g., vibration, impact), high burnup fuel cladding integrity needs to be considered



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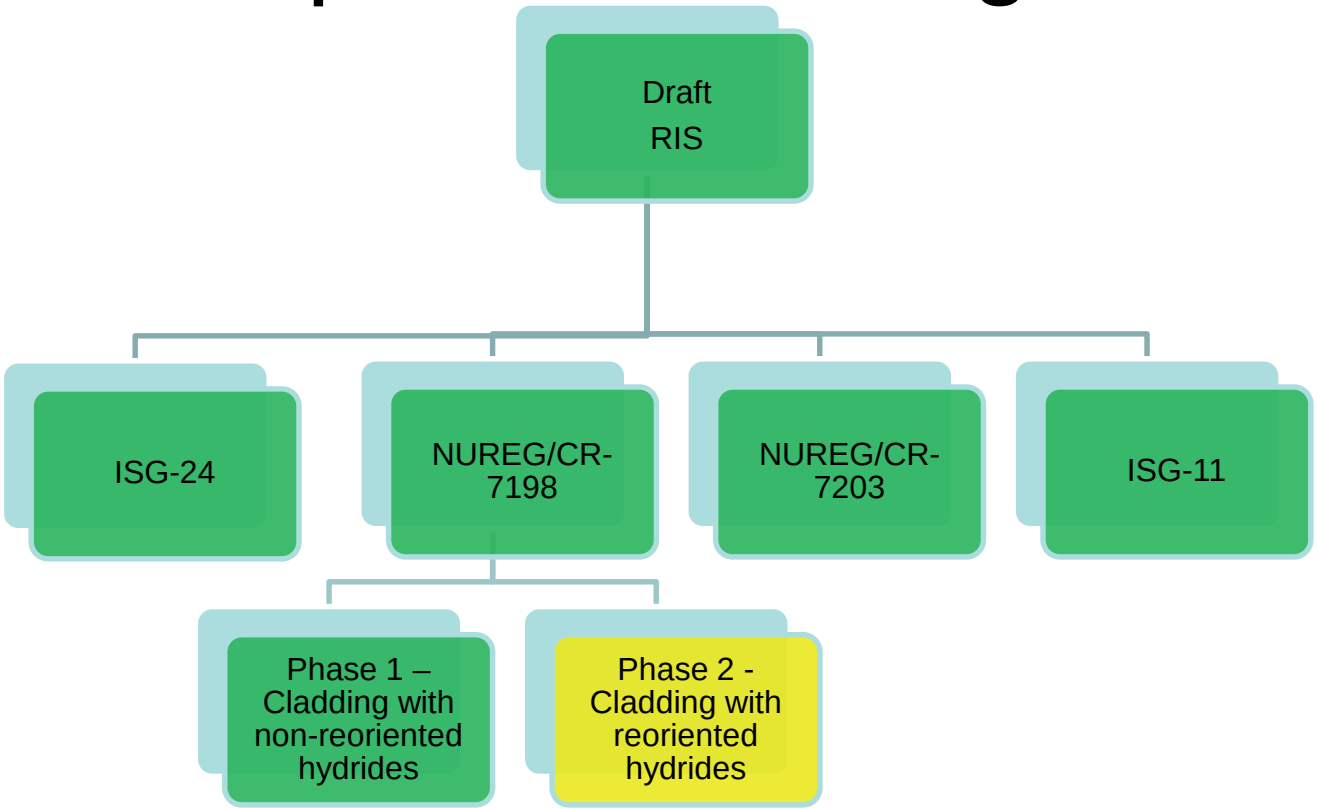
Draft Regulatory Issue Summary (RIS)

- Issued in March 2015
- Provides a road map on **some** approaches acceptable to the NRC for applications containing HBF based on the research and the guidance to date.

Guidance on Storage and Transportation of High Burnup Fuel



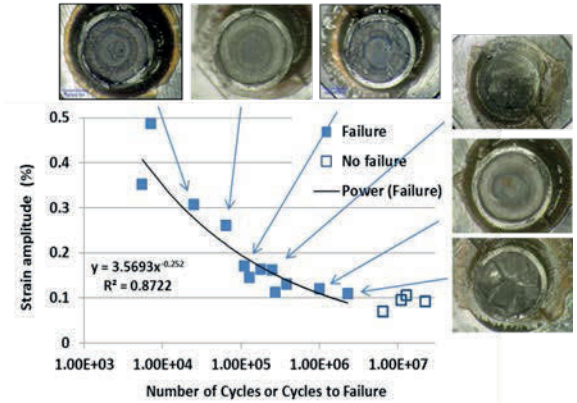
High Burnup Spent Fuel Storage and Transportation NUREG

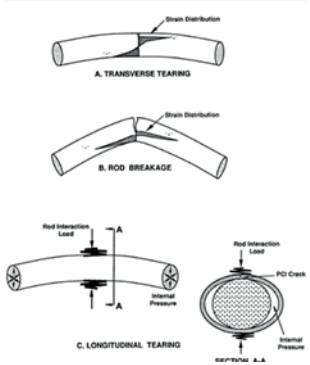
Interim Staff Guidance (ISG)

- ISG-11, Rev. 3
  - "Cladding Considerations for the Transportation and Storage of Spent Fuel"
- ISG-24, Rev. 0
  - "Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years"

NRC-Sponsored Research

- "Mechanical Fatigue Testing of High-Burnup Fuel for Transportation Applications," NUREG/CR-7198
- A Quantitative Impact Assessment of Hypothetical Spent Fuel Reconfiguration in Spent Fuel Storage Casks and Transportation Packages," NUREG/CR-7203





Cyclic Integrated Reversible-Bending Fatigue (CIRF) Tester

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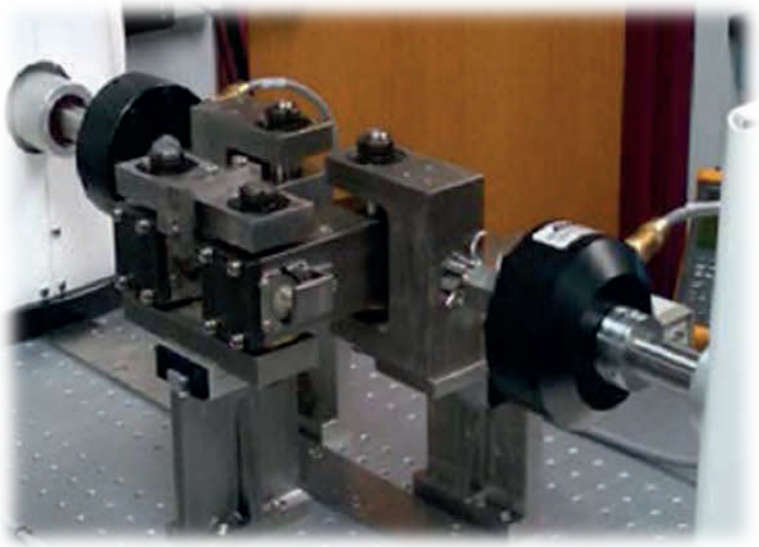
- How does the presence of fuel impact the flexural rigidity (bending stiffness) of the fuel rod?
- How does the presence of fuel impact the failure strain of the cladding?
- How many cycles to failure for high burnup fuel rods at a range of elastic strain levels.
- Will radial hydrides impact the bending stiffness or fatigue life of high burnup fuel rods?



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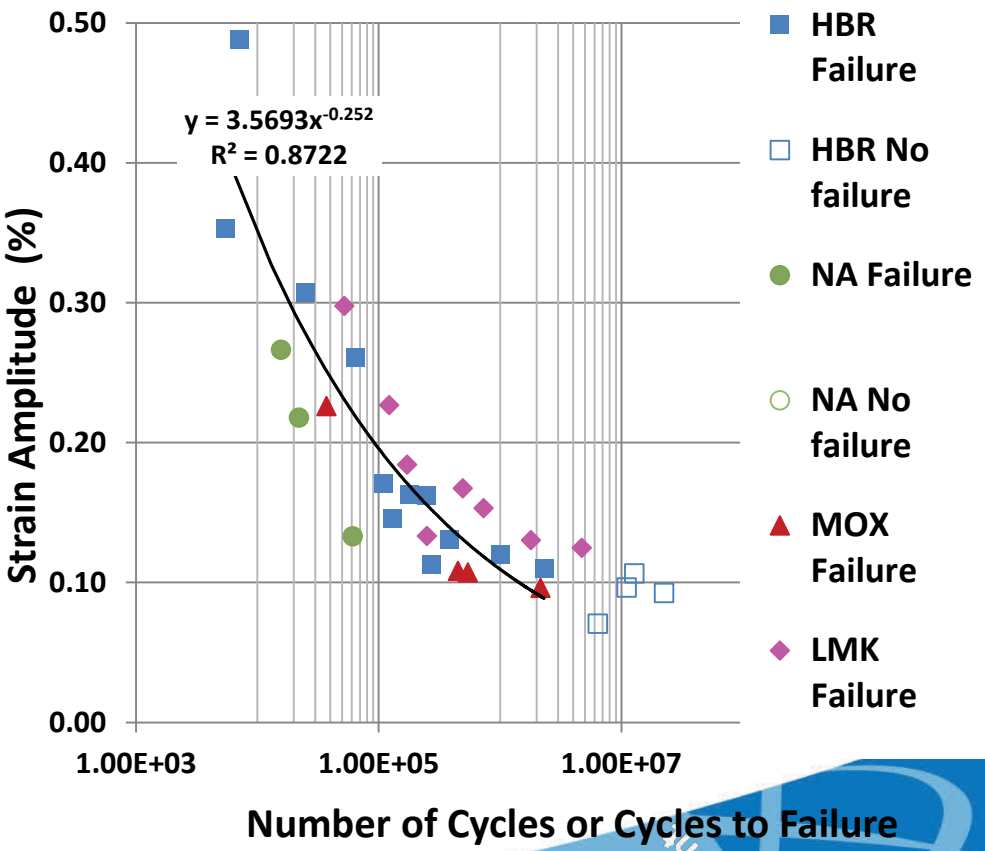
CIRF Tester (cont.)

- PWR Spent Nuclear Fuel (SNF) with Zircaloy-4 Cladding
- Burnup ranged from 63.8 to 66.8 GWd/MTU

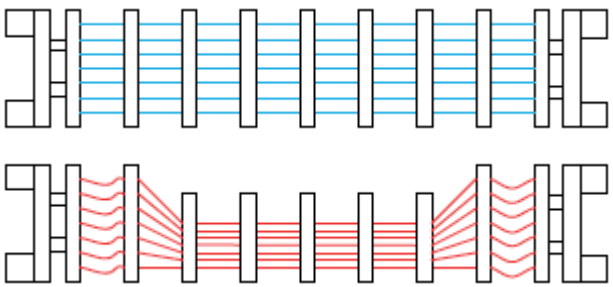
- Phase 1 test (non-reoriented HBF samples) program
  - Static bend tests have been completed on 4 samples
  - Vibration fatigue tests have been completed on 16 samples, at a wide range of bending moment amplitudes

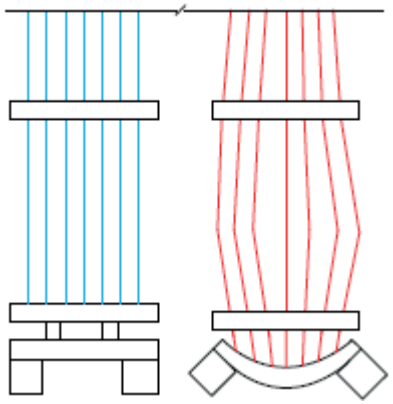
- Phase 2 test (reoriented HBF samples) program
  - Static bend tests will be performed on 1 or more sample
  - Vibration fatigue tests will be performed on 3 or more samples, at a range of bending moment amplitudes



Spent Fuel Reconfiguration Study

- Three categories of reconfigurations
  - Cladding Failure
  - Rod/assembly deformation
  - Axial alignment
- Consequences
  - Criticality
  - Shielding
  - Containment
  - Thermal





Spent Fuel Reconfiguration Study

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- The reconfiguration scenarios involving cladding failure and fuel axial relocation exhibited the largest impact in the technical disciplines evaluated
  - Criticality: <5% Δk_{eff} increase for plausible scenarios
  - Shielding: <3x difference between intact and 25% redistributed fuel
  - Containment and Thermal: allowable leakage rate and decay heat are decay-time dependent so consequences associated with geometry changes may be offset by the longer storage times
    - Equivalent allowable leakage rates for PWR failed fuel fractions of 0.03, 0.10, and 0.15 and BWR failed fuel fractions of 0.03, 0.4, and 0.7 at 5-, 40-, and 100-year decay times
  - Thermal: basket temperature increase ~130 C from nominal and cask surface temperature ~10C Redistribution of the thermal energy source term within the canister can alter the heat transport paths from the fuel to the canister wall.
- The consequences associated with cladding failure for the criticality and shielding technical disciplines are very sensitive to the modeling assumptions, and will be strongly dependent on canister- and assembly-specific characteristics.

