With all the 20 years that I have been in the United States, I thought I was going to be acclimated by now, but still very cold for me. So, thank you for coming here today. My name is Yoira Diaz-Sanabria. Just to spell it, Y-o-i-r-a, and S-A-N-A-B-R-I-A, and I want to welcome remember that while we're in session, we'd like to have all of your telephones off or on mute so that they're not a distraction to us in here. Make sure you have your badge with you.

Let me introduce the next Deputy Director for the Division of Spent Fuel Management, Chris Regan. He has had leadership positions in different NRC offices. Chris is currently Deputy Director in the Division of Engineering in the Office of Nuclear Regulatory Research. Prior to joining the NRC, Mr. Regan was employed as the testing director at the Department of Defense, U.S. Combat Systems Test Activity at the Aberdeen Providing Ground. He received a Bachelor's degree in Mechanical Engineering and a Master's degree in Engineering Management from the University of Maryland.

No worries. My slides are not that important. The NRC's vision is to demonstrate the principles of good regulation in performing our mission. Those principles are independence, openness, efficiency, clarity, and reliability. Throughout the course of this conference, we expect that these principles are put into practice, especially in promoting opens in our communications. What we hope to accomplish during the two-day conference is to have fruitful conversations with all of you. In particular, members from the public and stakeholders. You will have opportunities to share experiences, ask questions, and provide insights on providing regulatory processes. We expect that we can achieve constructive dialogues and obtain input while we communicate NRC understanding of technical and regulatory issues. We themed our conference, "Building on Experience to Improve Spent Fuel Management," because part of the principles of being a reliable regulator is to base our regulatory function on the best available knowledge from research and operational experience. We've gained a lot of knowledge throughout the years in the technical and regulatory areas that has helped us shape up our regulatory framework to continue to be an effective regulator. We are looking systematically at the way we license and perform oversight activities due to the rising of the national interest on the management of spent fuel and radioactive materials, as more sites enter decommissioning activities.

Our keynote speaker will touch on this and provide insights about how the NRC is preparing for the upcoming workload. In the next few days, you will hear in more detail some of the activities and initiatives the NRC and the industry are embarking on. For example, the NRC has collaborated on initiatives in gaining more confidence in the computer modeling for thermal analysis. This effort will reinforce our licensing decisions, ensuring that storage technologies are safe as vendors -- changes that are closer to the thermal criteria.

Another area of high interest is transportation. And you will hear presentations on the different efforts conducted by the Department of Energy, the industry, and the NRC's process to ensure secure shipment of packages. Another area of main focus is oversight and how are we leveraging the knowledge from the inspection activities to verify the long-term safety performance of these systems, especially as these enter their period of extended operations. Before I introduce the keynote speaker, I want to leave you with this quote from our Chairman,

during her closing remarks in the Commission Briefing of January of this year. Quote, and so, as we move the agency on these informed applications, this is kind of where the rubber meets the road. It's independent, you know, the independent expert judgment that needs to be. I know we have models and calculations out to many, many decimal places. But as an engineer, I'm comfortable that in all disciplines, this is where we exercise some engineering judgment that needs absolutely to be done here. So, I leave this discussion very impressed with all of you of what you're doing to stay on top of that, to continue to look at.

Yes, margin is reduced. How is that affecting safety and my confidence overall about the long-term performance of something that may sit on a concrete pad for a long period of time? Closing quote. These words resonated with me as we embrace transformational changes in the spent fuel management program. As a regulator, it is our responsibility to continue to carry on our safety mission and conducting regulatory decisions in the most efficient manner.

Marc began his NRC career in 1989 as an Operations Engineer in the Office of Nuclear Reactor Regulation, and has held leadership positions in NRC, Regions I, III, IV, and now in NMSS. He received a Bachelor's degree, and served in the U.S. Navy's Nuclear Powered Submarine Program.

After leaving active duty to join the NRC, he continued his military service as a member of the Navy Reserve, retiring in 2012. Please welcome Marc Dapas. [Applause].

MARC DAPAS: Good morning, everyone. I apologize if my voice sounds a bit gruff. I was over-enthusiastically routing for a losing cause with the Navy this weekend. I had to acknowledge to my deputy, Scott Moore and Division Director Trish that are die-hard army fans, I had to acknowledge that defeat at our staff meeting. It was cold in Philadelphia like it is here, so I appreciate all of you coming this morning and being here to start this on a timely manner. Let me start out with the expression that I know many of you, if not all of you have heard, may we live in interesting times. It is certainly an interesting time for the nuclear industry and for the NRC. More power plants are decommissioning before the expiration of their current license. Of course economic factors are primarily driving those decisions for the operators. We're seeing new business models when it comes to decommissioning. License transfer, where a current licensee transfers to an entity that conducts decommissioning in its entirety. And then ownership of the property, of course, and the independent spent fuel storage regulation would transfer back. And then there's another business model where a separate entity takes responsibility for decommissioning and spent fuel management in the context of an NSFE, and that would also involve a license transfer.

And those approaches to decommissioning have an impact on how we conduct the inspection program and the various licensing actions that we pursue. I think the most recent example of a license transfer was the transfer of the license to North Star in connection with Vermont Yankee. There's uncertainty of funding for Yucca Mountain for high level waste repository. My understanding is the industry is hoping to leverage this lame duck session. We'll see what comes out of that in terms include funding for high-level waste. And as you all are aware,

Congress did not proceed with storage facilities that are currently undergoing licensing review, and there's going to be an adjudicatory process with that. We engage in that process. I will speak a little more about that in a few minutes. Transformation and innovation. We recently submitted to the Commission a Commission paper entitled, I believe, Becoming a modern risk-informed regulator. And there are discussions about initiatives and approaches and actions that the staff should take in the vein of transformation. And we're continuing with our various innovation forums. You know, I look at innovation as more incremental change and transformation being more -- transformation is in the eye of the beholder. Some think that change is transformative and others think it is more incremental. But I do believe that we are focused as an agency in trying to be more transformative. And that includes how we more fully incorporate do risk insights into determining the scope and depth of our licensing reviews? And then another significant activity that I wanted to touch upon that some of you may be aware of is the Futures Assessment. We at the NRC are aware of several developing changes that are underway, which highlight the need to proactively plan for an evolving future. For example, we're aware of 13 nuclear power reactors. Some describe where shut downs result in a total of 74 nuclear powers operating in 2030. This would remain a significant nuclear power presence in the United States, a reduction of that magnitude may necessitate infrastructure changes. We need to look at our processes, procedures, training, how we're organized as an example. As another example, the NRC's average work force age is looking at conducting scenario planning now to help us identify other drivers and scenarios that exist as well as potential recommendations on adjustments that can be made in the near and midterm with respect to activities in order to position us for continued mission success in future years.

So in connection with this future's assessment, we have an engaged with a contractor called Deloit. And this is a management consulting firm. And they are helping us with an approach that involves three phases. The future is beyond 2025, which would include scenario outcomes, key sensitivities, internal and external drivers and associated impacts. We would then assess the NRC's current state and how the scenarios that I just mentioned as part of phase one would impact that current state. And then looking at identification of challenges to our infrastructure, meaning our regulatory processes, our procedures and organizations that stem from the identified scenarios. And we hope that that will help provide insights on the appropriate skills, budget, organizational structure, corporate support and cultural change initiatives that are necessary to adapt to those scenarios. And then we will evaluate the contractor's report to determine how external and internal drivers as well as potential future scenarios could affect our near-term decisions. One is nuclear nirvana where there is innovation. There is large-scale interest in small modular reactors. There is potential for light water reactors being developed domestically.

A lot being developed in the area of diagnostic and therapeutic use and sources. With that scenario, how would that have an impact on our infrastructure and what's necessary. And there's another scenario, as an example, where new nuclear in the United States is not coming to fruition, but there is extensive development and engagement internationally.

So, you look at those different scenarios and you try and identify themes and commonalties regarding what actions we can take now sources will remain the same. Whatever is the scenario that we may decide is have the greatest likelihood to actually be what we have to address what comes to fruition. What is expected to change, though, as a result of the various circumstances that I described is how we do our work.

We are examining ways in which we can more effectively and efficiently accomplish the mission by focusing on the safety significant aspects of spent fuel management. More fully utilizing -- from 30 years of licensing activities as well as new data to help reduce some of the uncertainties which have -- to support safety findings in the context of reasonable assurance of adequate protection. Reasonable assurance of adequate protection, two subjective terms, right? In the past, we have had uncertainties and we have had to approach things more conservatively. Now with this new data, which we'll get to things like thermal analysis and modeling, cladding integrity, dry storage safety margin. I think Rob is talking about that topic tomorrow. When you incorporate some of that new information, it allows us to take a more risk-informed approach and not have to include some of the same conservatisms that we have had to leverage in the past. So in terms of focusing the scope and depth of our licensing reviews on the safety significant aspects, we've undertaken a couple of important initiatives.

We have revised the guidance in 72.48 regarding methods of evaluation. A lot of engagement to reach alignment on methods of evaluation. I'm happy to say that we have reached an alignment on what is an acceptable approach. And that guidance will better define when licensees and vendors can use the change process in 72.48 or whether an amendment is needed. Transnuclear America has submitted proposed changes to its certificate of compliance as part of a pilot effort. While placing other compliance features in the associated certificate holders to realign their certificates this is expected to reduce the number of certificate amendments and pro -- to non-technical specification related items by using the 72.48 process. I see these two initiatives as significant. Allowing greater flexibility in the use of 72.48, less in the technical specification so that you can make changes to your facility without requiring NRC review and approval. And there was, again, the methods of evaluation was a particularly challenging area, and I'm glad to see that we were able to work through that. I know there were a number of folks that wished we had reached closure on that in a more timely manner, but some of that did involve, and I'm going to call some changes in approach and understanding and thinking about what constitutes a change with respect to a method of evaluation. So, if you would change one assumption associated with a calculation, is that a change in a method of evaluation?

So in conjunction with those initiatives that I just mentioned, we do plan to gather insights and learnings from the transformation efforts involving the power reactor program, and will incorporate them into our spent fuel management licensing and oversight program. That paper includes recommendations, and it is operating reactor centric. But there will be learnings from how the initiatives and recommendations end up being implemented, and that's assuming that the Commission does approve the approach going forward. They will be learnings that will be applicable information is key to building a more effective and efficient regulatory program.

I think one example is our participation in research with the Electric Power Research Institute and Department of Energy to develop a best estimates approach for addressing uncertainties in the thermals models. This should lead to more predictable outcomes. You will hear more about this research tomorrow afternoon. I think I heard Yoira mentioning that. There is new information on cloud -- for high burnup that is being developed. NUREG-7198 entitled “Mechanical Fatigue of High Burnup Fuel for Transportation Applications” was issued in late October 2017.

NUREG-2244, Dry Storage and Transportation. The comment period for that document ended in November, and the staff is currently addressing comments that have been received. Both of these documents provide data that shows that high burnup fuel is not as fragile as was once believed, and addresses previous uncertainties for certain transportation safety assumptions. Efforts are continuing for developing and clarifying guidance documents. NUREG-2214, “Managing Aging Processes and Storage reports” or MAPS is nearing completion.

We will develop an inspection procedure for inspections of licensing activities to approve programs. We are continuing to work with industry for the renewal applications in NEI-14-03.

Format content and implementation -- based aging management. And we have a couple consolidations, NUREG-2216, which is consolidation of transportation standard review plans. Those have been developed for efficiency. And although no new guidance is contained, the consolidation of several plans and interim staff guides provides for clarity on the licensing review process. And you'll hear about those updates and other guidance documents in session one this morning. And I do want to thank NEI for their comments that highlighted some potential gaps and inconsistencies in our guidance as part of that consolidation effort. Let me shift the discussion to casework. We do expect to see increases in our near-term workload. The operational benefit and economic desire to move spent fuel from the spent fuel pool is to dry storage in shorter time periods has resulted in licensing requests for storage systems that can safely handle the higher heat loads this is one of the drivers for anticipated workload increase. Our workload for storage certificates and ISFSIs renewals is expected to increase as the number of certificates approach the end of their initial 20-year term. We are also expecting several certificate holders to submit early renewal apply KIGSs. These have not been included in the budget forecast for 2019, however we are confident that we can accommodate these additional reviews through effective management and contractor expertise.

With respect to that, we completed environmental scoping meetings, six meetings including Albuquerque and New Mexico. Our safety review is continuing with our request for additional information, and assuming that we receive a high quality response, we should complete our licensing review in July of 2020. That's the projected schedule. Interim storage partners, Request for additional information with respect to that licensee, and we're looking at August 2020 to complete the review. I should say applicant versus licensee. Hearings on applications. Both applications, we've received contentions during the respective notice opportunity for hearing. Holtec have approximately 45 contentions and with interim Storage Partners, it's been about 40 contentions. The board has designated a schedule, and has established -- I believe it's oral arguments in the case of hold tech, and for interim, we're going through and providing staff

comments on the various contentions and whether those are considered admissible. What I find interesting in this process is there may be some contentions that may be assessment. We may reach a conclusion that the facility if constructed as designed can be operated safely, but we may have to complete the adjudication process. I don't have the crystal ball to know what number of contentions, if any, will be considered admissible. We would go through that process.