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Next Steps

- Issue final RIS – December 2016
- Issue draft NUREG on HBF – September 2016
- Issue final NUREG on HBF – July 2017

References

- MC Billone, TA Burtseva, and MA Martin-Rengel, and RE Einziger,"Ductile-to-brittle transition temperature for high-burnup cladding alloys exposed to simulated drying-storage conditions," J. Nucl. Mater. 433 (2013) 431-448
- RIS 2015-XX, Considerations in Licensing High Burnup Spent Fuel in Dry Storage and Transportation
- SG 11, Cladding Considerations for the Transportation snd Storage of Spent Fuel, Revision 3.
- ISG-24, The Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years, Revision 0.
- NUREG/CR-7198, Mechanical Fatigue Testing of High-Burnup Fuel for Transportation Applications
- NUREG/CR-7203, A Quantitative Impact Assessment of Hypothetical Spent Fuel Reconfiguration in Spent Fuel Storage Casks and Transportation Packages

Acronyms

- DBTT – Ductile to Brittle Transition Temperature
- RIS – Regulatory Issue Summary
- ISG – Interim Staff Guidance
- CIRF – Cyclic Integrated Reversible-Bending Fatigue
- HBF – High Burnup Fuel
- HBR – H.B. Robinson
- NA – North Anna
- MOX – Mixed Oxide
- LMK - Limerick

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» Backup Slides

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HBF Storage

Uncanned fuel

Dry Storage up to 20 years

Normal, Off-normal, and Accident Conditions

No deviation from current licensing approach

Dry Storage beyond 20 years

Normal, Off-normal Conditions*

or

TEST DATA

A demonstration cask program in accordance with Interim Staff Guidance (ISG)-24, "The Use of a Demonstration Program as Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years"

ANALYSIS

Confirm that the initial assumptions on fuel conditions remain valid
+
Perform, as part of defense-in-depth, safety analysis assuming 1% fuel failure for normal conditions, 10% for off-normal conditions, or other justifiable values

Accident Conditions

Available materials data?

Yes

TEST DATA

Perform structural analyses using appropriate materials property data

No

ANALYSIS

Perform safety analysis with reconfigured fuel assuming 100% fuel failure or another justifiable value

Canned fuel

Normal, Off-normal, and Accident Conditions

Demonstrate structural performance of the can used for damaged fuel. Perform safety analysis with fuel reconfiguration confined to the boundary of the fuel can

**This approach is valid provided results from the demonstration cask as described confirm the original fuel condition licensing assumptions.*

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*If minimum fuel temperature is above the ductile-to-brittle transition temperature (DBTT), then fuel can be treated as directly shipped from pool

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HBF Transportation

Uncanned fuel

Direct shipment from the pool

Normal Conditions of Transport and Hypothetical Accident Conditions

Use guidance in ISG-11, "Cladding Considerations for the Transportation and Storage of Spent Fuel," to determine the maximum cladding temperature and verify the minimum temperature that maintains ductility of the cladding

Fuel that has been in dry storage*

Normal Conditions of Transport

Available materials data?

- Yes: **TEST DATA** — Perform structural analyses using appropriate materials data
- No: **ANALYSIS** — Perform safety analysis assuming 3% fuel failure, or another justifiable value

Confirm fuel meets content specified in the Certificate of Compliance prior to and after transport

Hypothetical Accident Conditions

Available materials data?

- Yes: **TEST DATA** — Perform structural analyses using appropriate materials data
- No: **ANALYSIS** — Perform safety analysis with reconfigured fuel assuming 100% fuel failure, or another justifiable value

Canned fuel

Normal Conditions of Transport and Hypothetical Accident Conditions

Demonstrate structural performance of the can used for damaged fuel. Perform safety analysis with fuel reconfiguration confined to the boundary of the fuel can.

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Risk-Informed Application for Dry Cask Storage Systems

Donald Chung, PhD
Meeting with Advisory Committee on Reactor Safeguards
Subcommittee on Metallurgy & Reactor Fuels
Framework for Storage and Transportation of Spent Fuel
March 23, 2016

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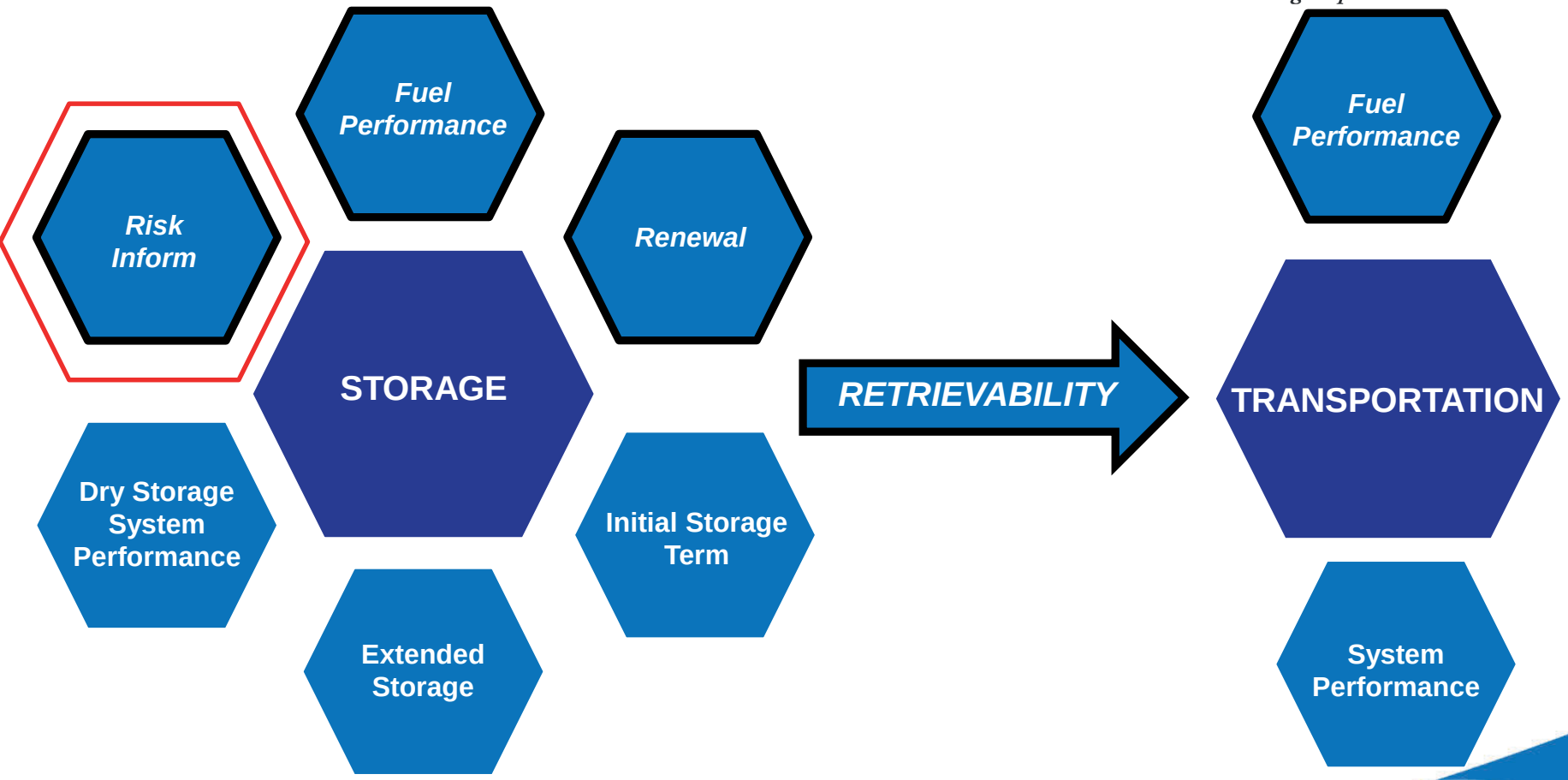

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Risk-Informed Decision-Making at The US NRC

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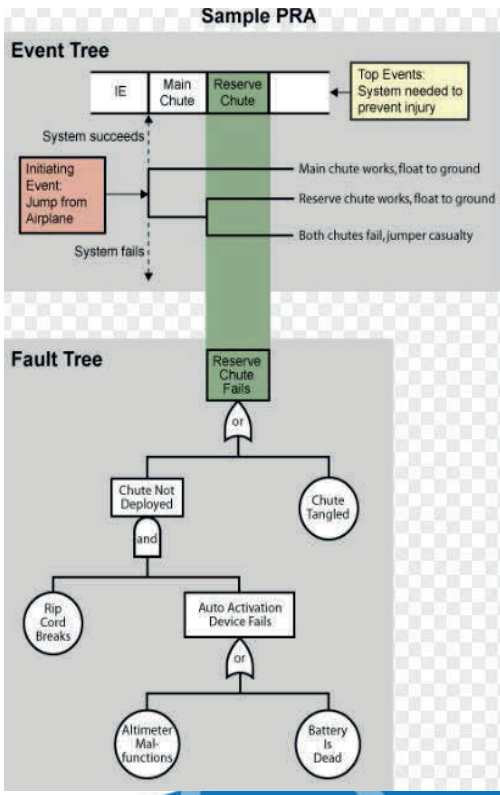
- Commission has a long standing policy on increasing the use of Probabilistic Risk Assessment (PRA) approaches.
- Risk-informed decisions are extensively used in licensing and oversight activities for operating reactors.
- PRA modeling/insights with Core Damage Frequency (CDF) and Large Early Release Frequency (LERF) are used as metrics for reactors.



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Background - Dry Spent Fuel Storage PRAs

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Previous PRAs of Dry Cask Storage Systems (DCSS):

- NUREG-1864, “A Pilot Probabilistic Risk Assessment of a Dry Cask Storage System at a Nuclear Power Plant” (2007).
- EPRI Report, “Probabilistic Risk Assessment of Bolted Storage Casks: Quantification and Analysis Report,” (2003).

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Latent Cancer Risk Comparison

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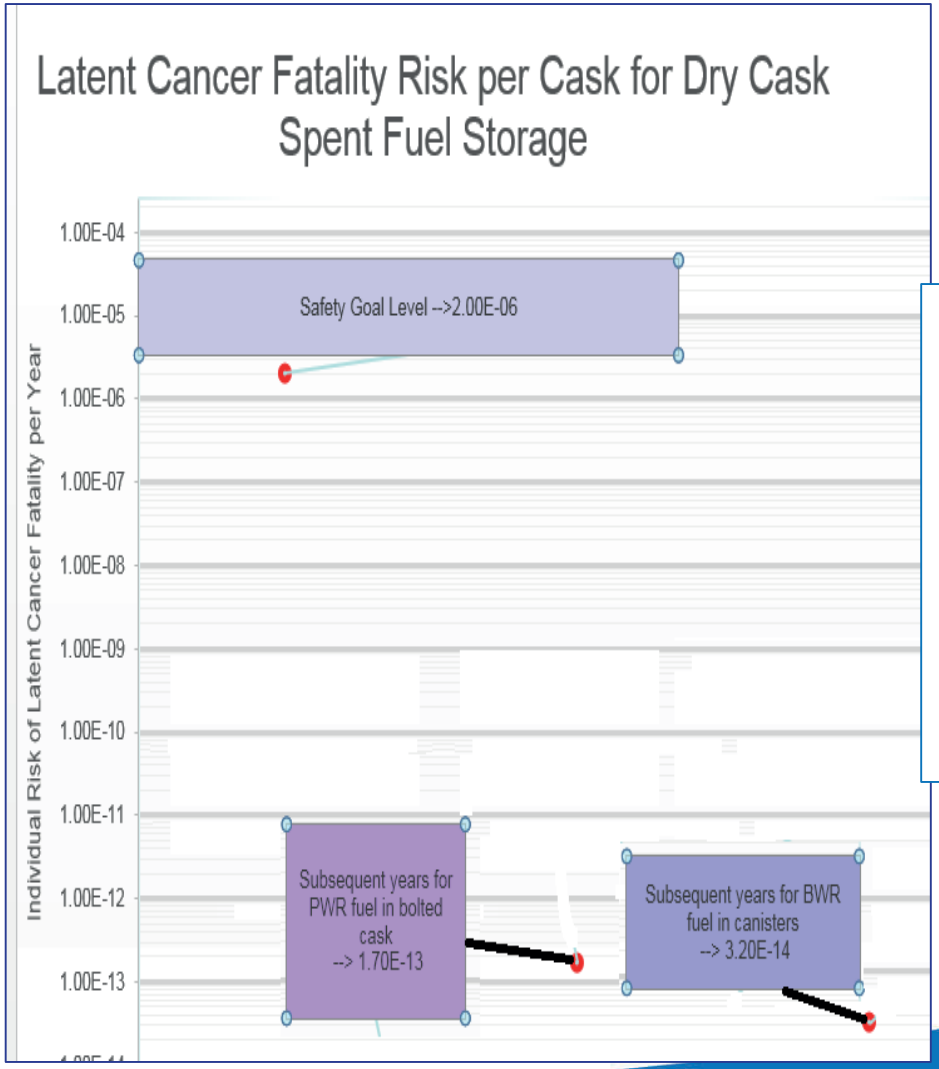
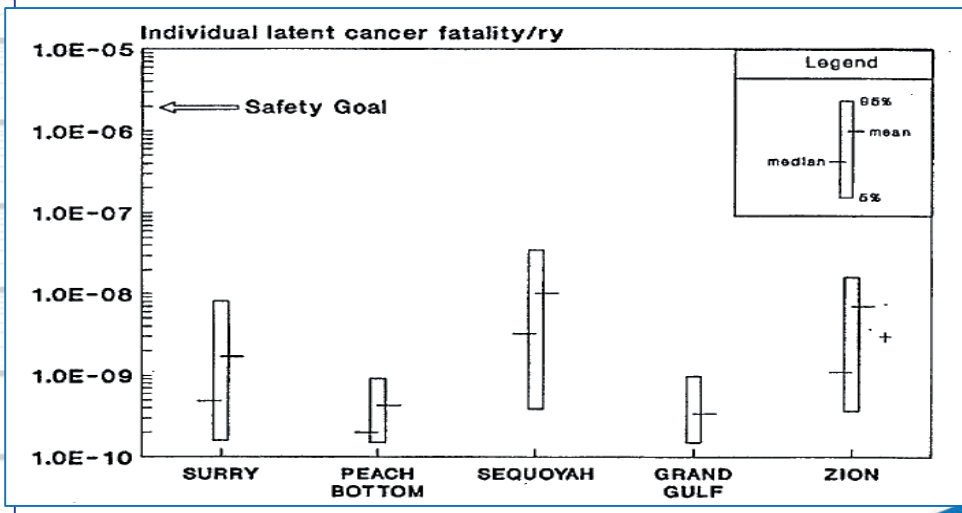
Dry Cask Storage System PRAs



NUREG-1150, "Severe Accident Risk, An Assessment for Five U.S. Nuclear Power Plants"



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What has Changed Since The Last PRA Studies

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- Increase storage duration to beyond just 20 years.
- Aging issues - Chloride-induced Stress Corrosion Cracking (CISCC)
- New information on manufacturing defects
- Data on spent fuel canister misloads
- Additional data on human error during cask preparation
- Historical data (20 years) indicating no detectable release from existing ISFSI

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Objective of Risk-Informing Dry Cask Storage Systems

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- Better focus regulatory efforts.
- Be prepare to evaluate changes in risk.
- Establish decision metric (confinement breach frequency) for assessing risk significance.
- If PRA results continue to indicate very low risk, staff could re-examine criteria for dry storage safety requirements.

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Phases of Operation

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1. Cask/canister loading and preparation
2. On-site Transport
3. Storage in Independent Spent Fuel Storage Installation (ISFSI)
4. Cask/canister transfer

Safety Functions Required in for DCSS

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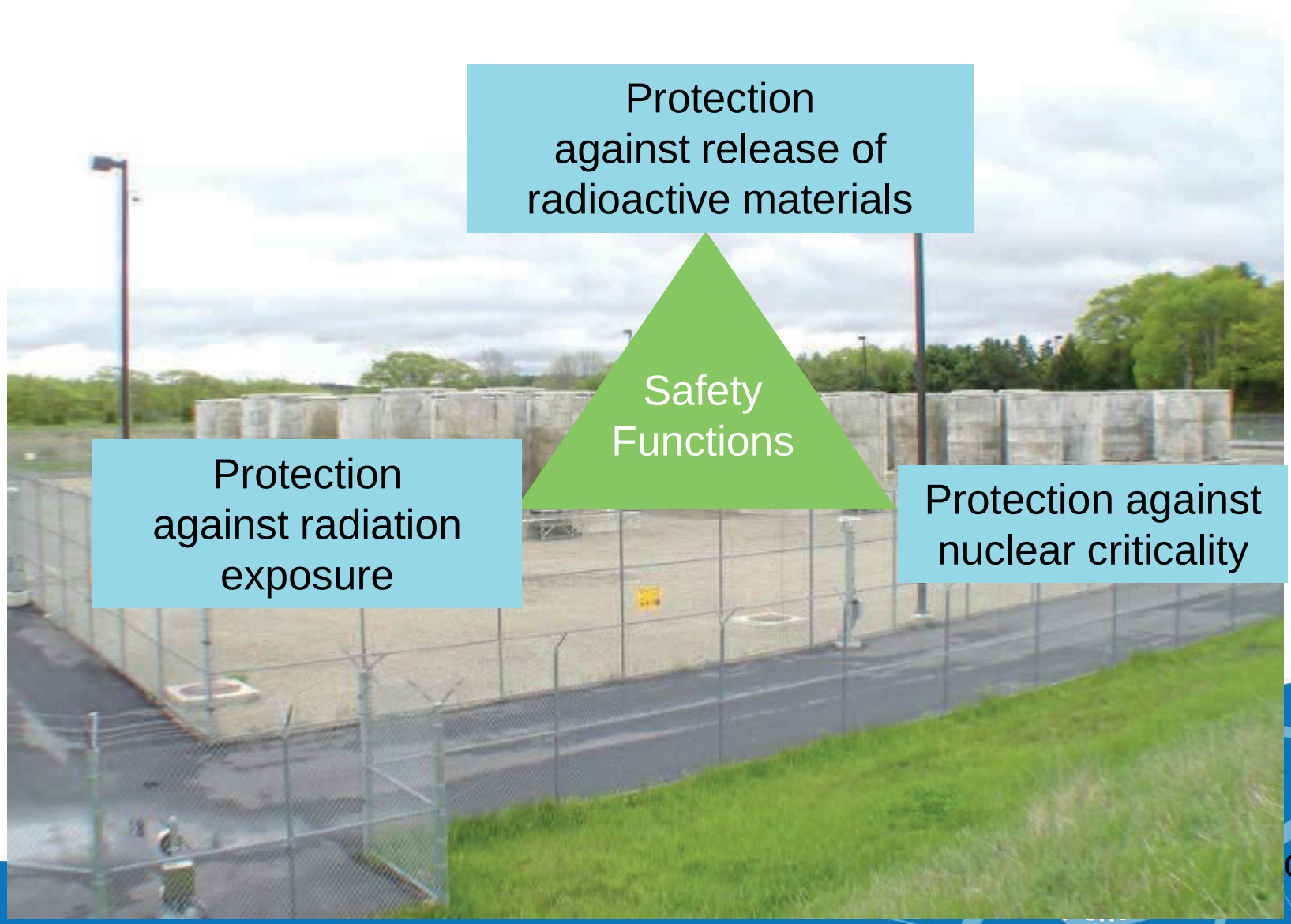

Defense-in-Depth
Three levels of safety

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Level 1, Prevention
(10 CFR 72, CoC, SRP, AMP, MAPS)
- Prevent release of radioactive material
- Prevent criticality
- Limit radiation exposure

Level 2, Mitigation
- Accident assessment
- Perform remedial actions
- Perform Repair

Level 3, Emergency Actions
(10 CFR 72.32, Emergency Plan)
- Accident detection/assessment
- Notification
- Protective response

Dry Storage System
Vertical Dry Cask Storage Systems

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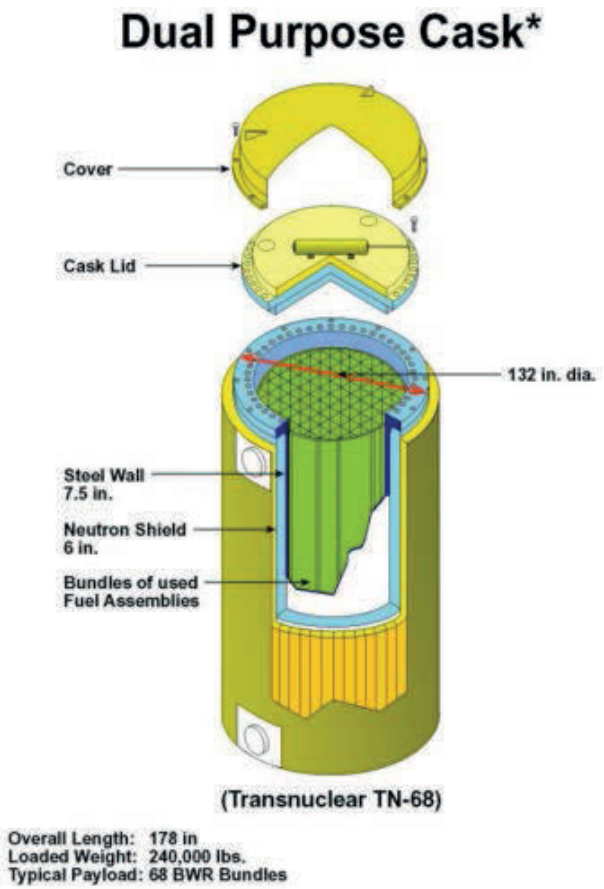