Another area where I see potential growth and work is in the area of accident tolerant fuel. And not only will there be licensing actions regarding fabricating the new fuel, but in the request to use various transport casks associated with that new fuel. So, that represents potential new work. We have an action plan associated with accident tolerant fuel. We have had a Commission briefing on that. So, Mike Layton and his team are continuing to maintain awareness of industry activities. That includes transportation of lead test assemblies to be placed into existing operating reactors. That needs to be transported and looking at things in the context of risk informing, where we have traditionally looked at cladding integrity where we may be able to step back and look at safety analysis that may obviate the need. I mention that, because we traditionally have looked at cladding as one of the barriers regarding vision product release, if there is an accident, etc. And there may be other approaches that we can adopt that look at something more holistically. I would encourage you to participate in discussions over the next two years. I find with any conference, there's a lot of discussion that takes place on the margins. I encourage you to take advantage of sharing your experiences with your colleagues, with the regulators that are present. As I can see from the agenda, there are a number of panels that will cover topics that involve the industry, vendors, the NRC, the national laboratories. We are very interested in hearing your perspectives on how we can improve this meeting, and how we can be more effect and efficient on how we adopt regulatory approaches and fulfill our mission.

In terms of, I mentioned that we are looking at increased or attrition and retirements, etc. Associated with that is a loss of corporate knowledge and experience. I will mention, this will be my last REG CON. I will retire at the end of January. I'll leave it up to you to decide whether that represents any loss of corporate knowledge or experience there. But, it's been almost 30 years for me, and it's been of spent fuel management and transportation. Decommissioning. A lot going on in that area. I think there is real opportunity for us going forward to be more risk-informed in our regulatory decisions, which I would offer would translate to less burden on the licensees in terms of the content of the application and the number of licensing actions that you have to pursue. So, I am excited to see, you know, where are we going to end up here in a few years here with how we approach things in the area of spent fuel management and transportation. So with that, I'll conclude my planned remarks, and I'll be happy to take any questions that you might have. So, Thank you. [Applause]

Now's your chance.

If you do want to speak, please line up at the microphone. Operator, do we have anybody online that would like to ask a question?

OPERATOR: To participants on the phone line, if you do have questions, please press star one on your phone to ask a question.

DANIEL MUSIATTI: I would like to commend you for being on time. We're about three minute ahead of schedule right now.

MARC DAPAS: I will offer that I don't know who will be the next Office Director. That is a Commission decision, not a decision made by Executive Director for Operations, the EDO can propose a name for Commission consideration, but that will be made. So, I do not know, right now, who will be taking my spot. So, I leave you with that. That's just to avoid a number of individual questions here that I might be asked in that regard. But again, thanks. And I hope all of you have a very productive couple of days. [Applause]

Thanks again, Marc. At this time, we should probably move right on to the session on the Progress Reports on DSFM Initiatives.

TRAVIS TATE: Good morning. Let's let the panelists take their places here and we'll get started.

All right. Good morning. My name is Travis Tate. I'm Chief of the Criticality, Shielding, and Risk Assessment Branch in the Division of Spent Fuel Management. The goal is to report on progress and expected upcoming activities for several ongoing initiatives associated with the management of spent fuel. We have four presenters for this session to present on the initiatives, including an industry perspective on a very important initiative on a graded approach for spent fuel licensing and activities. Each of these initiatives have engagement with stakeholders on a prior form or process, therefore we have structured this session where we are today and what our net stats are lot of information, we have planned this session for a time of Q&As following the completion of all four presentations. So, I will start with the introduction of our first speaker, who is Wendy Reed. Dr. Wendy Reed is a Chemist in the Renewals and Materials Branch in the Division of Spent Fuel Management in the Office of Nuclear Materials Safety and Safeguards. She has worked at the U.S. NRC for over nine years. She holds a BS with honors and a PhD, both in Chemistry from the University of Manchester in the UK. Let's welcome Dr. Reed.

WENDY REED: Thank you very much, Travis. Good morning, everybody. It's nice to be here. And so thank you for giving me the introductions. I'm a chemist, but also the project manager responsible for the two initiatives that I'm going to talk about, 2214, the managing aging processes in storage or MAPS report. And status update on the two NUREGs. I'm going to begin by explaining how these documents fit into the guidance framework of Part 71 and Part 72. For each NUREG in turn, I'm going to talk about the following. For those of you who are not familiar or want a recap, I'll give you a quick overview of the purposes of the NUREGs. I will then provide a status of the document. Since both documents have been issued for public comment, I'm going to inform you of where we are in terms of addressing those comments and give examples of some of the themed increments that we received. I will end by giving a very rough schedule for issuing final documents.

Next slide, please. So this little diagram just gives you a very high-level overview of the storage and transportation review framework that we're moving towards. It has undergone a very extensive effort to consolidate a lot of the guidance in the SRPs in NUREGs. In the case of renewals, the NRC is going to see an influx of dry storage specific license and compliance renewal applications in the next few years, which in part provided the impetus for the NRC to revise the regs. And produce the MAPS guidance, NUREG-2214. NUREG-2224 is what unique, as it's going to inform staff reviews and applications into DSFM's entire per view. I'm hoping to provide the NRC has ensured that discussions are consistent without the suite of documents. So, moving on to MAPS. NUREG-2214 is a guidance document that's intended to provide the staff technical position regarding the aging mechanisms that may challenge the function of spent fuel storage system components in the period of 20 to 60 years of storage. Its details acceptable aging criteria. That provides one acceptable approach to demonstrate compliance with the dry storage renewal rules. It also helps to increase the efficiency in which storage renewal applications are prepared and reviewed by the staff. The staff are going to focus their review on areas of an application where different approached aging management is proposed. So we received over 300 comments in the comment submissions. These have now been addressed. The NRC is considering changes as a result of these comments. And the final NUREG and accompanying public comments response document are now undergoing final review prior to publication.

Next slide, please. So this slide highlights some very common themes that we received in the comment submissions. Many focused on general issues regarding safety, while others were more specific, questioning the credibility of various aging mechanisms and environmental assumptions that were made in MAPS. And other comments focused on aging managements documented. As a result of the comments we received, we are considering some changes to the aging management programs in MAPS. For example, we received several comments on acceptance criteria. In addition, as a result of some of the comments we got, we are considering removing this as well, because we found the technical specification requirements cover the ventilation monitoring.

Overall, however, it's unlikely that the NRC is making significant changes from the draft MAPS as it finalizes the document. So a schedule for finalizing MAPS. So, as I said, the comments have been addressed, and the document has been edited, and it's undergoing management review with of 2019. So moving on to the HBU NUREG. It provides an update on the technical basis on how HBU spent nuclear fuel clouding performance, and as you can see, the technical information previously provided in a summary. And the NUREG provides an engineering assessment of recent NRC sponsored mechanical testing at Oakridge national laboratory, and -- in dry storage and had two public comment periods for this document.

The second ended last month. And we reckon right now we have about 400 comments that have been identified in the comment submission. If you're interested in reviewing the comments that were submitted, you can find them by going to regulations.gov, and searching for the docket ID NRC20180066. So as I mentioned, over 400 comments were received, and staff is very early in the process of reviewing all of the comments and addressing them. And like has

been done for MAPS, a document detailing how comments were identified in the comments are the extension of the comment period. And due to the technical comment period. So, the NRC agreed, and we reopened the comment period. And as I said, the second one just ended in November. Many comments related to the general safety of high burn up spent fuel during storage and transportation, and others were more specific relating to the static testing and fatigue strength results. And others expressed concerns pertaining to specific plant and ISFSIs. So the schedule for finalizing the NUREG is, as I said, we're still in the very early stages of addressing the comments with the goal to present the somewhat finalized HBU NUREG and accompanying public comment document to the ACRS in June of next year. And then, depending on the extent of changes we'll make to the document as a result of meeting with the ACRS, our goal will be to finalize and issue the final document. I would say towards the end of 2019, beginning of 2020. So that's all I have. Thank you for your attention. [Applause] .

TRAVIS TATE: Thank you, Wendy. Our next speaker is Kris Banovac. Kris is responsible for developing guidance and managing reviews of renewal applications for specific licenses and Certificates of Compliance for dry storage of spent fuel. Prior to her current assignment, Kris worked in the licensing -- and environmental protection on the west management and decommissioning power reactors, research and test reactor, and test sites. Welcome Kris. [Applause]

KRIS BANOVAC: Thank you, Travis, and good morning. Today I would like to present an update on where staff is and the review of guidance and also the 10 CFR Part 71 rule making for our transportation regulations. I'm just going to pause for a moment to give the slides a chance to catch up. Thank you. Hopefully everybody can see the slides on the webinar. So, slide two. So, the Nuclear Energy Institute, or NEI developed NEI14-03, which is the format content and implementation guidance for dry cask storage and operations-based aging management. This is for the licensees and also our certificate of compliance or COC holders to assist them as they develop their renewal applications. The guidance also addresses the essential role that operating experience plays in the management of aging I effects for ISFSI -- along those lines, NEI14-03 does apply two concepts of a learning aging management program.

They are periodic points when licensees would evaluate the data and perform an assessment to confirm the continued effectiveness of the aging management programs and ensuring the safe spent fuel storage in the period of extended operation. NEI 14-03 discusses a database that was established by industry. And this database provides a framework for the aggregation and dissemination of aging related experience across the industry through AMID, which stands for aging management input database. And that database will be used by -- as we conduct our aging management programs. The intent of the guidance in 14-03 was to complement the existing guidance in NUREG 1927, which is our standard on various revisions. I also included the accession numbers on this slide for reference. And I just wanted to highlight a couple of things on this slide. I wanted to mention that NEI14-03 from 0 to 1 was a significant expansion of the guidance to include more detailed guidance on the format of applications to assist specific licensees and COC holders in their development of renewal the NRC staff review was put on hold to work on other competing work, which includes our renewals cases that we're currently

reviewing. Other case work including the centralized storage facility applications and guidance, which you heard a little bit about from Wendy, the MAPS, the fuel NUREG, the instruction that Marc mentioned this morning, and consolidated SOPs for storage and transportation, which have also been mentioned a few times this morning. So, we took a break and came back to revision two this summer, and we started our review.

On slide four, I wanted to present our preliminary findings on revision two of NEI 14-03. These are preliminary because we have not yet communicated these to NEI. We plan to issue a letter shortly that does document our review and findings on revision two. So, what we found is that revision two mostly does address NRC's comments on revision one. The staff does take one exception to a position in the guidance on the use of surrogate inspections. And surrogate inspections or aging management inspections that are conducted at another ISFSI site that -- as a substitute of inspection at their own site. We do take exception to the way that is presented. We also identified several clarifications to the guidance. Some of those are just a result of our review experience over the last couple of years, since revision two was submitted. Some things that we've learned.

So, there are some clarifications that we would like to suggest for the guidance. We believe that there are two options to proceed with NEI 14-03. At this time we feel that a partial endorsement of 14 -03 revision two is ready, and it would note the one exception that we take to the surrogate inspections and also the several clarifications that we would make to the guidance. And the other option is that NEI could develop a revision three to NEI 14-03 to address NRC staff's remaining comments and submit a revision 3 for revision staff to review. We would have to review that. If we determine that we can do a full endorsement, we can do that at the time. With those two options, because of schedule and resource constraints, and I think a shared desire here with our stakeholders to complete the work on NEI 14-03, staff is recommending pursuing a partial endorsement of NEI 14-03 revision 2 at this time.

This slide presents the staff's recommended path forward. If we pursue the partial endorsement, we would do that through development of a draft guidance document that we would plan to publish for public comment. The two guidance vehicles are an update to NUREG 1927. There are two mentions in NEI 14-03 already. We do talk about the tool concept, and the operating experience database. So, we thought we could expand that considering a NUREGulatory Guide that would serve for partial endorsement for NEI 14-03. The since either issuing the last update or reflect in the NUREG guide. That would include MAPs that Wendy spoke to. We have not yet developed a schedule, because we have not yet agreed to a path forward yet, since we are still awaiting issuing of our letter. I will mention here that the schedule will depend on our resources and also the completion of some of the other guidance documents that you have heard about. The numbers here, the NUREG 2214 for MAPS. 2014 is consolidated storage. 16 is transportation, and 2224 is fuel regs. Resources and efforts will shape our schedule for the partial endorsement of NEI 14-03, Rev 2. I would like to transition to a completely different topic, which is the 10 CFR rule making.

On slide seven, this provides the authority and scope for this rulemaking. So, in SRM-SECY-16-0093, a plan was approved to arm NIZ with the IAEA's specific safety requirements number 6 document, which is referred to as SSR-6 for short. And it would be both a 2012 and 2018 editions of SSR6. I do want to mention, even though the staff requirements memorandum came out in 2016, at that time, the IAEA did have a draft of before the actual final version of SSR6 was available. The rulemaking action also includes various implementation and clarity of 10 CFR Part 71. It includes reforming revisions to the supporting guidance for Part 71 and includes changes to NUREG 1608, 2216, and Regulatory Guide 7.9.

Slide eight. So, really the purpose of the rulemaking is to harmonize and align regulations with the IAEA requirements both the 2012 and 2018 editions. The purpose is to also ensure the continued compatibility of Part 71 with the Department of Transportation regulations. I do want to mention that the Department of Transportation is harmonizing regulations in 49 CFR with the IAEA safety requirements. Just to repeat, another goal of this rulemaking is to improve the implementation of Part 71 with those various clarifications we plan to make. Slide nine?

This slide provides a history of the rulemaking, recent rulemaking. So, in 2015, both the NRC and DOT, which were in TS-R-1 the 2009 edition. The requirements in SSR-6, the 2012 edition were not addressed in that 2015 rulemaking to 10 CFR Part 71. As I mentioned in 2016, the IAEA issued a draft update to SSR-6, and that final version of SSR6 was issued in June of 2018.

So this slide provides a current status. At this time, the staff has prepared the draft regulatory basis concurrence package. That has been completed by the staff, and that's making its way through NRC review. I will mention that the rulemaking schedule has been delayed from the schedule that was originally published, and that was mainly because of the delayed publication of the final version of the IAEA SSR-6 which came out in June 2018. Staff does plan to submit an extension request at this time. With that, that completes the status of the rulemaking. I would be happy to take questions when we go to the Q&A portion at the end. Thank you for your attention this morning.

[Applause].

TRAVIS TATE: All right. Our next speaker is Donald Chung. He is at the U.S. NRC. He has over 30 years' experience working in the nuclear industry. He supported the NRC Office of Nuclear Reactor Regulation and risk informed regulatory decision making for over ten years, and is currently he is leading the effort to improve the efficiency of regulatory activities for spent fuel dry storage. Prior to joining the NRC, he held the position of Senior Engineer to SciTech. He holds a Doctorate of nuclear engineering.

Welcome, Donald. [Applause]

DONALD CHUNG: Good morning and welcome. My presentation has two parts. They are both basically updating on statuses. The first is updating on the great approach pilot.

Next slide, please. Okay. The grate approach pilot is currently being done under the revised 16-01. The NRC industry held multiple public meetings and workshops during 2016 and 2017 on the approach. We are trying to basically focus resources on nuclear safety and improved efficiency. And this led to the RIRP for improving the regulatory framework. The requirements for specific information to be included in the certificate of compliance contained in 10 CFR – for specific license, the regulation for the content of the tech spec is contained in 10 CFR 71. But the regulations do not apply to dry storage systems CoC and tech spec. And given a lack of regulatory requirements for this, over time, the CoC and tech spec have become voluminous and difficult to implement and limits the application of 7248. Key actions to date, NEI submitted the RIRP in May 2017 in Orano, formally TN Americas provided the pilot. This is CoC1004, amendment 16 pilot to the RIRP. The pilot does not include changes to the dry storage system, design or operational requirements. It's purely a form and content review. The goal of this pilot is to basically test if it was possible to make the CoC and tech spec less voluminous while meeting the regulations and retaining safety and risk focus in these documents. And the review process are evaluated against the selection criteria to determine if the information needs to be retained in whole or in part. Or entirely relocated to another document. This is probably a little bit hard to read for you. This is a list of the amendments that are associated with the new CoC 1004. Originally, the CoC was issued in 1995. And the first amendments were made in the year 2000. As you can see with all of these amendments, basically grew over time. And of course, in a nutshell, this here is a problem, because this document is so big that it has so much information, that it really restricts what you can do in terms of 72.48.

Next slide, please. Again, this is primarily a status update. When we see the pilot, we see 99 evaluation forms. Every LCO, every administrative requirement, every table, every requirement that's in the COT and tech spec was evaluated against established criteria, and each one of these evaluation form. And we reviewed these evaluation forms. And again, as you saw on the previous slide, there were 14 previous amendments. With a lot of these we had to go back and check requirements being there. Right now we're down to basically one issue. We're going to complete a safety evaluation report. Document the lessons learned and have a public meeting on the SER. And we're going to plan for the RIRP closure. We're going work with industry to develop a guidance -based document based on lessons learned from this pilot. And we plan to incorporate the information that we've gained from this pilot and incorporate it into the future risk action plan. Okay. And next slide, please. Now, on the transition to a different topic entirely. This is basically the status on the storage and transport, SRPs. This is purely an update on the status.

Next slide, please. First one is the storage SRP status, again, the final NUREG-2215 is standard review plan for spent fuel dry storage systems and facilities. We have incorporated feedback on draft from internal and external stakeholders. Currently it's in final include comments and resolution table. Next slide. The next is the status for the transportation SRP. Staff is finalizing the draft for publication. It includes feedback received during the review of the storage review plan. We expect to issue the draft for public comment in the first quarter of 2019: We tentatively are planning to brief the ACRS Subcommittee in April 2019, and we expect a final publication in fall of 2019. Path forward. Right now we're basically looking at the

consolidating guidance provided in NUREG-2215 and 216. Future update to SRP as needed. This will include things such as graded approach lessons learned, 72.48 guidance, and risk insights initiatives. And of course including harmonizing Regulatory Guides with the SRP changes.

Next slide. And that's concludes my presentation, and I guess we will have questions.

Don has spent 19 years with constellation energy, assigned to positions involving Part 50 licensing, relicensing, system engineering and maintenance. More recently, don has spent 13 years with TN Americas, which is known as Orano, as a licensing manager. Welcome, Don. [Applause].

DON SHAW: Thank you, Travis. Good morning, everyone.

Slide three, please. My presentation is, of course, related to the graded approach ongoing initiative that Donald just discussed. I will be providing the industry perspective. I just heard Donald's presentation for the first time. There will be a little redundancy, but not too much. I will give a brief background and then cover progress to date, the current status, and a recap of where we've been agreed that part two licenses, certificates and tech specs have grown to contain too much detail. We have agreed to establish the IRP item to track this initiative. The RIRP documented that there's too much detail in Part 72 licenses and COCs. The detail is not commence rate with dry cask storage risk. Extraneous information needs to be removed. This will improve licensing process efficiency, and we need to provide risk-appropriate criteria for content based on expert judgment of required safety functions and risk assessments.

Slide five, please. So, will this really benefit the industry? The whole industry? Reducing the license and CoC level of detail? What if an ISFSI general licensee has many storage systems already loaded under several CoC amendments or finished loading all of the site's fuel? Slide six, please. A reality I believe we should keep in mind is for Part 50 and Part 72 site specific licensees, only the current license and tech specs matter. But for Part 72 SER FIF cat holders, all amendments are in effect and matter. Previous amendments are not superseded. General licensees can upgrade. So, the graded approach results will not immediately apply to existing loaded systems, and may never benefit those licensing bases. Something to keep in mind and assess in the final analysis.

Slide seven, please. So, how much information are we talking about? How big is the elephant? Our latest amendment 14 has four pages in the CoC and 314 pages in the tech specs. Each previous amendment is independent and still in effect. TN still holds others, so our total page count is approximately 2500 and growing. That's the CoC and tech spec only, not the TFSAR. For this graded approach item, there are three major phases. Phase one, workshops to develop agreed upon license or CoC or tech spec criteria. Phase two, create a pilot application. And phase three, develop regulatory guidance. That phase is pending the outcome of the pilot.

Slide nine, please. I would like to briefly run through the phase one history, developing the selection criteria. We had three workshops in the latter half of 2016 in August, October, and November. Those workshops involved much energy, much interaction and much interest. They were nicely led by NRC and strongly attended. Risk considerations were included. Several actual tech spec examples were presented with thoughts on whether they were would stay or go. There were mixed reactions. This demonstrated that agreement was paramount, and that a pilot licensing action must occur.

Slide ten, please. As a result, NEI issued a letter to NRC in January 2017 to update the RIRP status. A final workshop in March 2017. In May 2017, NEI issued another letter with the latest status and a key attachment described on the next slide.

Slide 11, please. That was titled ISFSI license and cask CoC format, content, and selection criteria. It became the basis for the pilot decisions. The attachment contained background information, and then CoC and open -- contained specific selection criteria for approved contents please. I'm fairly certain that most of you are familiar with the industry standard tech spec format, and I thought you would find the new format of interest. The current license and CoC contained descriptions of the dry fuel storage systems and a few conditions. The new format for the license CoC and appendixes are that the license or CoC body itself will have certify design in two sections. Section one, technology, and section two, design features. A new appendix will have inspections, tests, and evaluations, and will contain items of that nature. Section one, definitions used in application, state your name as the standard format. Section two, approved contents, also the same as the standard format. And section – LCO -- and then section four, administrative controls. In the standard tech spec format, or design features. So, tech spec section five will shift up to become tech spec section 4.

Slide 13, please. So, at that time of the second NEI letter, phase one, developing the selection criteria was complete. Let me please share how the phase two pilot has gone. As I mentioned, the NEI key letter attachment provided a split table for documenting the assessment results. TN turned the split table rows into individual assessment forms that Donald had mentioned. Each form accounted for a CoC condition or a tech spec requirement. Some forms covered multiple pages, which had the same purpose, like tech spec tables or figures which cover the same requirement but for different canister designs. Some paragraphs needed multiple forms to cover all of the multiple requirements contained in those paragraphs. The goal was to focus on individual requirement items without distraction. 99 forms resulted from the assessment.

Slide 14, please. The initial pilot application was sent in June of 2017, CoC amendment 16. Only the 99 assessment forms were sent. No CoC, ITE, tech spec, or UFSAR, until we had agreement on the items. Based on recommended moves, the page count would be approximately 50%. NRC suggested public meetings to share feedback and plan the next steps instead of the normal process of issues request for supplemental and/or additional information. That was a great idea.

Slide 15, please. With two public meetings, which occurred in August and September 2017, NRC provided initial feedback on the 99 forms. The results are shown here. TN says that 66 should stay and NRC agreed. TN assessed that 19 items could go out of the CoC and tech specs and go to USFAR and TN said that 13 could go and NRC said they should stay. That could be a line or two or several pages. The asterisks provide detail. The alternatives, which are 36 pages or 11% of the page count will need to stay. And several other items representing about five pages total or 1.5% should also stay. So, after this initial feedback, the overall page reduction became approximately 37.5%, which is still over a third of the pages.

Slide 16, please. I thought it might be interesting to consider the 20 items agreed to move out of the CoC or tech specs. This slide and the next provide the actual CoC and tech spec numbers and a brief reasoning. On this slide in particular, you see the word redundant quite a few times for items redundant to regulations, tech specs or to UFSAR. It does not remove a requirement, but it does remove clutter, which meets the aspect of too much information. Although the main RIRP premise was that the information belonged in the UFSAR, or was not necessary at all. Eliminating an item redundant to UFSAR information meets the RIRP premise and shifts the authority from the amendment to the 72.48 process.

Slide 17, please. The second slide shows additional items being removed, and some are because of redundancy. Slides also show several items being removed or eliminated based on safety of risk assessment, which meets the intent of the RIRP. When the overall consideration for the RIRP occurs, these two, redundancy versus safety and risk would need differentiation.

Slide 18, please. After NRC's initial reaction, TN had submitted revised forms and also new CoC, ITE, tech spec, and sections for review. Based on those, a third public meeting occurred in February 2018. New feedback on 16 qualification tables, otherwise known as FQTs were included. They were originally planned to move to the UFSAR, with certain parameters to remain in tech spec fuel specification tables. They were 2.5% overall page reduction if they remain. So, resolution of this item is key.

Slide 19, please. So, what has happened since that February meeting? In March and then again in April, NRC and TN had FQT clarification calls. In May, a public meeting, and as a result, TN committed to and examples were submitted. In July, NRC had a call with TN indicating that they are having to the industry. Industry is following this and looking forward to seeing the NRC position paper.

Page 20, please. So, let's recap. NRC, NEI, and industry agree that there is too much detail in licenses and CoCs, so we created an RIRP item. Workshops in 2016 developed risk based assessment criteria. It was piloted. Agreement has been reached on 98 of 99 items with potential for a 37.5% reduction. One item must be resolved. NRC is developing a fuel qualification position paper, which industry is very much looking forward to. Industry guidance will then follow.

Slide 21. This brings me to my acronyms slide, so I shall close. Thank you very much for your time. [Applause].

TRAVIS TATE: Thank you, Don. I thank all the presenters. We are staying right on schedule here. So, thank you guys for staying on schedule. I'm going to open up now for Q&As.

DANIEL MUSIATTI: As a reminder for the phone lines, it's star followed by one if you do have a question on the phone line.

Thank you, Robin. Go ahead, please.

BRIAN GUTHERMAN: This is Brian Gutherman. This question is for Donald. If the RIRP is successful, and the dog catches the car, now what? The regulations allow updating the licensing basis for casks already in service to a later CoC amendment than the one they were loaded to. However, there's often time things in that later CoC amendment that are in conflict with how some of the storage technology components were fabricated. There might be a new design feature, test, or inspection that really is a barrier for a general licensee to take advantage of the new streamlined CoC. Are you thinking about that next step when you develop the guidance down the road? Or is it going to be requiring an amendment to the CoC that addresses those design feature differences so that general licensees can go ahead and take advantage of this? Are you thinking about that, I guess, is my question.

DONALD CHUNG: The short answer is that we recognize that issue, but we have not really put a whole lot of effort into addressing that at this time.

TRAVIS TATE: I would add to that, Brian, that we do -- I think part of your question is do we plan to provide guidance, and I would say yes to that question. We do plan to develop some guidance based on the Lessons Learned. I think with that particular question, we would look at that, you know, considering what we learned from the pilot on issuing some guidance.

Yes, I have a question for Kris. What is the schedule for revising Part 71 to bring it in line with the SSR-6?

KRIS BANOVAC: So I will defer that question to my colleagues. I had the pleasure of presenting, I'm actually not working on it. So, two of my colleagues are in the audience. Latif, I believe he will be able to provide more information on far as the rest of the rulemaking, we think it's going to be another year beyond the current schedule.