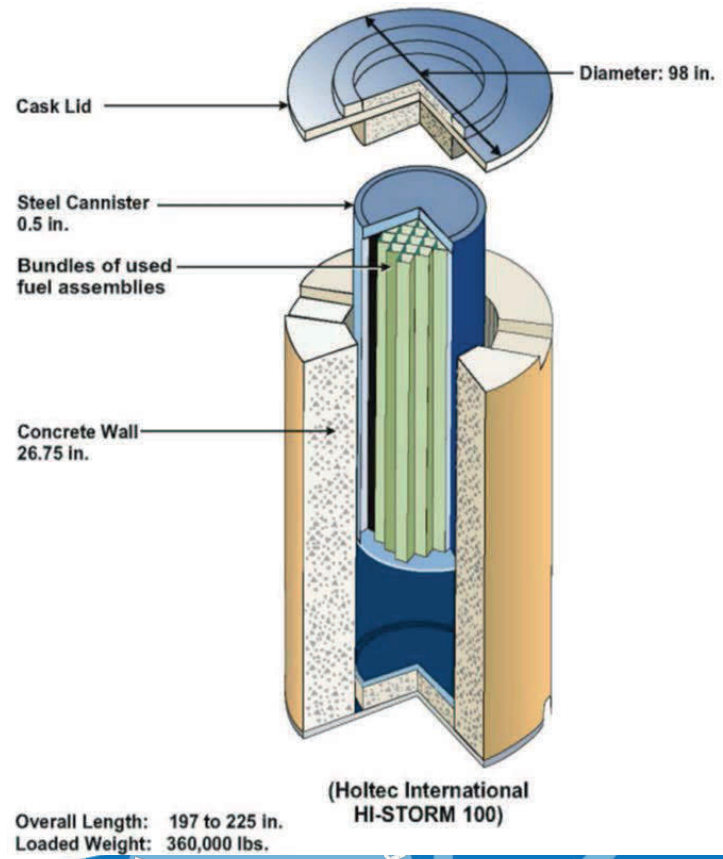

- HOLTEC HI-Storm 100 Cask System with MPC
- Dual Purpose Cask TN-XX
- MAGNASTAR

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Dry Storage System
Horizontal Dry Cask Storage System

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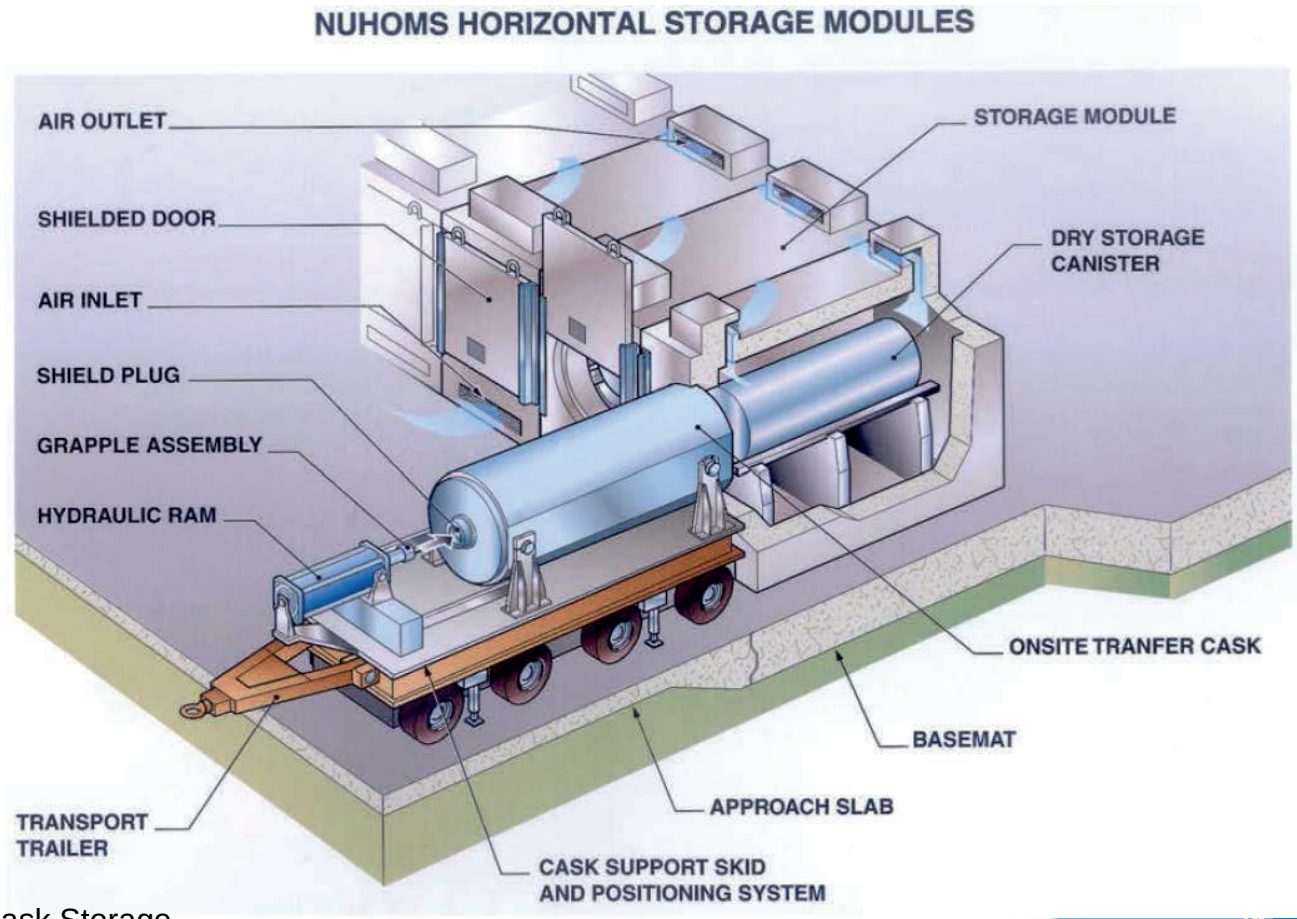

NUHOMS Dry Cask Storage
- Horizontal storage module
- Dry shielded canister

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Dry Storage System
Underground Dry Cask Storage Systems

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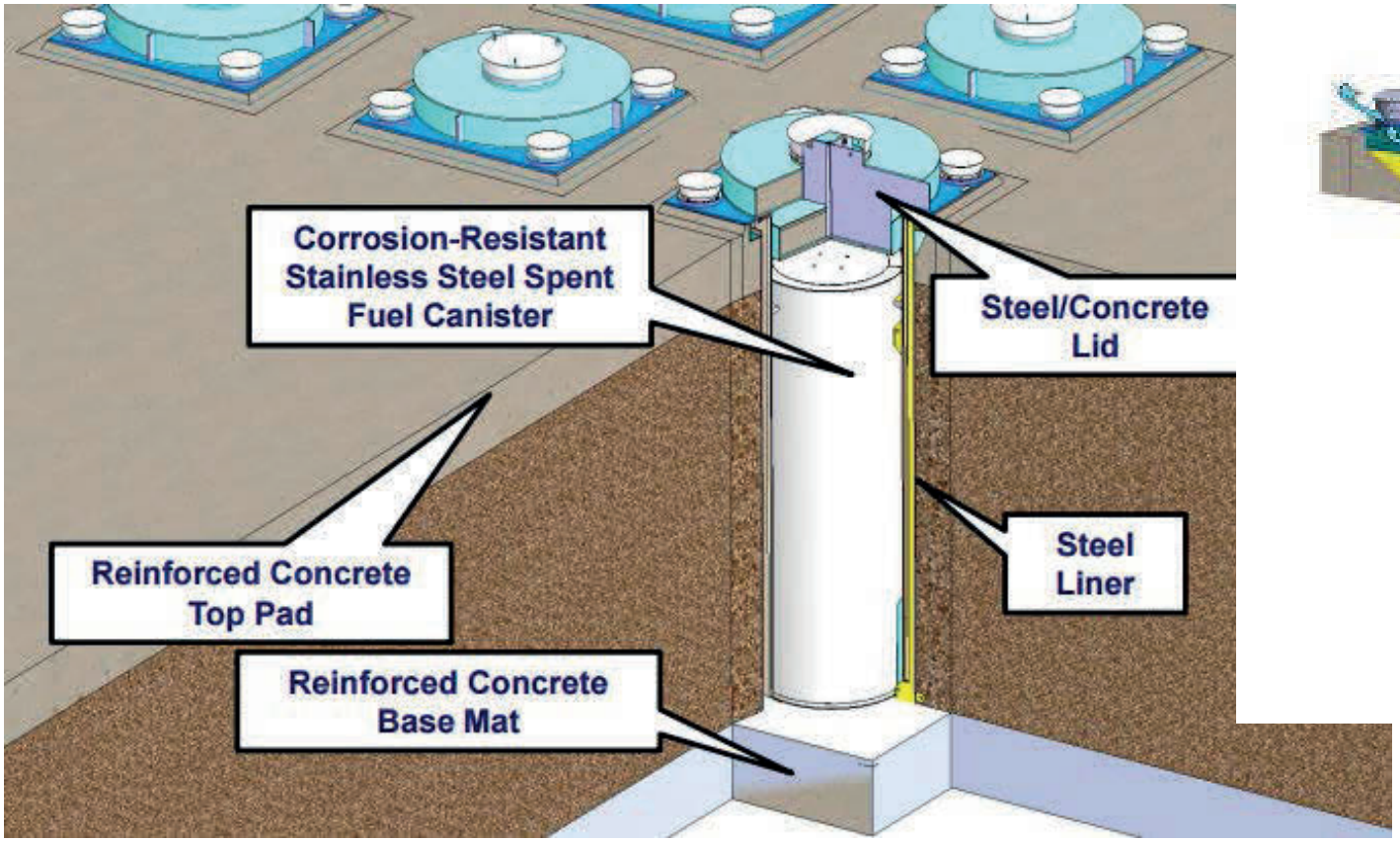

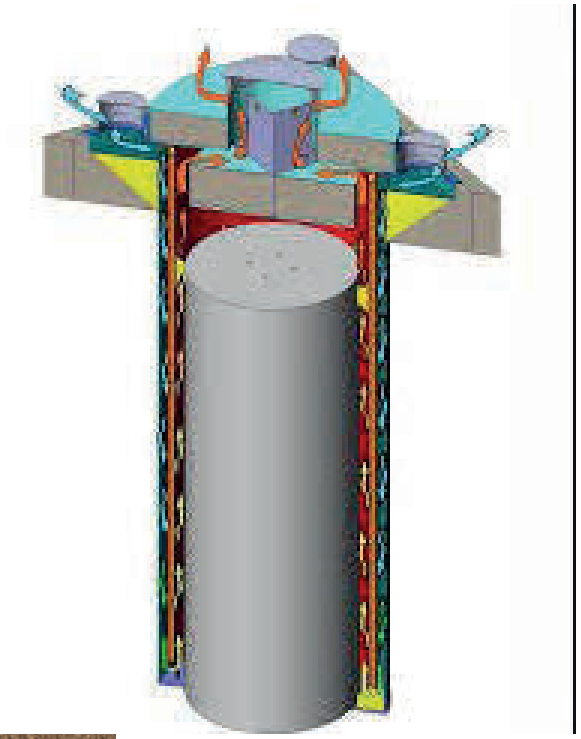

- HI-STORM UMAX
- HI-STORM 100U

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Proposed Risk-Informed Regulatory Framework

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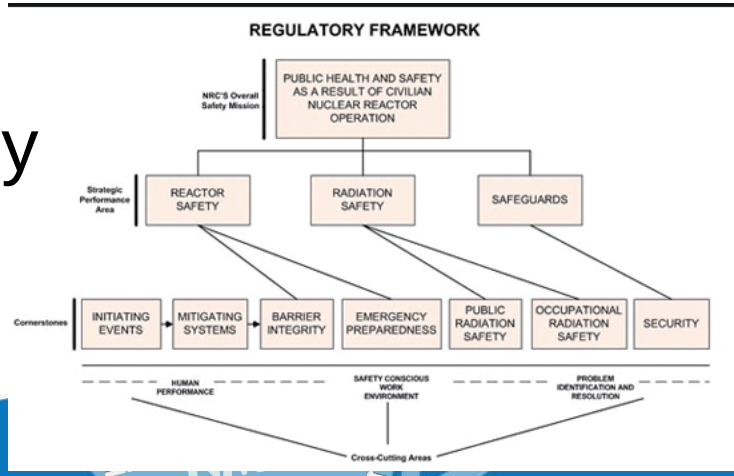
- Generic framework for all DCSS
- Adopt *Confinement Breach frequency* (CBF) as the metric for risk
- Set a CBF limit for storage in ISFSI. (Numerical Guidance)
- Propose risk-informed regulatory guidance. (Decision Metrics)

Quantitative Safety Goals of the U.S. NRC (August, 1986)

Quantitative Health Objective (QHOs)

Early and latent cancer mortality risks to an individual living near the plant should not exceed 0.1 percent of the background accident or cancer mortality risk, approximately 5×10^{-7}/year for early death and 2×10^{-6}/year for death from cancer.

- The prompt fatality goal applies to an average individual living in the region between the site boundary and 1 mile beyond this boundary.
- The latent cancer fatality goal applies to an average individual living in the region between the site boundary and 10 miles beyond this boundary.



CBF as Metric for Risk-Informing DCSS

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Reasons for selecting Confinement Breach Frequency (CBF) as the metric for risk:

- Precursor to release of radionuclides;
- Indicator of risk to Workers
- Indicator or risk for environmental contamination

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Dry Storage System PRAs

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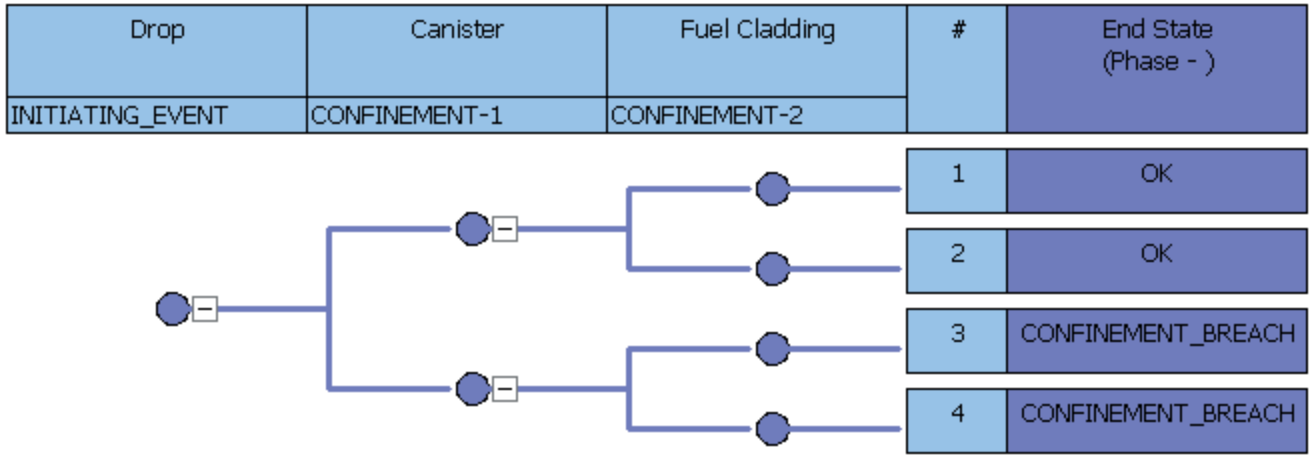

Confinement Breach Frequency = Frequency of Initiating Event X Probability of Canister Failure X Probability of Fuel Cladding Failure

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Dry Storage System PRAs - continued

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Initiating Events:

- Mechanical Events
  - Accidental drops or tip-overs
  - Seismic event
  - Water currents during a flood
  - Strikes from heavy objects
  - Shockwaves from explosions
- Thermal events
  - Vent blockage
  - Lightning
  - Fire from aircraft fuel

NUREG-1536, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility".

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Dry Storage System PRA - Continued

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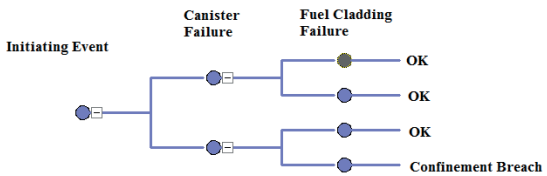
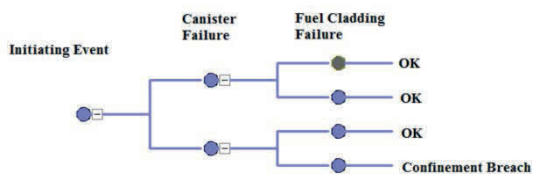
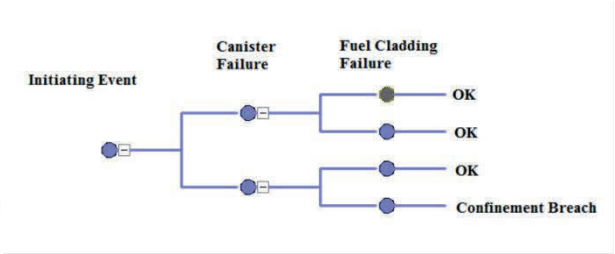
Drop



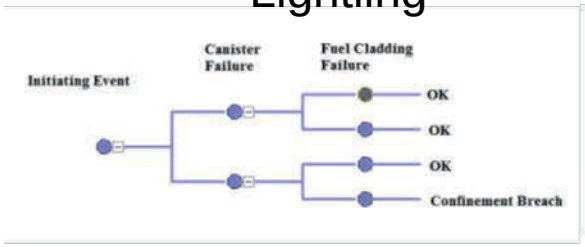
Tornado



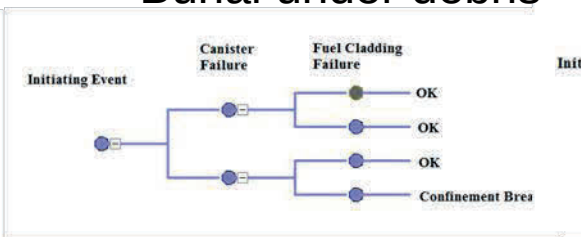
Earthquake



Lightling



Burial under debris



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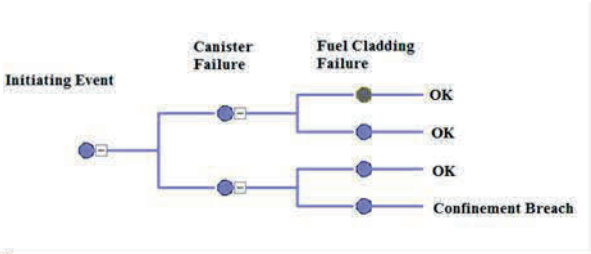


CBF =

CBF(flood) + CBF(tornado) +CBF(earthquake)+CBF(lightning)+CBF (burial)+CBF(other)

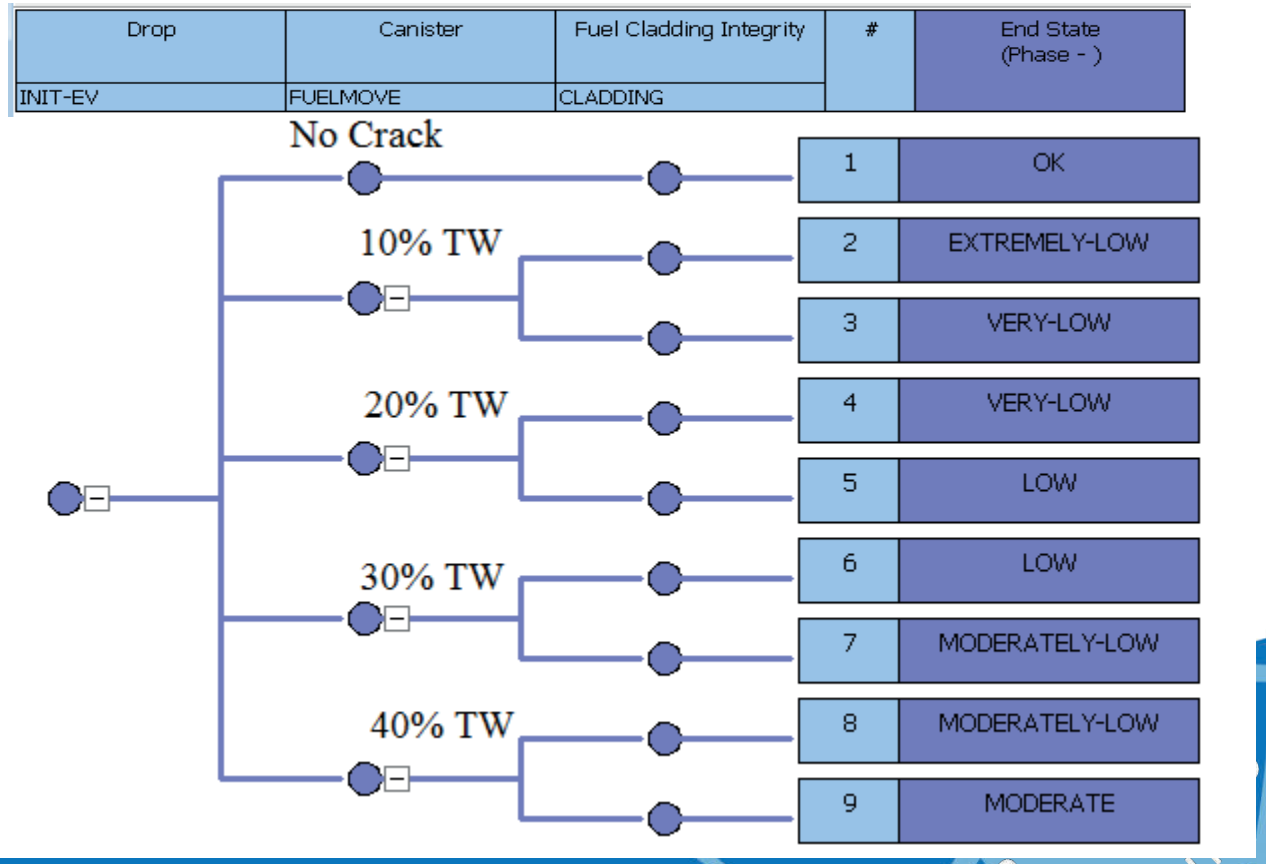
NUREG-1536, “Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility”.

NMSS Division of Spent Fuel Management

Dry Storage System PRA - continued

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

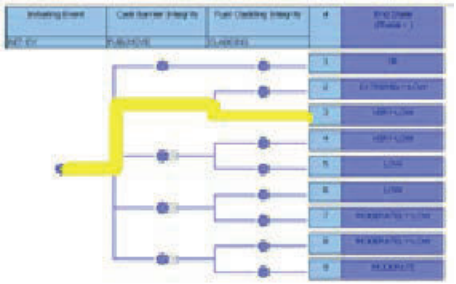
What is the increase in MPC CBF for an mechanical event if there is a partial through-wall (TW) crack?