So the current schedule was 2018? I was not aware of what it was.

Please January 2019. The reg basis

Okay. I just wanted to have a rough idea. Okay. Thank you.

DANIEL MUSIATTI: Is there anybody else in the room that would like to speak? Please remember that these are directional microphones. If you're not speaking directly into the microphone, you can't be heard or recorded for the transcript. If you're conversing with somebody, a follow-up question, make sure that microphone follows with you. Anybody in the room? Let's try Robin, first, our operator, and see if there's anybody online.

PHONE OPERATOR: I'm showing no questions on the phone line. But as a reminder, star followed by one

DANIEL MUSIATTI: Okay. By all means, if you've got a question, please come forward.

This question is for Kris or maybe John. Back in 2012, industry sent in a Petition for Rulemaking, and part of it was the impetus for the RIRP effort that's going on now. But also included in that petition were a number of things in the Part 71 rule that really do need to be fixed. And its six years hence, and we don't know if that's fallen off the table. It was also in NRC's long-term plan for improving regulatory framework at the time. Those changes are still necessary, and the industry would like to see them. Is there any chance that that will come back from the dead?

DONALD CHUNG: Thank you for the question, Brian. The first item is being addressed right now by this RIRP. The other five items, currently there is effort in rulemaking. We're currently beginning to look at the other five items right now.

Okay. Is there anybody else?

The way that this works is that we have published an agenda with specific start times, and people that are online and expecting to be able to listen to a specific section expect that specific section to start at the time that it's on the agenda. So, it would be a disservice to them if we took our 15 minute break early, and then started the session early when somebody would want to join in and they come in and they're in the middle of the discussion already. That's not fair to them. If we don't have any more questions, I'm forced to make this a longer break for everybody. This will actually help a little bit. It will give you a dry run to realize just there's a bunch of you and only one barista. One more time, with the phones, Robin, is there anybody who would like to make a comment?

I'm showing no questions

Okay. One more [Laughter]

Hi. Good morning. This question is for Don Shaw. Can you share lessons that you have related to the graded approach process for the licensing process that you were talking through?

One of the areas I didn't really go into in the interest of time was that we turned some LCOs into non-LCOs, and some other tech specs that were in paragraph form into LCOs. I found that

interesting. So, there was some recharacterization that also went on, which I think will serve the users better in the future. The point I made about redundancy, I thought was interesting. Again, it's always good to declutter your house or tech specs or whatever the case may be. And so that happening is a good thing. But the count of the items coming out isn't. That was something we didn't necessarily anticipate that we learned. Nothing else comes to mind, but I'll give it more thought and follow-up.

Another question here.

I'm Chris, and my question is for Donald and maybe Don, too. The NRC has approved license applications that don't contain fuel qualification tables. So, my question is, is the concern in the RIRP on the fuel qualification tables specifically related to the application itself? Or is it a more general broader concern that would apply to any license?

DONALD CHUNG: You brought up a very good question. Over the years, over the, I guess, decades, because there is not a very well-stated content for the CoC tech spec, there's a variety of CoC and Tech Specs out there. Some instead of challenged to review things differently. Our goal is for this pilot to be able to basically identify, you know what is really required in terms of content? Once we established this going forward, hopefully we will eventually get to the point where there's variety and we'll be able to be more efficient and be more risk-informed, and we will be better at doing our work.

DANIEL MUSIATTI: Okay. One more last time on the phone? Anybody there?

PHONE OPERATOR: I am showing no questions

DANIEL MUSIATTI: Okay. And I didn't see anybody jumping up in the room here. We're going to start precisely at quarter to 11. So, I invite you to take a break now. Go grab some coffee. Make sure you keep your badge with you at all times. And I'll see you -- I'm sorry. Did I say the wrong hour? Quarter to 11:00. Okay. Oh my goodness. That is long. All right. You're going to get a half an hour break here. My bad. I misread the thing before. Remember that while we're in session, we'd like to have all of your telephones off or on mute so that they're not a distraction to us in here. Make sure you have your badge with you.

And at this time, I'd like to give a shout-out of thanks to Kevin McCormick, who's been our guy in the booth up above here. He has been doing a yeoman’s job trying to make sure our electronic version of this has gone out to the public. It's normally an auto-pilot program, but today there's been technical glitches, and he has been quite helpful in solving those. We're into what? Session two now?

Session two, and continuing on with the morning of the first day of the 2018 REG CON. Who's our leader on this? It's all yours.

MERAJ RAHIMI: Good morning. My name is Meraj Rahimi, and I'm the Chief of renewals. That was a previous job, chief of criticality. Renewals and material branch at the NRC. For those of you who don't know me, I've been at the NRC for the past 20 years.

Prior to that, 13 years in private industry. So, when I was asked to put this session together, really the title of it before was the status of initiative. But I really wanted, you know, the session to have a focus, you know, on our recent activities and also the industry activities. So, the title of the session is this: Spent fuel integrity. We decided to do really to set the context for this session, I would have a few slides in terms of the -- we at the NRC in the division of spent fuel management, which regulates spent fuel transportation with respect to climate integrity. Where we are, where we have been, and where we're going. So, providing a direction after 20 years or 30 years. And so what is the basis underlying to that? What's the issue of the structural integrity or doing storage, doing transport?

Other than they have to take the design basis loads on the storage size. You have the tip-over, seismic events. They have to take the loads. So, when you get down to the factor, it's more the heat removal. That is on the long term. As long as you maintain the inert environment in your cask, the parameter that becomes bringing back to structural integrity is the heat removal. If you don't remove the heat, you know, you'll have high stresses, high pressure, and you know, creep comes in, and all of those issues.

So, that is why you will see in our guidance document that is the one parameter that is the, you know, fuel cladding temperature that is focused on very much. Next slide, please.

So, given that the heat removal, temperature really is the point, is the factor, is the driving one. So, our guidance documents really is based on that. So, ISG interim staff guidance 11, revision 3, which was issued, you know, I think about 15 years ago, and you will see in that, those criteria is the fuel temperature and how you control that temperature that you stay below minimum stresses. And that guidance was really focused on two main factors. It was a high dry reorientation, which actually if you have that phenomena happening, it kind of contributes to degradation of the structural integrity under the design basis loads, meaning design basis loads, if you have a tip-over, seismic event, or under transportation, you have a 30-foot drop, the spent fuel assemblies see about 40 to 50 G loads. So that's what the ISG was for, cladding and also creep. Those were the two factors when you read the interim staff guidance, that it was discussed quite a bit. And that is really the basis that feeds into these NUREGs that, this morning, you also other type of guidance, 2215, the revised consolidated storage 2214, which is MAPS, which November 9 was the last day of public comments. Now we're in the midst of responding to those the cladding integrity to all of these guidance documents.

So, next slide, please. So just going into a little bit into ISG-11r3, the criteria, peek clad temperatures 400 ° Celsius. What drove that limit is I said 400 ° Celsius and 90MPa, which was actually the stress inside the rod. And also, limiting the thermal cyclings that the fuel goes through. And that was mainly to, as I mentioned, to address two factors: High volume orientation and thermal creep. In our SRPs and MAPS will be issued, there will be other mechanisms that

will be -- are discussed, those mechanisms. And they're all listed on the right side. So, our position at this point is that really, none of these mechanisms, especially when we perform the tests at Oakridge, on the high burn-up fuel, which Robinson, harbor and others in the 60s, the burn-up. And you know, we need fatigue test and a burn test. And that confirmed, really, our sort of positioning in terms of these high burn up claddings. They're not really as fragile as once thought to be, because they were looked at the entire system, with the fuel pellet in it. Maybe if you look at the cladding itself, that might be the issue. But if you look at the whole system, it's not. So, we believe that fuel cladding integrity, you know, is maintained, can be maintained.

And again, provided, you know, you stick with the criteria, removing the heat. Don't let it -- you know, the cladding get into the range that would sort of degrade its condition. And we believe that because we were focused mainly, a lot of 4, and DOE program is to do other type N5 zero load. And will further confirm our position. So, what is as far as NRC, what is the next step for us? Where are we going? And what we have learned, as I said, it was a better understanding of hydride reorientation. And the DOE under the program will perform additional confirm Tory testing under the clad. And the better understanding of the rod internal pressure, gas communication within the rod. One of the questions was, you know, is there increased temperature? Is there -- how is the pressure is distributed inside the rod? And some tests, naturally always will present that data showed the good work that DOE programs are doing. There's really good communication within the rod. And then improving benchmarking of thermal models. So, as far as at NRC is concerned, the direction we're going, we're going back and actually visiting the new metrics, you stress? Those are some of the things that we're going to revisit. And also, we're going to try to, from these criteria, the temperature limit that we've set. So what happens if you go higher than 400 C? What's happening in terms of the pressure? In terms of stress? And then defining the -- we're going to try to come up with the technical bases and really explore. Right now our research program is focused on exploring beyond the 400°C. And that's the direction that our research is going.

And so, with this sort of a context, we're going to hear first from Keith. And the title of Keith's presentation is the Spent Fuel Cladding Integrity. And Keith Waldrop is with EPRI. He's a Principal Technical Leader. In this role, he is responsible for research related to management, storage of spent fuel in dry casks and the behavior of high burn up fuel in dry storage. Keith has over 34 years of experience working in the nuclear power industry. Keith? [Applause].

KEITH WALDROP: Thank you, Meraj, for teeing up this session for us. So, I'm going to talk a little bit about some of these ideas that Meraj has teed up, looking at where to next? Before we get there, I'm going to first go back and look a little bit more at how we got to where we are.

Regulations are that cover this. So, I just wanted to throw this up here and remind us the two maintain geometry so that we know what we're analyzing. Keeping that in mind, the licensing basis evolution. I want to first of all start out saying that Albert, if he was here, he would probably be giving this presentation instead of me. He was a big driver in developing a lot of this through the time that this work was going on. So, thanks to Albert. I'm going to present a summary of some of his information. So before 1999, the cladding integrity was governed by a

diffusion cavity growth mod toll set temperature limits to insure your integrity. A limit of 15% cladding cross section that couldn't be exceeded with that type of damage. This was documented early on in the first SRP for dry storage, NUREG-1536. And then a lot of work with EPRI, with that in 1999, ISG-11, Rev. 0 came out. It no longer supported the cavity growth model. It looked to a technical basis, promoting storage of high burn up fuel based on ensuring the cladding remains intact. It defined 45 gigawatt days as the limit. There was not a lot of data to support the analysis. As a back-up, said that you need to can your high burn up fuel so that no particles would be released. It was a good step in the right direction, but not enough. So in 2000, ISG-11r1 was published. And it set a preliminary criteria based on important characteristics.

First, fuel rod cladding oxidation limits set a creep strain limit of 1%, a structural ability to at the time. This was a very good step in the right direction, but it was very hard to implement. It meant that utilities had to measure or vendors had to calculate oxidation levels for the oxide thickness of the fuel. The creep strain limit was one that could be worked, except that there was very little data on fuel under these conditions to support the development of those models.

So then in 2002, ISG11r2 was published with a different set of revised set of acceptance criteria. It determined that creep is the predominant mechanism affecting degradation of dry storage. I saw some testing that showed there was significant creep capacity left in these rods so long as you ensured other things that I'll get to. It also raised for the first time the concern of hydride reorientation, where this could reduce the ductility of the cladding by orienting hydrides in a radial direction, and Mike will talk more about that. Ultimately, it set a limit of 400°C for your cladding to ensure integrity. And that was able to ensure no gross rupture caused by creep if you stay below 400. And it would minimize the radial hydride orientation.

Another key consideration that this was no longer applicable to transport. They decided that this was -- that you needed to do transportation on a case-by-case basis. And now this criteria was much more easier to implement. The vendors could verify the cladding temperature was going to be less than 400. The utilities could load based on decay heat curves, and all was good. Finally, ISG-11 rev 3 was published in 2003 and really provided some clarification as far as low burn up fuel, adding 90 megapascal limit there to be able to address low burn up fuel as an option. Now I'm going to quickly review some of the research results that feed into what we now know today, since we've going to talk more to this. Basically what we've learned here is that temperatures are nowhere thing that we've learned. The rod internal pressures are not as high as what we previously thought, which means the hoop stress which drives hydride reorientation is not a driving factor.

Meraj mentioned good gas communication, so that's an important factor here. That means the pressure will be evenly distributed within the rod, and you will not get local pockets of increased stress. Segment bend tests to determine how good the fuel was. And that was published in NUREG-7198, Rev 1, and they determined basically that the fuel rods have a significantly greater rigidity than the other rods. You take an empty rod, and it's easy to bend.

Could you please put your phone on mute?

Robin? Robin?

I'm sorry. No questions on the phone line.

We've got somebody bleeding through, and they need to put their phone on mute, please.

Okay. Thank you.

Okay.

KEITH WALDROP: So this surf testing provided the basis for the NUREG-2224 that was recently put out for comment on high burn up fuel, showing that the cladding properties of basically four-year analysis, the fueled cladding system is seen as more robust and that the orientation of the hydrides really didn't have an impact on assuming uncladded mechanical properties to use in your analysis. So, next slide. So, the last set of research results I'm looking into is some work that EPRI has been doing looking at high burn up fuel is bonded to the clad based on the experience we're seeing, so what effect does that have? We have done some analysis there and looking at how does that impact the hoop stress? Low and behold, creep was a beneficial thing here. It actually acts as a stress relaxer in this case. So the hoop stress for bonded cladding is going to be actually better and make that fuel more resistant to radial hydride orientation.