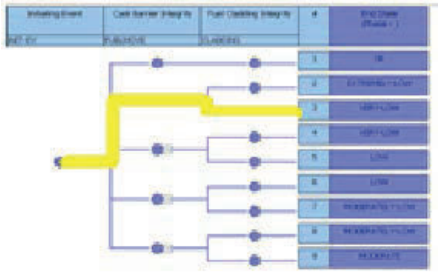
Dry Storage System PRA - continued

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

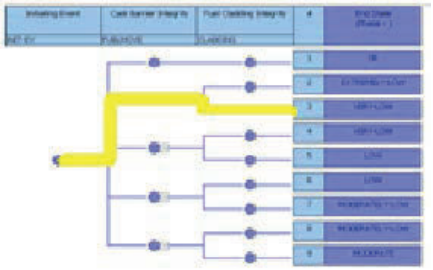
Drop



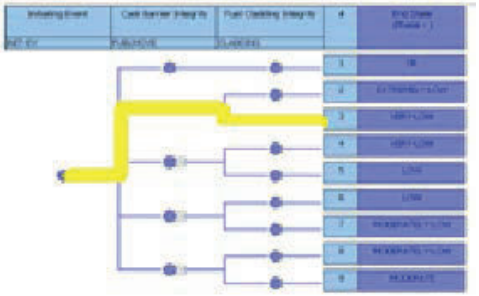
Tornado



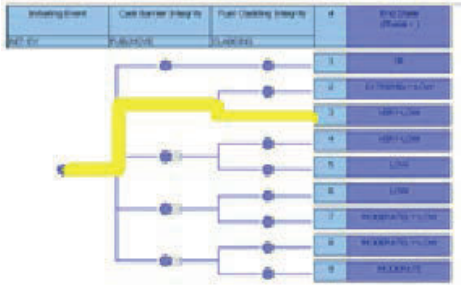
Earthquake



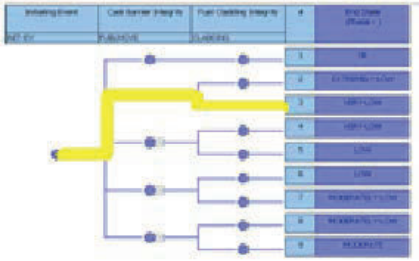
Lightning



Burial Under Debris



Other



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Numerical Guidelines for DCSS

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Based on Commission Safety Goal Policy definition of "negligible risk"
- Based on NMSS Quantitative Health Guideline (QHG) defining "negligible risk" as less than 2.0E-06/yr.* additional cancer fatality.
- CBF for QHG, needs to be evaluated by a level 3 PRA consequence assessment. (e.g., Less than 5.5 E-03/yr.**)

*Risk-Informed Decisionmaking for Nuclear Material and Waste Application, Revision 1, February 2008.
**Based on consequence calculation from NUREG-1864.

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Proposed Decision Metric for Risk

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Decision Metric should:

- supports evaluation of quantitative changes in DCSS risk.
- provide basis for assessing acceptable changes in risk.

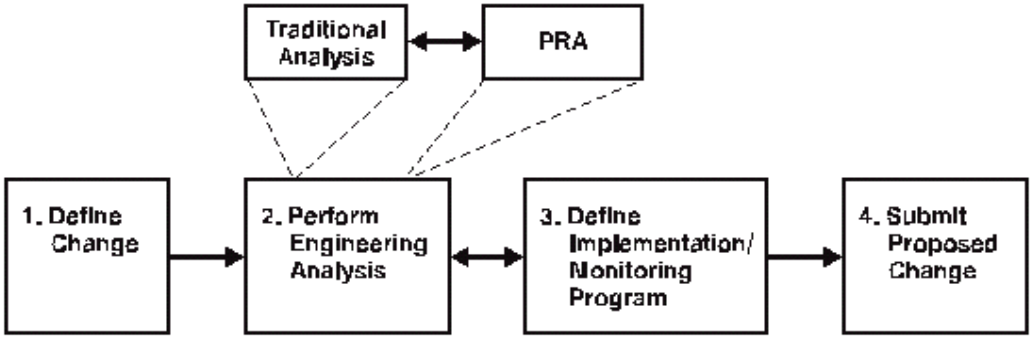

Figure 2. Principal Elements of Risk-Informed, Plant-Specific Decisionmaking

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Proposed Decision Metric for Risk-Informing Dry Cask Storage -continued

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Proposed guidance for decision metric is taken from the example in RG 1.174*.
- Specific requirements may be relaxed if the initial risk is already low and the incremental increases from a change are also small.

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

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Proposed Decision Metric for Risk-informing Dry Cask Storage - continued

U.S.NRC
United States Nuclear Regulatory Commission
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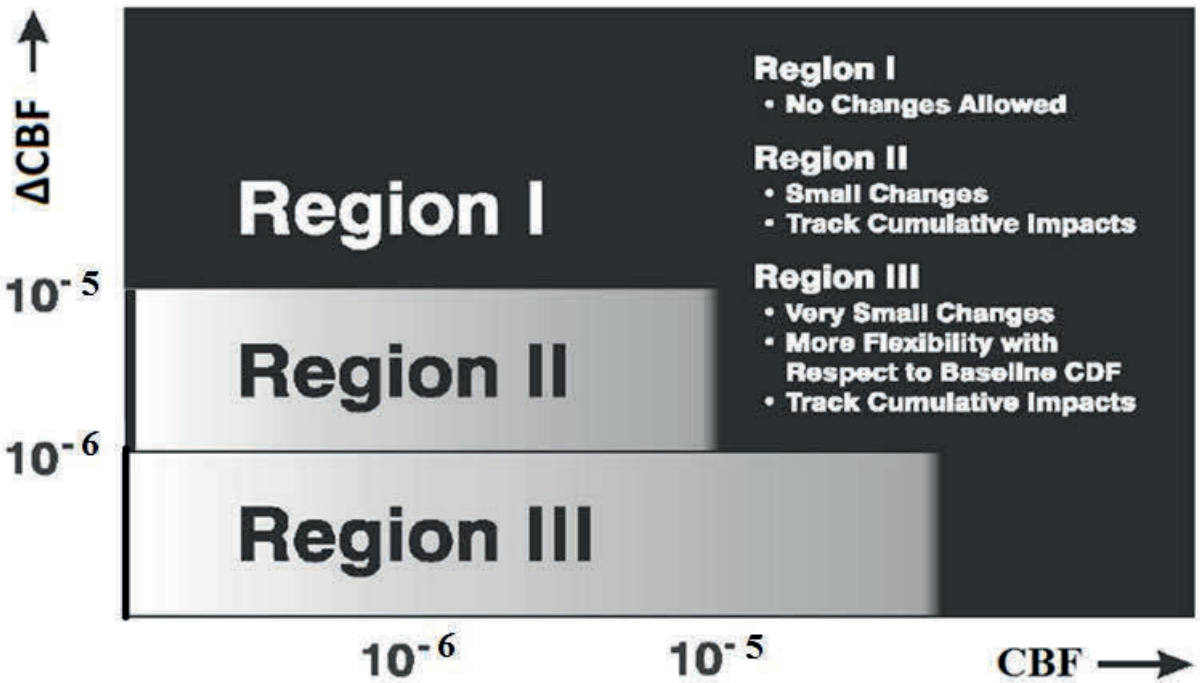

*Adopted from RG 1.174, An Approach for Using PRA in Risk-Informed Decisions on Plant-Specific Changes to Licensing Basis.

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Information Needed for Risk-Informing Decisions

U.S.NRC
United States Nuclear Regulatory Commission
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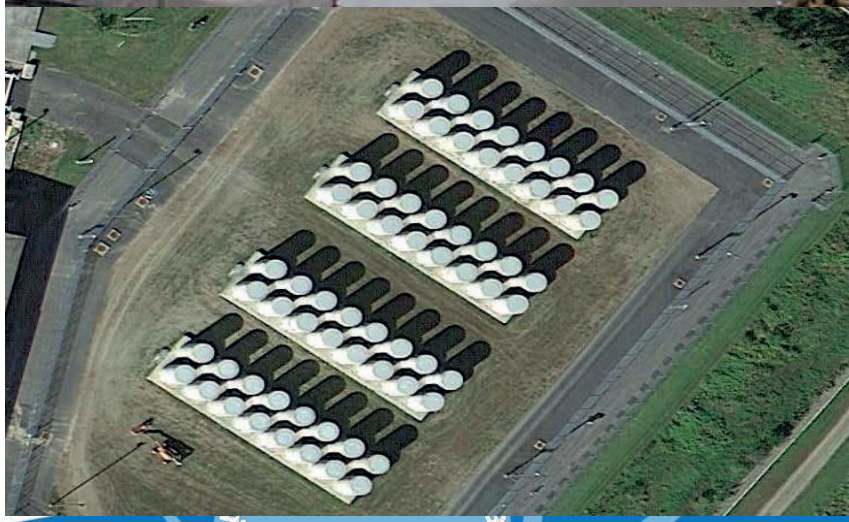
- aging affects during storage,
- canister failure probabilities for accidents
- Level 3 PRA evaluation of consequences
- common cause failure,
- uncertainties



Options for Going Forward

U.S.NRC
United States Nuclear Regulatory Commission
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- Option 1: Develop the required PRA information to support risk-informed framework.
- Option 2: Consider adopting a deterministic risk framework for DSS, since risk is significantly lower than for reactors.

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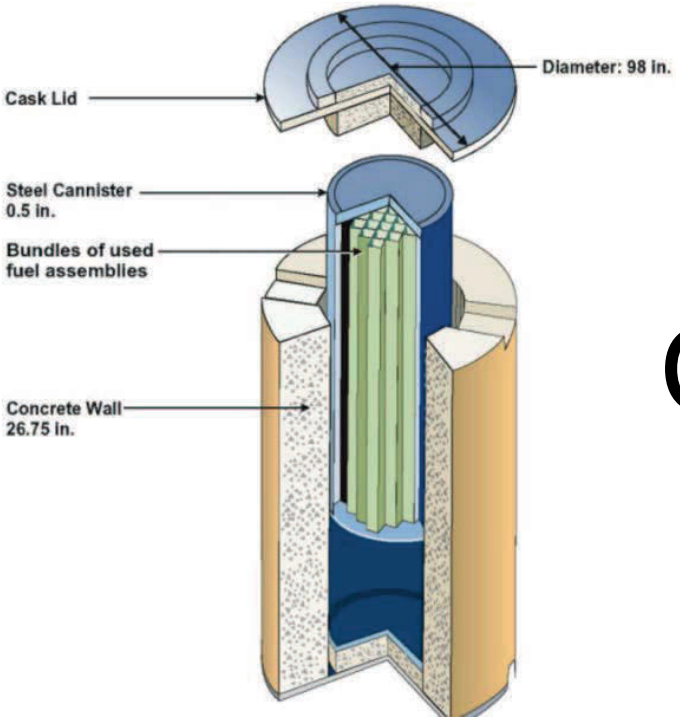
Cask Lid
Diameter: 98 in.
Steel Cannister
0.5 in.
Bundles of used
fuel assemblies
Concrete Wall
26.75 in.

Questions?

References

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- EPRI 1009691, “Probabilistic Risk Assessment (PRA) of Bolted Storage Casks, Updated Quantification and Analysis Report,” 2004.
- NUREG-1150, ”Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants,” 1990.
- NUREG-1536, “Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility,” Revision 1, 2010.
- NUREG-1864, “Pilot PRA of Dry Cask Storage System At a Nuclear Power Plant,” 2007.
- NUREG-1927, “Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance,” 2011.
- NUREG-2150, “A Proposed Risk Management Regulatory Framework,” 2012.
- RG-1.174, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis.”
- “Risk-Informed Decisionmaking for Nuclear Material and Waste Applications,” Revision 1, 2008, Office of Nuclear Regulatory Research, Office of Nuclear Material Safety and Safeguards.