We're planning some additional work in this area as well, and there's also in our nuclear fuel clad bonding effect as well as a couple other topics there. Pinch load testing is a big one. There's limited data there. And lastly, looking at the high burn up sister rods that Rose will be looking at, they are looking at doing some additional sampling, additional testing there. It will be much more applicable looking at fuel segments as well as treatments up to 400°C. So, with this information, one can conclude, basically, that you know, how are we doing? I would say that ISG-11, the 400 degree temperature limit has served the industry rather well. The quote I have here of it being simple and robust? That came from Albert in a report that he published looking at some of the REI responses at the time dealing with this.

And I think that's a key phrase here -- simple and robust. It's allowed the industry to go forward with high burn up fuel, but maybe it's been too robust. And we're learning some things now that perhaps we can understand better, the conditions that we're protecting against, the actual conditions are far removed from that as far as from a cladding integrity standpoint. So what do we need to do with this information? Where do we go from here as Meraj put it? Do we need a new metric for cladding integrity instead of a temperature limit? Do we need to link hoop stress in there somehow? So, what we plan on doing is we're going to explore this option. We're going to start doing a PIRT, phenomena identification ranking table. Never done one, seen one, or been part of one, but we're going to work on one. To look at what are the important factors here?

The information coming out of that should be able to tell us what directions are possible? What things could we do? And then before we take direction, we need to understand let's not go down the road of something that's hard to implement. We want to make sure that in the end, the cask vendors, the utilities can implement this. We've got to keep that in mind in our path forward. And lastly, I would like to make sure that whatever we do going forward, that we bring transportation back into the mix here. And whatever we do with cladding integrity, let's bring that on. There's activities going on, and hopefully we'll be doing more transportation in the future. [Applause] .

MERAJ RAHIMI: Thank you, Keith. We will go through all the speakers, and at the end we'll have a Q&A session. Next speaker is Dr. Michael Billone. Oh, Brady! Oh! Okay. The order was not right. Okay. Sorry. Dr. Brady Hanson, the next speaker. Dr. Hanson has a PhD in nuclear engineering from 25 years where his research has focused on spent fuel degradation issues. For the proposed repository at yucca mountain and then for storage and transportation. He currently serves as the lab lead for the experimental work for the DOE nuclear energy program spent fuel and waste science and technology program. Brady? [Applause] .

BRADY HANSON: Thank you, Meraj. The reason I'm going first is I'm supposed to speak at a very high level, where my colleagues Mike and discuss, talk about the cladding data gaps that we developed. The integrated approach, which is really, to me, the most important thing of how we're closing these data gaps. Talk briefly about REG CON meeting last year in October, we were just talking about doing it. Now it's done, and I would like to give big kudos to Keith Waldrop, who was the project manager overseeing that. And go into two issues with the integrated approach, which are the thermal and the hoop stress. So in 2012, when we were kicking off this project, we went through and did a very detailed data gap analysis. That's not to say that there wasn't data to support the technical bases for what was going on, but we felt there could be more data in many areas, and I want to point out that the Department of Energy side, we take a much more holistic approach, because we are obviously very concerned with storage, transportation, potential storage, more transportation, and finally ultimate disposal, and/or if this country ever said we want to reprocess, we need to make sure we can retrieve fuel and do whatever we need to all along the way. With that in mind, we did our gap report, which was published in 2012. You can see where I identified some key gaps where we felt more data was necessary, specifically in hydrogen effects both on hydride reorientation and embrittlement as well as delayed hydride cracking. I want to point out that clearly, most of these phenomenon are highly temperature-dependent. And most of them are also stress-dependent.

Before I go too far, I want to say that back in mid '80s, we did what we call a demonstration 15 years, and then some of the people in this room led the charge in opening that cask, examining the fuel, testing it, and said for low burn up fuel, everything looks fine. Most of these issues dealing with hydrides or DHC, for example, become a concern at higher burn up. As Keith said, that's defined as burn ups greater than 45 gigawatt days per ton. But it's not when you get to day 45, you magically have a problem that didn't exist before. You have a continuum. You continue to a cliff that you just fall off.

And that's very important when you stop and you look at a lot of the data that's out there, because here in the U.S., NRC limits us to 62gigawatt day peak average burn up. If you look at the data out there, especially from our colleagues in Europe, Germany, they're reporting from the 70s all the way up into the 100s. Clearly things are different for especially because as a nuclear engineer, I can tell you in all of my classes, you always read the statements that burn up is continually increasing. You will hear that even today. I realize you can't see this table very well, but it's from what's called the GC859 database. So, in 2015, they had been in their reactors as of 2013. But the key is, if you look at the last two columns where it reports what the average burn-up is, and we're only -- now this is the rod -- excuse me. Assembly average burn up, and it's only in the 44, 45. It's right at the limit for high burn up. You will have some rods that are burned up and many that are not. When we talk about high burn up issues, please keep in mind that our inventory in this country is nowhere near what it is in, say, Europe.

So I want to talk about this integrated approach that we came up with. Four years ago, I was tasked as the lab lead for experiments to say how are we going to solve this problem? And at the time, we really thought we had a problem. When we looked at what was in the ISGs, and we looked at the data that Mike Malone had generated at Argonne under an NRC program, we all talked about how high burn up cladding turns brittle. So, we said how are we going to approach this? Six different items that you see there, we're going to look at the thermal analysis. What are realistic temperatures? For years based on ISG, we said okay, we're close to 400°C. We knew we would. We thought there were some conservatisms, but we had no idea how much there might be. Same with hoop stress, over time as assembly designs have changed going from 14 by 14 to 15 by 15 to 17 by 17, with each iteration, the initial floor pressure has decreased. And even in the same design, over time, I think you'll see what Rose presents, the rod that we have that's 30 years old had a much higher initial fill pressure, and therefore much higher initial end-of-life pressure.

So, things change. What is the real hoop stress that we're looking at? We're very familiar with the ring compression test. The key is instead of picking extreme or very bounding temperature and hoop stress results what do we get? Do we really lose ductility when we're under the realistic temperature in hoop stress regimes? We have heard both Meraj and Keith talk about the surf test that Oak Ridge does under an NRC program, it continues: Rose will talk a little bit about their important one. When we put this plan together four years ago, we said okay, even if somehow must brittle material. But even if I did, think about if you have a glass rod, think glass rod. That is a brittle material. But if you sit and tweak on it, it doesn't bend until you exert enough external force on it. What we said is we need to understand what the external forces are, even if I have a brittle material, are they strong enough to actually break the cladding? And then finally, we want to make sure that the material properties that we use post-drawing, which is of course, what everything will be, are real. And again, Rose will go into that. So there's been a lot of confusion, a lot on my part, I guess, when I talk about what happened with the demo.

So, I just wanted to outline this that when EPRI was chosen as the contractor to run the high burn up demo project, and their partner Dominion Energy, one of the reasons that Dominion

was chosen is they already had a history of loading TM32 casks. The reason that was advantageous for us -- it is plain and simple where that was chosen, but Dominion had experience with that. You will see with their previous loaded systems what kind of criteria they had. It was low burn up, relatively low maximum decay heat per assembly, total decay heat, longer cooling times, and a peak cooling temperature of 28°C.

What we did with the demo cask to allow us to load this, I want to emphasize, we were pushing the limits of this cask. We went to higher burn up. We went to higher decay heat per assembly. We would be allowed a higher total decay heat in the system, much shorter cooling time, and a higher cladding temperature. So, again, we were pushing this as hard as we could. So before we loaded, actually in the audience, we have Jim Ford and David Richmond who did all of this work, and so I want to make sure to give the credit to them. But we did a lot of modeling to see what things looked like.

On the very top row, we have peek clad temperatures on the left-hand side, minimum on the right. When we used the dimensions and properties in the FSAR, we assumed a 100 degree Fahrenheit ambient temperature. And you can see -- probably too small, but 315°C as the peak cladding temperature. We had colleagues at Oak Ridge who said industry typically calculates the heats very conservatively. They went through and said it's the real decay heat, same assembly and same everything else is only 30.6 kilowatts. That dropped from 315 down to 271. And then finally in the bottom row, we actually loaded the system in November of 2017 as opposed to the planned loading in July. So, the decay heat is a slight bit different. But clearly our ambient temperature was not the assumed 100 ° Fahrenheit. It was only 75. And again you can see we have now dropped the peak cladding temperature from 271 to only 258. Just want to show, yes we did load the cask. That's what it looks like. You can see the rod assemblies that we just show so we had seven lances. Each lance had nine axial spaced thermocouples in it. You can see as a function of that axial spacing what the temperature was.

Point out during vacuum drying, it was only 237°C. After a steady state soak in the fuel handling building, only 229°C. So, a lot of people said this test wasn't worth anything. It's going too low. I'll address that in a second. I just want to show very quickly, the left-hand graph showing the axial profile distribution for all seven thermocouple lances and mapped to the figure on the right.

And no surprise, the two assemblies in the very center are the two up on top, the assemblies that are in that middle ring form the next row, and the ones at the bottom are the ones in the outer ring. So, you have quite a radial distribution as well as an axial distribution within your cask.

So after we got the real temperatures, the PNNL models went through and said how come the model is still so much higher than what the reality was? And one of the big things was when you take the dimensions from the FSAR, there's an assumed gap between the basket and the rail. Clearly during, after you have loaded, that basket heats up. It's made out of aluminum. It expands. It closes that gap. And said what happens if we close that gap some? By doing so, they were able to get the model temperatures to match very well with what the measured

temperatures were. But to me, the big important thing was when they asked David to do that histogram, that little bar off to the far right that is 230 to 240°C. There is less than 2% of all the cladding in that cask that is anywhere close to what we're calling the peak cladding temperature. And that's very important to remember. Again, when we talk about a temperature of a system, you have huge variations. Only a small amount of the cladding is really affected by these higher temperatures.

So just to summarize, we had an FSAR value at one level. Industry -- actually NRC said, oh, you're a little too close to the temperature of the thermal or the neutron shield, so industry sharpened their pencils a little bit, was able to reduce the total heat loading, dropped the peak clad temperature down, did the modeling efforts, and dropped temperature even more. And then again, you can see that those are still high compared to the actual measurements. So, how do I summarize all of that? We know that a lot of our models have conservative decay heat calculations. Lots of 20 to 50 or more degrees Celsius margin. We know that doesn't apply to this system, but if someone says my design is for 35 kilowatts, but you only load it to 29, there is no way that your temperatures can be anywhere near what you predicted in that design basis. Your ambient temperature affects things. Jim will discuss that more tomorrow. So, the big thing is, as Keith said, we're nowhere near this limit for systems loaded to date. And I want to emphasize, PNL standards database. And everything that we have modelled, the highest temperature that we have seen is 325°C, significantly lower than this 400. Lastly on hoop stress, David Richmond here in the audience did this analysis for NRC. It is not bounding. It does use a 400°C peak clad temperature, but the very top table, table three -- excuse me, table one is one that is most important. What are the calculated hoop stress taking into account the temperature variation along the rod, various thickness of the cladding because of oxide layers, all of that.

So, pretty realistic. And again, you can see that hoop stresses are much lower than what we were talking about in the past. So, last slide here. You know we have models that work if we put in the correct inputs. I would like to say that it's not an uncertainty that we have. We purposely bias our results by putting in known conservatisms as inputs. A conservative decay heat, ambient temperature, conservative in our production gaps, things like that. That is a bias making it so taking advantage of these things that we've found, and we'll have to make sure that that is done correctly. But, long story short, temperatures and hoop stresses? Much lower than what we thought. And whereas four years ago when we put together the integrated approach, I incorrectly at the time said not a single one of those six points was a silver bullet. I am now willing to say with the data that we have in hand, with at least four out of those six bullets, that's each one of those bullets is enough to kill the werewolf. The werewolf is dead and cladding should not be considered a problem as long as we stick to the hoop stresses and temperatures that we just discussed. So,

Thank you. [Applause].

MERAJ RAHIMI: Okay. Thank you. Now our next speaker is Mike Billone. He received his PhD in Mechanical Engineering from Northwestern University, where he later served as Associate

Professor in Northwestern's Mechanical and Nuclear Engineering Department. He is currently their leader of their Irradiation Performance Program at Argonne National Laboratory.

His 40 years of research experience at Argonne include modeling the behavior of fuels in fission and fusion environments, and include managing experimental work in Argonne's irradiated water reactor cladding -- during design bases. And on light water reactor spent nuclear fuel planning behavior, doing drying, transfer, storage, and post storage transport. Spent fuel research has continued under DOE, and NOE, nuclear energy sponsorship. And he has years of dry storage and transport. Mike? [Applause].

MIKE BILLONE: Thank you, Meraj. Sorry. I might need to demonstrate. Thank you for attending. You can ignore most of my titles, because we're reorganizing at Argonne again, so my titles will change. My presentation is on sister rod research that has been conducted at Oak Ridge National Laboratory, PNNL, and Argonne National Laboratory.

I think Brady gave you enough background, but let me tell you what sister rods are. Brady mentioned the demo cask, which has already been loaded with 32PWR fuel assemblies. That included four cladding types: Standard Zircaloy, LIRLO, the cladding and five cladding. And the cask has been monitored in ten years and subjected to visual examinations and characterization. So the sister rods are selected, there's 25 of them. They were extracted either from assemblies that went into the demo cask, or for similar assemblies that experienced the same kind of irradiation history. Same cladding alloys, except now in terms of number, we if we lump the ZIRC -- 12 and 9M5 rods in the range of about 49 to 59 giga watts per metric ton, which is certainly at the upper limit. Oakridge has already completed the non-destructive examinations. Ten other rods were shipped to PNNL. And one half of rod one equivalent will be non-destructive examinations, except -- since we are not going to talk about them, I will tell you what work was done. Oakridge did excellent work. Imaging, gamma scans. Any current measurements to determine oxide plus crud layer on the outer surface of the cladding. Final lengths and outer diameters of the outer surface of the cladding. That's all documented in a DOE report, which is referenced in the slide. As far as the subject today, this and the next presentation, there are a lot of destructive examinations. I will explain our phase one plan, and you will get some progress report from the next presentation that Rose is going to give. All right.

So, what are our objectives in phase one? Characterization and material properties: We want to generate data that can be compared to the ten-year stored rods. When you look at the temperatures Brady showed you, they're less than 250 ° C peak cladding temperature. That means most of your cladding is well below that. We really don't expect anything dramatic to happen. We don't expect the softening to happen. We don't expect hydride reorientation of any significance. This little hydrogen solution at these low temperatures. So we feel like if we just took our as irradiated cladding, the stuff that came out of the pool and never went through drying, that that would be a good baseline for comparison to the DEMO cask rods. In addition, we plan to generate data for cladding mechanical properties, both in the as irradiated condition. And I should mention that those of you who use mechanical properties, particularly the PNNL

database, that that's as irradiated. That's than eight hours. And the important thing is cool slowly under pressure to see whether we get any radial hydrides of any significance.

So what do we hope to accomplish other than, I should mention that the mechanical properties data is extremely important, particularly for M5 cladding where we don't have much in the literature. But even for ZIRLO cladding. We would like to determine is are radial hydrides an issue? The data we have to date suggests probably not. But we would like to really pin this down. So, we plan to heat treat at 400°C, which is the recommended limit. Depending on how much hydrogen you have to begin with, the maximum you'll put into solution is about 200 weight parts per million. Assuming you have that much to begin with.

And we will be using actual rod internal pressures. I apologize for this acronym, RIP, which is also rest in peace. I did not create this. I do not own this acronym. So, if we look at the peak rod internal pressures, what I mean by we're going to be measuring them at roughly 25°, hoop stress is going to go up. If we go all the way to 400°C, that's going to give us a reasonable upper bound pressures and hoop stresses. We're going to cool at less than 5°C per hour. Under the cooling will be decreasing the internal pressure and the stress. Now, to assess the effects of radial hydrides, we're going to be doing burst tests and ring compression tests, which I'll demonstrate in a moment. The plan is under phase 1 that the rod internal pressure at about 25 ° C will be measured for 18 of the 25 fuel rods. We will not be doing destructive evaluation on all 18 in phase 1. All right. Next slide is so busy, there's no way you can comprehend it from there. Basically, this is the goal was to do one visual describing all many, many tests that can be performed, tests that will be exciting to be performed. But we had to prioritize what kind of data we needed and what tests should be done first. So, the important thing is that Oakridge will be doing their tests with fueled cladding. PNNL will be doing their tests with defueled cladding. Argonne will be doing their tests with defueled cladding. We will be looking at the baseline. Even I can't see that. This is much clearer here. What kind of tests are we going to be doing? There's two types of materials. There's the as irradiated material, and there's the heat-treated material. That's heat treated under pressure and stress.

So, we're going to be doing a variety of characterization, which means that we will be looking at oxide thickness, passionate as I am, we will be taking cladding and simply pulling in the axial direction to get the axial tinsel properties, and the ones we're interested in are yield strength, yield stress, the ultimate tinsel stress, and two ductile criteria, so simply pulling. That will be done with fueled and defueled cladding. We will also be doing tests in which at 25°C and 225°C. We'll ramp the pressure until we get burst of the cladding. In that kind of test, you know what your pressure is. You control it. That gives you what your hoop stress is. And then the challenge is to measure the increase in diameter as a function of time. So, that's the burst tests. We'll also be doing the Oakridge test will be applying dynamic moments up and down up four-point bend tests. Let's keep this in hand. If you look at my two thumbs in the four-point bend test, the thumbs are applying the displacement at a constant rate. And between my thumbs, you have a uniform bending moment. So, if the sample is highly ductile, this happens. This is M5. Then you see what the final product is. Instead of a straight, you get a curve. That's an indication of how much plasticity or ductility you have up to that point of loading. If you have a brittle material, and

this is really from our coolant accident program. The sample has been embrittled by heating it under pressure and steam to 1200°C, and the embrittlement is due to oxidation, wasn't strong enough to bend any of those other tests. This one, I think I could break. And it breaks where the burst opening was, and essentially you get no change in shape. So, the load displacement was linear up to the fracture, no plastic flow at all.

And it happened, fortunately, to break where it should have broken at the thinnest part of the cladding. All right. The last thing I want to demonstrate is the rate compression test. Again, for this cladding size, I'm not strong enough to compress, so we'll use this hose clamp to demonstrate. And essentially that test, my bottom thumb is fixed. The top is going to be displaced at a constant rate. And you're going to do that through a fixed displacement. You either get all the way to the end of that displacement with no cracking, or somewhere in between you get cracking. So you measure the diameter prior to the test, and then you record it online as a function of time during the test until you get a sharp load drop indicating that you had a significant crack. So, that's the ring compression test. That induces a different kind of bending. This is bending in the hoop direction. So if you had radial hydrides, and they were a source of embrittlement, they would show up in this kind of test. Next slide. We're talking about circumferential hydrides. And I haven't showed you what they are. If you look at the top two slides, that's ZIRLO with low to moderate hydride content. You will see most of the hydrides are in the circumference direction. On the top, you will see a dark area, that's about a 26 micron oxide layer, so that's the water side of the cladding. And where the labels are approaching the fuel side of the cladding. In one of 12 images is what you see on the right, you'll see actual radial hydrides from as irradiated cladding that will likely occur during cooling from full power to 0 power with full pushing on the cladding. Those hydrides are benign, even in the radial direction, because there's very few of them and they are fairly short. As you go to the same material, but go higher up on the rod, that's high hydrogen content of 650, which you will see is a denser hydride rim near the 60 micron oxide layer. What I'm showing you is the 3:00 orientation and the 6:00 orientation. You will significantly around the cladding. So, really, your hydrogen content that I've given you as the average is 650 plus or minus 200 with hydrogen varying around.

That's your starting material, at least for ZIRLO. What happens now when you cool under stress after elevating the temperature during drying? So the slide on your upper left was subjected to 80 Nano pascals and cooled with decreasing pressure. And you see a very, very short radial hydride on the inner surface of the cladding. If you go all the way around on the average, your radial hydrides are only 9% of the cladding wall. That material behaves the same as the irradiated cladding. It's too short, and it's too dispersed. There's not enough of them. If you move to the picture on the right, we've increased to 88 megapascals. Now you can see radial hydrides, and yet the material is ductile down to room temperature, because on the average, those radial hydrides are only 20% of the wall thickness. Drop straight down, and that's 89 megapascals, same thing. You can see radial hydrides, but ductility down to room temperature. It's only when you get to the 111 megapascal picture where you see longer radial hydrides more frequently, and then your ductility transition temperature jumps from room temperature to about 100 degrees increase, to about 120°C. So, that's kind of the critical stress range. We have

additional tests and intermediate stresses to narrow that down. So I have shown you what circumferential hydrides and radial hydrides. In 2003, for the DEMO cask fuel rods, again, the less than 200°C means a very small amount of hydrogen in the solution, less than 44wppm. Let us go to the next slide.

All right. This is a collection of end of life gas pressures that we've collected prior to the Sister Rod program. Those are the open blue circles. And you come up with a three sigma upper limit of 5 mega pascals based on old data from the '70s and '80s. If you look at the dark point, that's the data that Rose will show you from sister rods, they are within that range. If you stay below five, you will not have an issue with radial reorientation. Next slide. Okay. What's important is my middle solution to start with. Right now I'm calling it 60 weight part per million. You need peak cladding temperatures greater than 285°C. You need high enough internal temperatures, greater than 10 at temperature. And high enough, at least greater than 80 megapascal hoop stress to get radial hydrides. We have a lot of results that I don't have time to show you. Peak cladding temperatures of 400°C and 350°C at various stresses. I have to conclude with my last slide. This slide is more of a point of information. It doesn't summarize everything ZIRLO that 93 degrees is a critical temperature. You stay below it, you have no effect. The sister rods from test -- in particular, there's a four-cycle where the power was jacked up to get to high burnup. So, the sister rod cladding is more typical of observed radiation. We'll have more samples. We can do repeat tests. And it allows for us to possibly have M5 cladding with slightly higher hydrogen content than we had at the Argonne program. That is a rather abrupt ending, but my time you,

Mike. I think your students miss you. That was a great demonstration. All right. Our last and best speaker, Rose, because all of us, we say you will see it in Rose's presentation. Rose Montgomery began with Oakridge in 2016 after spending more than 23 years working on nuclear fuel design fabrication, and post radiation examination. She also has experience with radioactive materials, spent fuel shipping and storage container design. Rose is a registered professional mechanical engineer. In her role, Rose is the research lead in the post irradiation examination of spent fuel and is ultimately responsible for the design of new experiments and sensors supporting of my stuff already mostly from Brady and Mike.

But I'm going to go over for you the destructive examinations we have done so far on the Sister Rods, and talk a little bit about what we're going to be doing in the near future. So, Brady and Mike both touched on this some. You know, the goal of our destructive examination is to characterize these high burnup rods that we have for comparison with the cask rods, the rods that were put in storage, so when we pull those out in ten years, we can do a comparison and see whether they're the same or different, whether that storage period made any difference. And also to define the mechanical properties of interest for high burnup fuel and cladding, especially after they've been through the vacuum drying process in preparation for dry storage. We are going to do a lot of destructive examinations, which Mike went over. He gave you those wonderful demonstrations of the tests. We're doing axial testing. We're going to do the reversible bending fatigue testing, four-point bending, ring compression, micro hardness, and some fuel burst testing. All of those meant to characterize the composite fuel in detail and

mechanical properties. I want to say that Oak Ridge is focused on doing fueled testing, which complement the cladding testing that Argonne and PNNL should will be doing.

So, to get started, we picked a set of six rods. And three of those rods are as received at Oak Ridge, meaning they haven't been through the drying process. They haven't been in dry storage. These are the ones that came out of the pool. And three of those six, we took and we put into an oven that we developed to simulate the temperatures that are achieved during the vacuum drying process. So, we're going to be able to compare the three baseline rods with three that have been through a simulated vacuum drying temperature. And that should give us some information about how that process changes the mechanical characteristics of those rods. So this, you can see on the right, there's an image of that oven in our spent fuel -- or I'm sorry. In our hot cell.

And what we've done is we've got -- we've designed an oven that has seven different zones in it. That allows us to make different axial profiles on that rod. You can see one -- I don't know if you can profile on the rod, or we can do what we did for the first three rods, which is to put a flat profile on it. So, every axial elevation of the rod was subjected to 400°C for our first three rods. And we used a less than 5°C per hour cool-down rate, which as Mike time is about 38 hours. They spent eight hours at 400°C to avoid any irradiation damage.

And then about 100 hours cooling down from that. And then when we do our mechanical testing, we'll be able to compare those three rods, one and five, one ZIRLO and one Zircaloy rod at the different vantage to give us an idea of what changes or doesn't change. After we did that heat treatment, we took the three heat-treated rods along with the three baseline rods and then two others, and we measured the rod internal pressure of those. With the results between 3.2 and 4.7 megapascals, and that's at room temperature. You can see in the graph, what I've done is I've put it up there with some EPRI data that was available publicly. So, this is a large array of different types of fuel and different vantages of fuel. The sister rods are the filled in triangles and circles and squares. And the ones that were heat treated have the little orange outline. Basically what I wanted you to take away from this graph is that the Sister Rods that we've measured so far fall within the database very well. I do want to say that as Brady mentioned earlier, that the post-irradiated rod internal pressure is less strictly related to burn up than it is to what it was pressurized to at beginning of life. And so, not all of those rods are strictly comparable, but it does give you an idea of the envelope of rod internal pressure, and that these rods fall within that. And we didn't see any apparent effect of the heat treatments that were applied to those three sister rods that we put in the oven. We also measured the internal free volume of those sister rods. And just to remind you of what that volume is. Inside of each fuel rod, this is a stack of pellets. At beginning of life, you have that little bit of a gap between the pellet and the inside of the cladding. Most of the pal lets have chamfers and -- which give you free volume for gas. At the top, there is usually open space with some kind of a down, the stack grows, and rod dimensions change just slightly. So, we wanted to know what was the available volume inside of the rod at the end of its irradiation in the reactor. And we measured that between 11.1 and 39.5ccs for these particular rods. Again, the volume at the end of life is highly dependent on what the volume at the beginning of life was. Because it was slightly lower than

the rest of the historical data, that's not really any indication that these are different. I think these are more modern rods in some cases, and so we saw in some older rods. So, the volumes had changed over these last 30 years, and the designs. So, that's just an indication that we have a good range of sister rod designs. And again, we didn't see an effect on rod internal free volume from the heat treatments. So in addition to the measurements of the rod internal wanted to find out was whether or not the fission gases inside of the fuel rod could move freely along the pellet stack from the top of the rod to the bottom of the rod. So, in order to test this, we did it basically two different ways. The first way was we applied a pressure at the top of the rod and the plenum volume. And then we looked for the pressure that we had applied at the plenum down at the bottom of the rod. So, we look for the pressure rise. That would indicate that the gas that we put at the top of the rod had moved all the way to the bottom. In every case – we did this on eight rods, and in every case we saw communication through the stack. And the time that it took varied between like two hours and 20 hours, but we did see that communication. And we of our apparatus. And so, theoretically, the time is less for a real fuel rod in isolation. So probably about a third of the time that we measured. Now, one thing I do want to point out is that this test was at room temperature. As we all know, these rods are hotter in dry storage. So, we don't know whether or not that holds true at the higher temperatures in dry storage. We also took a sample of the fission gas from each of the rods, and we sent that off for analysis.