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Abbreviations

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

AMP	aging management activity
CBF	confinement breach frequency
CDF	core damage frequency
CFR	Code of Federal Regulations
CISCC	chloride-induced stress corrosion cracking
CoC	certificate of compliance
DCSS	dry cask storage system
EPRI	Electric Power Research Institute
ISFSI	independent spent fuel storage installation
LERF	large early release frequency
MPC	multi-purpose canister
NMSS	Nuclear Material Safety and Safeguard
QHG	Quantitative Health Guideline
PRA	probabilistic risk assessment
MPC	multi-purpose canister
SRP	Standard Review Plan
TW	through-wall

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Risk from Spent Fuel

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United States Nuclear Regulatory Commission
Protecting People and the Environment

One 35 year-old unshielded fuel assembly at 35 feet distance:

dose rate = 30 rem per hour

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Industry Perspectives: Ongoing Storage and Transportation Research

Keith Waldrop
Principal Technical Leader

Advisory Committee on Reactor Safeguards
Meeting of the Subcommittee on Metallurgy & Reactor Fuels
Framework for Storage and Transportation of Spent Fuel
Rockville, MD
March 23, 2016

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Main Research and Development Areas (1/2)

- Storage
  - Wet Storage:
    - Spent Fuel Pool Criticality - Full Burnup Credit
    - Neutron absorber materials performance (BORAL)
  - Dry Storage
    - Extended storage (>60 years)
      - Extended Storage Collaboration Program (ESCP)
        - Fosters global collaborative research
      - Aging management
        - Susceptibility of stainless steel canister to chloride-induced stress corrosion cracking (CISCC)
      - High-burnup (>45 GWd/MTU) Fuel Performance
        - Collect data on high burnup fuel in dry storage (with US DOE)

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Main Research and Development Areas (2/2)

- Transportation
  - Properties of advanced claddings after long-term storage
    - Hypothetical accident conditions
    - Normal conditions
  - Full Burnup Credit
- Disposal
  - Little to no involvement at this time
  - Monitoring ongoing DOE and international activities

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Aging Management of Dry Storage Systems

Chloride-Induced Stress Corrosion Cracking of Stainless Steel Canisters

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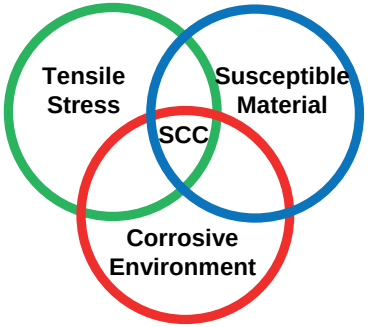
Aging Management of Dry Storage Systems

- Initial steps to perform a literature review and a Failure Modes and Effects Analysis (FMEA)
- FMEA identified **Chloride-Induced Stress Corrosion Cracking (CISCC)** as the most likely of potentially active degradation mechanisms to lead to through wall penetration
- CISCC of stainless steel *reactor* components has occurred when all three elements are present:
  - Elevated stress
  - Susceptible Material
  - Corrosive Environment
    - Surface contamination by atmospheric chlorides
    - Sufficient humidity



- EPRI has a multi-year project to
  - Develop aging management guidelines specific to CISCC
  - Develop and Demonstrate Inspection Capability

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Stainless Steel Canister Degradation Aging Management

Results of literature survey, FMEA, and flaw grow & tolerance assessment are utilized in:

- Susceptibility Assessment Criteria
  - Define site conditions and canister parameters associated with earlier potential for CISCC initiation and growth
  - Allow ranking of canisters to set priorities for inspection and other aging management efforts
  - Limited guidance on use of ranking criteria to identify canisters that are considered “bounding”; will be expanded in aging management guidance
- Probabilistic Confinement Integrity Assessment
  - Predicts cumulative probability of canister leakage due to CISCC over time; results reported on a relative scale where the “base case” value is set to 1
  - Compares results for various alternate inspection regimes to the “base case”
  - Includes sensitivity studies to understand the impacts of assumptions in the “base case”
- Aging Management Guidelines for CISCC
  - Integration of all these pieces into guidance
  - Key reference and input for ASME in-service inspection criteria being developed

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Stainless Steel Canister Degradation Aging Management

- Literature Review of Environmental Conditions and Chloride-Induced Degradation Relevant to Stainless Steel Canisters in Dry Cask Storage Systems
  - Published May 2014, EPRI# 3002002528
- Failure Modes and Effects Analysis (FMEA) of Welded Stainless Steel Canisters for Dry Cask Storage Systems
  - Published December 2013, EPRI# 3002000815
- Flaw Growth and Flaw Tolerance Assessment
  - Published October 2014, EPRI# 3002002785
- Susceptibility Assessment Criteria for CISCC of Welded Stainless Steel Canisters
  - Published September 2015, EPRI# 3002005371
- Aging Management Guidance to Address Potential CISCC
  - Will include Probabilistic Confinement Integrity Assessment
  - Planned Publication November 2016, EPRI #3002008193
- Dry Cask Storage Welded Stainless Steel Canister Breach Consequence Analysis Scoping Study
  - Planned Publication December 2016, EPRI #3002008192

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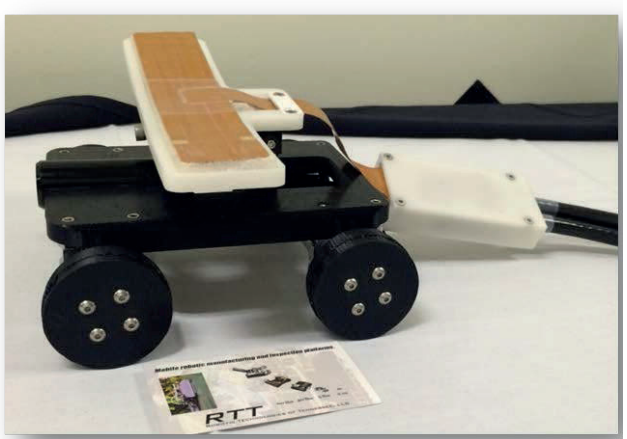
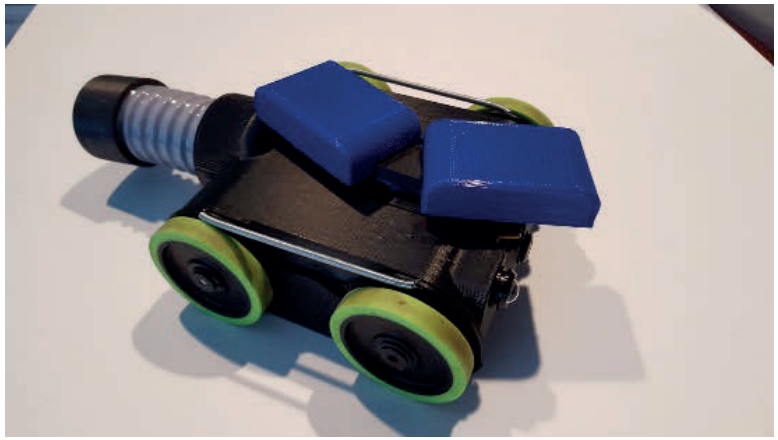
Stainless Steel Canister Inspection Capability

- EPRI is focusing on 4 main areas
  - Collaborations
  - Mockups
  - Nondestructive Evaluation (NDE) Technologies
  - Delivery Systems
- Goal is to <u>demonstrate</u> NDE techniques with a functional delivery system in 2017





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Cladding Behavior in High Burnup Fuel

High Burnup R&D Project (Extended Storage Demonstration, with DOE)

Performance of Advanced Cladding Materials during Extended Storage

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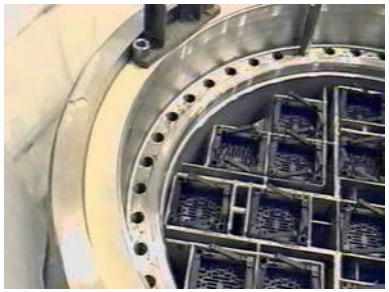
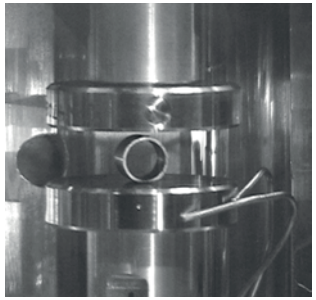
High Burnup R&D Project
Background



- Technical basis for Low Burnup fuel:
  - Based on demonstration with low burnup fuel
    - No evidence of degradation after 14 years
    - Still significant creep life left in cladding
- Technical basis for High Burnup (HBU) fuel:
  - Based on lab testing
    - Testing showed hydrides in clad can reorient during dry storage loading operations; can lead to loss of ductility
    - Bounding conditions of testing allowed guidance for licensing HBU fuel (ISG-11 Rev.3 – Limit peak clad temperature to 400°C)
    - Storage licenses limited to 20 years
    - Transport licenses very limited and restricted



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High Burnup R&D Project

Motivation

- Lack of data on HBU fuel under actual dry storage conditions
- Repeat earlier low burnup demo using high burnup fuel
  - Provide data on behavior of multiple types of HBU cladding under typical dry storage conditions
  - Provide data for benchmarking models to predict performance of HBU fuel over extended time periods
  - Supports need for data in renewed licenses for high burnup
    - Calvert Cliffs and Prairie Island
    - 10 more by 2020 (58 sites)
  - Supports future need for transport of high burnup fuel
    - US plans for consolidated storage in 2020s
    - International needs for transport of HBU fuel (e.g. Spain)

~20% of casks loaded in US contain HBU fuel

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High Burnup R&D Project

Overview

- Develop and implement the Final Test Plan
- Complete final design
- Submit storage license application to NRC
- Identify, extract and ship sister rods to conduct non-destructive and destructive examinations (pre-characterization)
- Modify the cask lid
- Fabricate instrumentation
- Obtain storage license from NRC (tentative, pending NRC review and approval)
- Perform dry runs
- Load Cask
- Begin data collection (temperature & gas samples)

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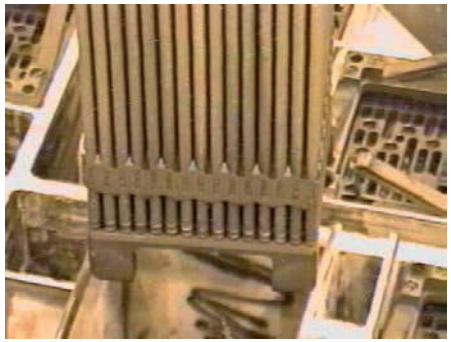
High Burnup R&D Project

Overview

- Store cask about 10 years
- Ship cask to a Fuel Examination Facility (to be provided by DOE)
- Open cask and visually examine the fuel
- Extract high burnup rods for non-destructive and destructive examinations of the rods at the national lab(s)
  - Compare end-of-storage and “t=0” cladding properties
- Option: re-close cask and continue storage; re-open again later



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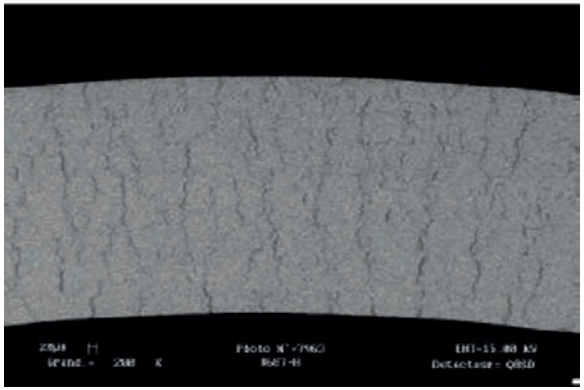
Performance of Advanced Cladding Materials (1/2)