And we were mainly looking at what the gases in there were. We saw the krypton, zenum and helium ratios where, and you can see that on the left graph. The filled in blue diamonds are the sister rod data, and the rest of it is historical data that I found in the literature, publicly available data. On the right, you can see the fission gas release that was calculated for these particular rods. And so, the four data points that are slightly above the rest of the grouping, even though the publicly available data is slightly lower than that, we have talked with Westinghouse. These are fully within their envelope, so we don't feel like these are high, either. So, with what we I meant to mention the fission gas release is, you know, that gas that's evolved within the pellet, not all of it is actually capable of leaving the pellet. So, this percentage is just the here. Okay.

So, what are we doing next? So, I mentioned a couple of times that we're planning to compare and contrast the heat-treated rods against the rods that came to us as irradiated. And we'll be doing 1M5 baseline, one M5 heat treated rod, one ZIRLO baseline and one ZIRLO heat-treated rod and one LTZirc-4 and one Zirc-4 heat treated rods. We plan to start testing at axial tension testing at room temperature at 200°C in February time frame. Four-point bending at room temperature 200°C sometime in April of next year. And along with hardness and fuel burst testing will be the last thing that we start working on. I want to emphasize that at strengthens the rods. It may unfortunately also introduce some stress risers. We want to see the difference in that and compare it and contrast the performance of fueled segments versus defueled segments. So in summary, we have done some early -- we have the results of our early destructive examinations including the rod internal pressure free volume. And those are consistent with the available data. The gas transmission tests that we performed showed that at room temperature that the fission gas can move freely along the entire pellet stack from top to bottom of the rod. Rod characterization is underway, which is going to include -- we're doing metallography, burnup determinations along the pellet stack length, and we will be doing

cladding total hydrogen measurements. Our destructive testing will begin soon, hopefully next week. And that’s the end of the presentation. And I will be happy to talk to any of you on the side if you have questions. Thanks.

[Applause].

MERAJ RAHIMI: Thank you, Rose. All right. So, we are in the Q&A session. Any questions? Ha ha!

Okay. We've got about eight minutes to be on schedule perfectly. But we have quite a long lunchtime here. I think we can probably extend into the lunchtime as long as we've got questions. Do we have any questions from anyone in the room? Okay, sir?

Come to the mic

Please start with your name.

Hi. My name is Antonio. I'm Tony, and I'm a structural engineer. This question's more geared towards Mike. I really liked your presentation. I wanted to know about the mechanical properties that you guys have tested. Was it due to anything other than typical quasi static?

What do you mean?

A lot of them are done at a slow rate. I was more curious about the cladding, how it behaves at a higher rate of loading, higher strain right?

That's a good question. The zirconium alloys tend to be -- we run our ring compression tests at a fast strain rate and a slow strain rate. I think the plan is to stay within ASTM standards, which is a slow rate. In phase 1. I'm sorry. What I talked about was phase 1. Issues of effects of strain rate, effects of annealing, of reducing soft ring properties has all been reserved for phase 2. I get your point, and hopefully we will have it all addressed by the end of phase 2.

Thank you very much.

Okay. Anybody else in the comments, it's star one. We have a question or comment from Donna Gilmore. Your line is open.

Hi, Donna

Who am I speaking to?

This is Dan. We have talked like this an awful lot, you and I have.

Okay! With over 4400 rods from around the world at different levels. that question?

What is the question? 4400 rods?

There's over 4400 rods were taken from actual operating reactors from around the world and plotted as to the oxide damage, and the hydride build-up, and mid burnup, it starts seeing a dramatic increase in oxide level. Has any discussion or review of that? I thought that data would be very useful.

Yeah, I mean, it is part of our research that we are involved in the international activities. And our folks in the office of research, they keep informed of all the data that are available. And so, I specifically don't know about that 4400, but I don't know if Mike or Rose...

ROSE MONTGOMERY: So this is Rose Montgomery with Oak Ridge National Laboratory. And I can comment that Oak Ridge is building a database of fuel based on the GC85, I think it was, data. And we are looking at all of the operating characteristics of those rods related to dry storage and I think somebody mentioned -- somebody talked about -- I think it was -- anyway. So, we are looking at the full database of rods that have been operated in terms of dry storage in that context. With the UNF standards database.

No, I'm talking about -- it sounds like you don't know what I'm talking about. That, you know, it's referenced in a 2010 nuclear review board report. So, it's been out a while, and I keep asking about this, and I seem to get those who are unaware of this data. I think it would be really critical. I know Bob -- I don't know if Bob is there, but I know he knows about the data.

He is now at the nuclear review board. And I also commented on it in the 2224 NUREG draft. Anyway, if anybody wants to contact me, Donnagilmore@gmail.com. But I can't believe you will just walk away from that data. It was referenced years ago.

Donna, I will get back with you specifically about this data you are mentioning. Let me check with our office of research and see that would like to make a comment?

I just want to say one more thing. HB Robinson data does not represent real operating data. I have studied how those rods were handled, and they were not handled in a normal fashion for how fuel gets burned up in reactors. So, that's my last comment
Donna, we've got to move on to somebody else. Somebody else on the floor?

Just a quick comment in relationship to that. Most of the fuel rods that have been available for testing have been lead test assembly rods, as I pointed out. They do not have the typical operation history. So, that's what we're looking forward to with the sister rods

Okay. There was a second question from the telephones? Robin?

I'm currently showing no further questions or All right. We're at 12:30. And if we don't have anymore questions either on the phone or in the room, then I can consider ourselves to be in recess for lunch. And we will start promptly in an hour and 15 minutes

Let's give a round of applause to our presenters.

The first session after lunch is always a challenge. But I am happy to say that they are up to the challenge. We have some very, very interesting presentations this afternoon. And my name is Chris Bajwa. I am the Acting Chief of the Containment Structural and Thermal Branch in DSFM. So, you all didn't come here to hear me speak, so I'm going to just jump right in to the session and the presentations. The first presentation will be from Bernie White. He joined in July of 1990 as a Nuclear Engineer in the Cask Certification section in the Transportation Branch in the Office of Nuclear Material Safety and Safeguards. Fun times. Mr. White held progressively more responsible positions with packages and storage casks. In October 2001, he obtained the position of Senior Criticality and Shielding Engineer. He was selected to be the Technical Assistant to the Director of the Spent Fuel Project Office, and then he transitioned to his current position, Senior Project Manager, Division of Spent Fuel Management. Bernie?

BERNIE: Thank you.

Chris. It just makes me sound old. I will be talking about transportation certificates of compliance, and the basis behind that term. So, next slide. Here is a bit of an outline of what I won't even go over, because they are just a bunch of information, which I will share with you certificates for transportation packages has always been more or less five years. If someone comes in early, they get it done early. If they come in late, they always get the five years.

The IG did an audit in 2017, the Office of the Inspector General with the NRC. Did an audit of the oversight for issuing certificates of compliance for radioactive material packages. They found that the Agency is relying on informal practice used by the staff. They queried everybody, almost everybody known to man at the Agency as to where the five-year term came from. Being the oldest one in the group, I had no idea, because it preceded me. Our Office of General Counsel did an in-depth review going back to even before we were NRC, and they couldn't find any basis for that term, any technical or regulatory basis for that term. To the IG determined that we're using an informal practice. It had no regulatory and technical basis to justify the five-year term. Not that it was wrong, there was just no basis to justify it.

And that NRC was imposing a requirement without in the slide, conduct an analysis and communicate the – regarding the technical basis for the certificate of compliance term. So in developing our regulatory basis, we had a government to government meeting with the Department of Transportation. The Department of Transportation issues certificate of compliance. So, we had discussions with hem about the domestic and international implication of the five-year term and whether it was longer or shortened. We evaluated the risk studies that were done for the NRC for transportation. We held a public meeting with stakeholders.

At the 2018 transportation safety standards committee, the IAEA, we had informal communications basis and its appropriateness. And we evaluated that along with the risk studies, and we developed a basis. So I will go over a little bit about each one of those. So, here is the four risk studies that we have done at the NRC for transportation. The first one, NUREG-

171 was the basis for 71 in its current form. It was done in 1977, and predates most of the technology that we have now to do a lot of the analyses that we have. They probably used slide rules. It wouldn't surprise me. In 87, 2000, 2014, we did the remaining studies. There is a full citation for each of these, if you're interested in further reading. So, when we reviewed the risk studies, what NUREG-170, the oldest, 1977, it focused on normal transport conditions and accident involving the transport vehicle. It looked at exposure of workers and members of the general public along the transportation route. The results were that risks to members of the general public was low, and that risk from accidents is small as well. Each of the subsequent studies that I showed earlier, the one in 87, 2000, and 2014, each subsequent study was a little more advanced, and each concurred that the risk was lower than what we found in the NUREG-170. The more precise you can be subsequent study than previously thought. As I said, we had a public meeting on this. We had outreach to stakeholders on April 26, 2018. We discussed the genesis of what we're doing, its purpose, developing the term. Some of the questions that we posed to stakeholders at the time were what factors should we consider as we evaluate a basis for the expiration term? How should we factor in risk? Or should we factor in risk? Is it appropriate to do that based on the fact that we approve a design and not a specific package? What are the national and international impacts as far as stakeholders are concerned? If we were to change the certificate term? And what are the implementation challenges of maintaining or changing the certificate term? We got some good important. Stakeholders felt that consistency between the U.S., between the NRC and DOT and international stakeholders was important. Risk, by itself, for the certificate term for a package expiration, it had no bearing in the risk. The risk is how you fabricate a package, whether it's fabricated in accordance with design, and maintained in accordance with design. Its use was more important than the term we put on the package and design.

Again, in 2018, we had at the TRANSSC meeting, we had outreach with international counter parts, and asked them about what their thoughts on the five-year term. Some countries, if you have packages approved, you know this. They may do a complete review of the design basis. At the NRC, we don't. We review it every time we do a renewal. They rely on operating experience to determine how the package performs. They felt that consistency was important, and that the five-year term is consistent with the current revisions of the IAEA regulars. They change on about a five-year basis, give or take. And all member states that we talked to recommended using the same term across the world for certificates of compliance.

So, the conclusions that we drew from this is safety is associated with fabrication and use of the package, not with the certificate term for the package design. The design on paper has no risk associated with it. It's the use of it. NRC staff has determined that a five-year expiration term is appropriate. Having said that, certificate holders can request a longer expiration term or come in well prior to the renewal to request an expiration date.

We've heard from some certificate holders that it's taking up to a year to get their certificates revalidated in other countries, so they're starting to come in even earlier requesting renewal. This ensures consistency with DOT, international counter parts and the IAEA international safety revision schedule. So our next steps are to finalize the basis document for the term. We

will be finished with that by the end of January. Either concurrent or shortly thereafter, we'll publish a notice in the Federal Register indicating that we have finished and completed it and it's available for public review. Our Division Instruction on Part 71 guidance has documented that term. So, it will be there for future generations. That's it. [Applause]

We have a few minutes for questions, if anyone has any questions.

Questions at the end

Okay. We're holding questions until the end. So that means we're going to move on to our next presentation. Our next presenter is Gerard Jackson from the Office of Nuclear Security and Incident Response. He is currently assigned to the Fuel Cycles and Planning, Coordination, and Management -- policies and programs for transportation security and physical protection of physical material during all phases of transportation. He conducts technical and regulatory reviews in support of regulatory programs, transportation approvals, rulemaking, and licensing. He manages partnership, outreach and coordination with U.S. government agencies including the Department of Energy, DoD, Department of Homeland Security, and Department of State. He represents the answer to the commission's tribal policy working group, supporting development, implementation, and outreach for transportation issues.

He works with the International Atomic Energy Agency in developing guidance for transportation security. Gerry? I will talk a little in left field here. We've talked an awful lot about the safety process and the safety reviews that we're going to spend. I'm going to take a dive into Part 73, which is the security requirements. The 73 is the overlay of the entire process. So, my presentation will talk a little application, the acceptance program, how we do it, the format for that application, how shipping routes are selected. Then I am going to talk about pre-planning and coordination, which is the key of the security program. And then a little bit about advanced notification.