- Issue
  - Data on “advanced” claddings (Zirlo™, Optimized Zirlo™, M5®, AXIOM, etc.) are needed to verify that the performance of these claddings will meet the regulatory requirements applicable to dry storage and transportation conditions
    - Guidance published in ISG-11 for storage of high-burnup fuel largely based on experimental data obtained on Zircaloy-4 cladding
    - Generically accepted guidance for high-burnup fuel transportation applications have not been established

Circumferential Hydrides



Radial Hydrides

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Performance of Advanced Cladding Materials (2/2)

- Actions
  - Participation in projects collecting post-irradiation data on fuel irradiated to high burnup
    - Thermal creep, Hydride Re-Orientation (HRO), Ductile-to-Brittle Transition Temperature (DBTT), Delayed Hydride Cracking (DHC)
  - Incorporation of data into cladding and fuel performance models
  - Provide active guidance to the DOE-EPRI High Burnup R&D project
- Goals
  - Resolution of regulatory issues associated with
    - Dry storage license extensions (>20 years)
    - Transportability of high-burnup fuel

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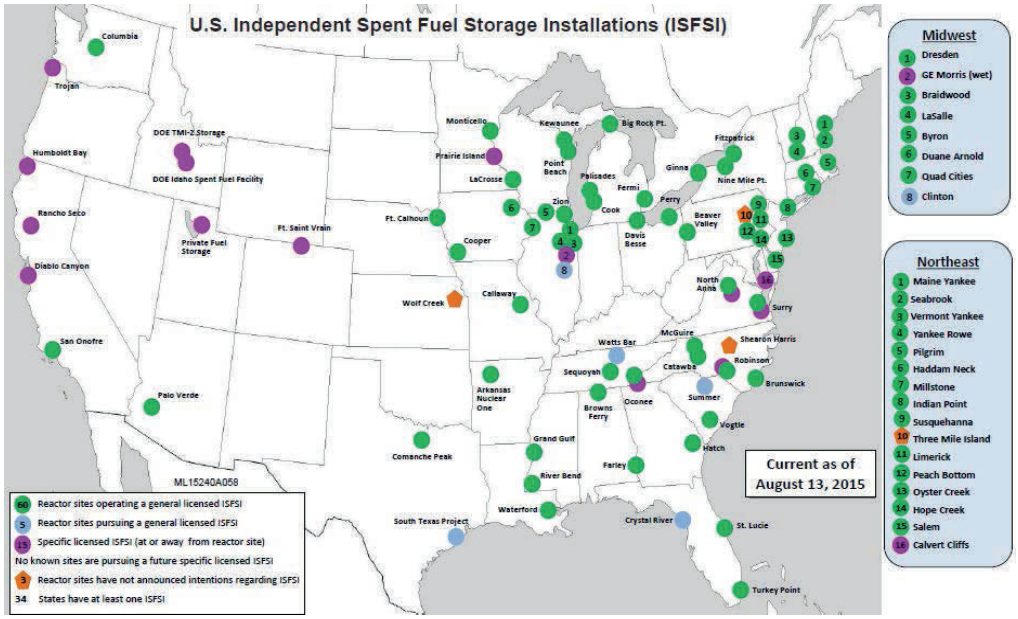
Industry Perspective on the Dry Storage Regulatory Framework

Kristopher Cummings
Nuclear Energy Institute
ACRS Subcommittee on Metallurgy and Reactor Fuels
March 23rd, 2016 • Rockville, MD

Used Nuclear Fuel in Storage in the U.S.

January 2016

- Used fuel inventory
  - Approximately 76,400 MTU
  - Increases 2 - 2.4k MTU annually
- ISFSI* storage
  - 97,843 assemblies
  - 27,726 MTU (36%)
  - 2,268 casks/modules loaded
  - 70 Operating ISFSIs
    - 1 pool ISFSI, 1 modular vault
- Projections for 2020
  - Estimating 86,000 MTU total
  - Estimating 35,000 MTU at ISFSI
  - 3,200 casks/modules loaded
  - At 76 ISFSIs
    - Almost all plant sites + Morris & INEL
  - Fuel from 119 reactors

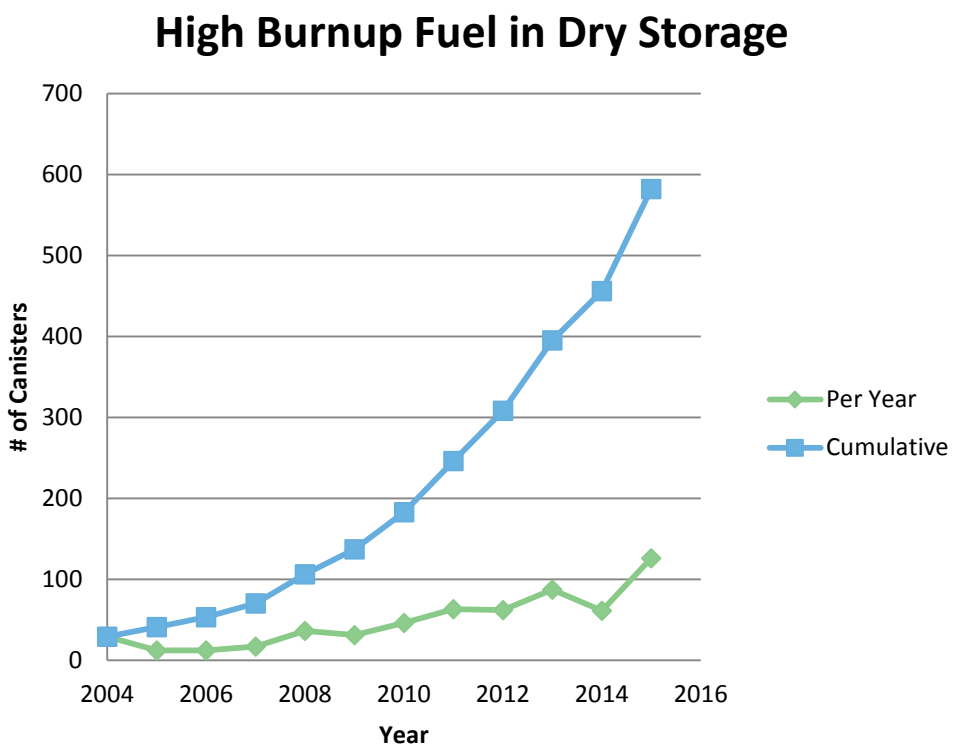


*ISFSI = Independent Spent Fuel Storage Installation

High Burnup Nuclear Fuel in Storage in the U.S.

January 2016

- ISFSI storage
  - ~9500 assemblies
  - ~600 casks/modules loaded
  - At 30 Operating ISFSIs
  - Up to ~58.0 GWD/MTU
- Projections for 2020
  - ~17000 assemblies
  - > 1,000 casks/modules loaded



Improving the Regulatory Framework

- Experience with and increasing use of dry storage demand a more efficient framework
  - Also consistent with NRC Project AIM
- Efficiencies can only be gained if the relatively low risk of dry storage is appropriately recognized
- Specific guidance and rule changes can be targeted:
  - Incorporation of the principles contained in PRM 72-7
  - Explicit recognition of aspects of defense-in-depth considerations
  - Guidance for a risk appropriate level of review for shielding, radiation protection and other evaluations.

PRM 72-7 Vision

- Standardize Dry Storage Licenses
  - CoC/Tech Spec Format and Content
  - Level of Detail
  - Consistency with Commission Policy Statement on Improved TS
- Achieve Appropriate Risk Prioritization in Dry Storage Licensing
- Place more information under licensee control
- Extend Back-fit Rule to CoC holders
- Make specific changes to the rule to improve its efficiency

Keys to Assuring Safety with More Information Under Licensee Control

- 10 CFR 72.48 Change Process
  - NRC and Industry must have confidence in a common understanding of process
- Aging Management Programs
- NRC Inspection Programs

Improvements to the Regulatory Framework

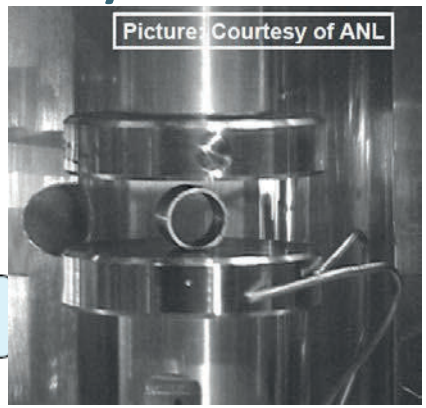
- Industry submitted 72.48 guidance (NEI 12-04)
  - Recent NRC meeting helped reach consensus on four fundamental issues of concern.
- NEI 14-03, "Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management":
  - Consistent format and content of license renewal applications (LRAs)
  - Operations-based aging management through learning aging management programs
  - Sharing of operating experience related to aging management - AMID
  - Periodic "tollgate" safety assessments

Regulatory Requirements - Cladding

- Storage - 10CFR72.122(h):
  - "The spent fuel cladding must be protected during storage against degradation that leads to *gross* ruptures or the fuel must be otherwise confined such that degradation of the fuel during storage will not pose *operational safety problems* with respect to it's removal from storage"

Risk-Informed Perspective: Fuel Cladding

- Risk-informed perspectives and risk analysis continually show low risks
  - EPRI and NRC Dry Storage PRAs conducted in 2007
  - Annual cancer risk between 1.8E-12 and 3.2E-14 *



High Burnup Fuel is Likely NOT Brittle

- EPRI Results
  - Best estimate: No or little re-orientation should be expected during dry storage
    - Consequence: no unexpected behavior during storage and transportation

- Fuel and cask/canister internals issue: "significant" fuel geometric rearrangement?
  UNLIKELY EVEN FOR ACCIDENT CONDITIONS

Radionuclide release (if any) due to loss of confinement is a slow, low health consequence process

* 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

Ongoing Cladding Research

- Sandia studies on loads during normal conditions of transport, fuel assembly shaker table experiments.
- DOE/EPRI demonstration program to provide additional verification for high burnup fuel.
- ORNL fatigue testing of high-burnup fuel (including fueled cladding segments).

Link to Retrievability

- Retrievability
  - Dry storage cask technologies have been designed to prevent/limit degradation or damage to fuel during storage:
    - Inert environment (i.e., helium)
    - Limited/no residual water via established drying process
    - Basket/canister design prevent significant fuel movement
    - Limitation of the peak clad temp below 400°C (realistically much lower)
    - Natural events fail to cause significant stresses on the fuel
    - Confinement boundary prevents water ingress
  - Technologies exist today to handle fuel with gross ruptures or structural defects without impact on worker or public safety.
  - A revised performance-based and risk-informed definition for "canister-based" retrievability is a good application of a risk-informed framework.

PRA Metrics

- Previous studies (EPRI 1009691) and NUREG-1864 have found the risk to be extremely low.
  - Latent cancer and prompt fatality metric provides for ready comparison to reactor related risks.
  - Use of another metric may confuse the issue and not provide for an easy comparison to other nuclear related risks.
  - Any proposed metric must address the consequences to be risk-informed.

- Industry supports continued use of latent cancer and prompt fatality metric.

Summary

- Efficient dry storage licensing processes are essential for effective management of the growing and aging dry storage cask population.
- Success in achieving a risk-informed framework has already shown progress in several focused areas:
  - Defining retrievability as canister based
  - Common understanding of the 72.48 process (NEI 12-04)
  - More efficient and flexible license renewal process (NEI 14-03 and NUREG-1927, Revision 1)
- Comprehensive reform (e.g., PRM 72-7) is needed to assure an effective and consistent regulatory approach.