So slide, please. So in application. If you're going to move spent nuclear fuel, you have to put it into the NRC for review. We're going to take a look at it. The acceptance review is going to be information is safeguards in there. We're going to look at the format. And in that format, what's the route you're going to take? The mileage? Have you gone out and actually driven the route? Review, when you do a route, every county, every state, every locality, and the states and if opted in tribal representation will have contact number, 24-hour contact numbers, locations of local law enforcement that will come in and respond if required to an event. So, we will look at all of those. We will look at the distances and some of the LOEA coordination. We're going to issue an acceptance letter. A lot of that information is found in NUREG-5061. This is nothing confidential. But what you develop and generate out of this can develop into safeguards information. In this document, it includes examples of route selection criteria. I'll touch a little bit about that. And it also has a blank template in the back that you can use to develop vacuum, and I'm going to touch a little bit about DOT requirements as well. When you're moving spent fuel, you look at transit time. The less you're on the highway, the better. You look at availability of local law enforcement. If you're moving material across hundreds of thousands of miles,

depending on when the interim or final repository ends up, you will have a lot of for a tractor trailer to pull over? Are they still there? Did the, you know, truck stop close down in the year between when you did the application and you got the acceptance letter, and you're going to move the material. Have you gone and made sure that the truck stop is still there? Technically disadvantaged positions? Are you going to move along open roads where there's no local law enforcement or no law enforcement? Are you going to go through restricted avenues where you can't make alternate or deviations. Have you taken driver considerations into play? Are you going to park the vehicle overnight? If you do, what do your security requirements look like? So and you can start filling it in. The tribal situation is if a tribe opts into being notified, they go on the website for the notification. I'll touch a little bit about notifications on the end. 24 state phone numbers. Every state has a 24 hour emergency contact. That's on the NMSS page. Who's that person? Their name? 24 hour contact notice? That information goes into this document as well. I actually have called, and I know most of them, because I've talked to them. Who's the rep? Who's the person that's going to receive the notification? Have you talked to the sergeant? Who's going to be providing the law enforcement escort? And again, what is that path across the route look like? So, as I mentioned, DOT plays a big part. NRC requirements were not established in a vacuum. When we looked at the revision, and we looked at DOT requirements, they have requirements for security plan, for driver training, emergency response procedures. So, by reference, R71.5 requirements, you have to look at the DOT requirements and make sure you're adhering to those as well. So, just a little more detail. I'm not going to read all of these for you. You can pull them up if you want. [Reading] So those are some of the DOT requirements as well. It was redundant.

Those requirements are already out there. Once we look at all of that, once I get this application in, and it takes anywhere from 24 to 40 hours of staff time to sit down and look at this document, I look at your route. I look at your phone numbers. I go on Google earth. I go on Google maps. I go on websites. I have proprietary software that I have access to that I can look at truck stops. What are their lighting conditions? What are their roadway conditions? Can you pull off? Have you made the proper coordination? I've got a great story. One of the routes that I looked at, there was a sheriff's department along one of the routes that we were going to be moving material. It was not spent nuclear fuel, but another type. But the sheriff wanted to be the safe haven, and it was his house. And his house had a long driveway. But it had a long driveway with a great big turnaround on it. The licensee was like, the sheriff wants us to drive to his house. Is hello call law enforcement? Is he going to be there 24/7? Does he know you're coming? Yeah. The sheriff's house is your safe haven. You pull off, and that's what you do. With us, you have to look at a lot of different variables, and that was just one of the variables that the sheriff wanted to be. And the neat thing is he was one of the only law enforcement agencies along a state route that they were going to move the material. So, it made natural sense that the sheriff was going to be the first responder. So pre-planning coordination. This is my favorite part. And you're going to hear a little bit about this. And you're also going to hear from Marc from NEI and Gil from the Navy, and they're going to talk a little about table top and full scale incidents. You don't want to be out there exchanging business cards at 2:00 in the morning when the bad thing happens. You want to pre-plan and coordinate your response activities before it happens.

These gentlemen have presentations on that type. I love this phrase. Yeah, yeah, I coordinated. Have you? Okay.

Slide please. Preplanning and coordination. I'm not weeks. We get route information requests a year ahead of time, because it just takes that much time. There may be back and forth questions. I may find problems with your application. These are the requirements we're going to talk about. Minimize delays in stops. Arrange for state law enforcement escort. What does that escort look like? Is South Carolina going to be the same as Pennsylvania, the same as New York? They're all going to be different and you have to take that into consideration. You have to arrange the hand-offs. Positional information. One of the neat things now is we have GPS.

Everybody has it. You can do geofencing with the truck. If the truck goes off, you're going to get notification. So, the positional information sharing is really key to the response capability for the protective strategy for this material. Developing your route information. Most of the folks that I know that do this actually drive the route. They go down the looking at truck stops and bridges and overpasses. They're talking to the state DOT. They want to know the weight capabilities of that bridge, because we're going to be moving a very heavy load over that bridge, so we want to know the capabilities. We know the safe havens, the local law route review? Could be. You would be surprised. That happens. You don't want to do that with a cask of material on the back of a heavy duty flat bed. Local law enforcement escorts. The you want to do the hand-off, safe havens, hand-off between states. Positional information.

Slide, next one. What do your roads look like? That's I-10 California after a down wash. They had a sudden rainstorm. I-10 was a route that a company was going to move material on, and now they're not moving material. The state said yeah, you can't go over that bridge. Obviously. But they coordinated with the state. They understood where they were, where they had to go, and what routes were available to them. They called us up and gave us notice and said we had to change the route.

Okay. Did you talk to locals? Did you talk to the state? They made the coordination. Developing community? The slide on the right is the baseball field. They were going to move material across Pennsylvania, and the Little League World Series was going on and they wanted to move material at the same time, and the low call law enforcement said no. We're going to be busy. There won't be enough response. We're just not going to have people there to do the escort, and if something happens, we're not going to be there for the response. Again, that goes to the coordination piece. What does your weather look like? Have you looked at weather.com? What's going on? Safe havens. The one on the top right, I like that one. The one on the lower left? Not so much. Okay?

Slide, please. Arrangement with local law enforcement. Who, where, what, what material? What are their capabilities, I can't talk about the safeguards. Response times, weapons capabilities, tactics. But you need to know that and understand the capabilities that local law enforcement can bring to the fight. Notification. States and tribes.

Slide, please. Notification to tribal and states. More details. We don't need to read that. Plus I got the five-minute notice. Next off. We look at it. Goes into a calendar. We track that.

Next slide, please. If there's changes, and there has been changes, I got a phone call. Bridge washed out. We change it. We make the adjustments. If you had to cancel it, you send a cancellation notice to the states and tribes as well.

Slide, please. How did I do? Good. Questions? Oh, that's right.

Sorry. Thank you. [Applause] .

CHRIS BAJWA: Okay. Our next speaker is Brady Hanson. He did such a smashing job in the previous session, that we decided to bring him back. This is his encore performance on spent fuel degradation issues, extended storage and transportation and service. Lab lead -- NOA science and technology programs. Brady. [Applause] .

BRADY HANSON: I need to apologize. You are getting the B team. The rest of the team are all in Germany right now, where very early this morning our time they conducted the first of two 30-centimeter drop tests on a third scale cask where the sole purpose is to look at what the accelerations of the assemblies inside were, so we can then drop a mock assembly with the same accelerations to figure out what the strains are during that. So, I got stuck to talk about something that I am not a real expert in, but I was asked to show the following video that talks about a test that you probably heard about a little last year, but seen it in video form is better than PowerPoint slides.

So, the reason we did this test is, like I said this morning. We were looking to see what kind of strains we would get in fuel during normal conditions of transportation. A number of cycles we have. Oh. Thank you. And you know, so we were going to elate this to the Oak Ridge surf test to make sure we their casks to use, fresh off of fabrication. We filled it with dummy assemblies. First, we loaded it with three surrogate assemblies. So, they look like real assemblies but do not have fuel in it.

29 just dummy mask assemblies. Lots of strain gauges and accelerometers all over the place so we can look at transmissibility. Everything with GPS and a very large data acquisition system. Even with all of the 20 large batteries, could only last for 17 days. You're seeing the dummy assemblies going in. That's one of the surrogate assemblies with all of the strain gauges attached to it being loaded into the cask. That was lots of fun with all the cables we had to pass through that. This is a full scale ENSA31P. The first test we're just handling to simulate putting the cask down. So, lowering it from 30 centimeters. Had different crane operators do it. Purposely emphasize, we had three different countries. The footage you're seeing right now is at the company in Spain. We had Korea participate, and of course the U.S.

First test was going from Spain doing a heavy haul truck test, because that's what the Spaniards are going to do, what they were casts to rail yards. You can actually see the truck right behind that is actually a pusher truck. They don't have the nice, powerful trucks in Spain that we do here. So, to get up the hills, we actually had to push out and pull. After that was done, loaded on to a, quote, barge. It wasn't a barge, but near a coastal transport with multiple stops going from Spanish facility in Santander going to Zeebrugge, Belgium, to be put on a large ship to be transferred to Baltimore.

We did pass through a pretty decent Atlantic storm, I was told. Once we arrived in Baltimore, we transfer the cask and cradled everything on to a 12 axel rail card. It went by rail to Pueblo. On the way there, did dedicated. How anything moves by general freight, I don't know, because that took 45 days. Getting the data acquisition and everything hooked up as it was put on the railcar.

The box in front, by the way, is the data acquisition system. And the big truck batteries? That's accelerometers being placed on the end of the conveyance. So, when we went by dedicated rail on the way out to TTCI so we could do what we call dedicated rail test. We know exact track conditions. We know exactly speed of the locomotive. Everything is well instrumented. Wheel set's instruments, and we can test conditions that are not supposed to exist in real rail, going much hour. You're not supposed to do that when you have real spent fuel. We were pushing the limits to see how that affected strains in accelerations. You can see a notch in the track to simulate different track conditions and a jump. These are the coupling tests where we did them forwards, backwards at different speeds. Those are where you got the largest shocks.

Once we were done at TTCI, sent it all back to Spain, and those four people there are the real A team, the ones that you should contact with any questions on this. Now we'll switch over to the boring death by PowerPoint real quick to see what some of the results were. As we said, we had accelerometers, strain gauges everywhere. In the first slide, there we go. In the green, we're seeing accelerometers that were placed on each end of the cask. The orange dots are triaxial accelerometers placed in the two different corners of the cradle. The blue represents where the triaxial accelerometers were placed on the actual railcar deck.

As you might have guessed, those at the end where you don't have the weight flop around a whole lot more than the one in the middle. So, the ones on the ends weren't really representative of what the cask sees. So this, then demonstrates where the strain gauges and accelerometers were on the three different surrogate assemblies that were inserted. One assembly that Sandia lab put together, and one from KHNP in Korea. We did a lot of pre-modeling to see where do we think the maximum strains in corners, because that was modelled to have the most response to vertical shocks. The blue assembly on top was placed there, because that's where you would expect to have the most lateral shock and so here are some of the results. First row is the peak strains as measured by the strain gauges are. Notice that is in microstrain, highest being 96.

Again, during one of the captain trap tests at TTCI, that is between one and a half and two orders of magnitude less than strain needed for failure. The other rows show accelerations. And

at TTCI, where we were pushing things beyond where you are supposed to be is where we typically had the highest observed levels. And it is interesting, at least to me, to note that the westbound rail, where we had a dedicated train versus the eastbound rail, where it was just general freight, you can see the differences there.

And just know that when we ship -- the plan is when the Department of Energy finally ships spent fuel, whenever that may be, it will be by dedicated rail, so that's important appropriate to look at. Have I gotten a sign yet? Just kidding. Oh, I did! I just wasn't looking. So the important thing is we talked about these strain gauges. Of course, that's very localized on your cladding. Nick, who works in the same group as David and Jim, and their boss, Tom, sitting right there, so pick on him if you have any questions, did all of this modeling using the structural dynamic model. So you can take what that strain is localized, sum it up along the length of the entire rod where all the different strains would be, and you get the strain energy. It's listed at kinetic energy in this table. And I thought Nick did a pretty good job of trying to say how do I relate that kinetic energy that this one rod sees to something that the public can understand?

Because when you talk in millijoules or microstrains, it doesn't mean much. You can see where he has that bracket that says one rod? What that says is what we observed during all of this testing, truck, ship, train, going to conditions beyond what we would expect, it's about the same as one.

So, if you stop and think about it, as I said this morning, even if I have a brittle material, which I don't, you know, I am not subjecting it to enough energy to cause that to break. So, in addition to the strain that might cause failure, you're interested in fatigue. So if you think of just taking a paperclip and bending it, if you do it just a little bit at low amplitude, it's going to take a lot of cycles, but ultimately, that paperclip will break. If you do big doing a lot of little vibrations and every now and then you would have a big one. What this graph shows you is Nick has taken all of these different shocks and vibrations, summed it all up in a cumulative fatigue damage fraction, and all of these are less than -- on the Y axis -- the number up on top is ten to the minus tenth. What that translates to is what I have down on the bottom. I need more than 10 billion trips of 2,000 miles each before I have enough fatigue that could possibly cause failure. I don't think we're going to ship fuel that many times. I have heard of 72 to 71 to 72, but not 10 billion times. I hope not, anyway. Next slide, last one.

So, conclusions: We were actually very surprised. We did not expect things to be this low. But shocks and vibrations are very low. We honestly don't believe that there's any issue with cladding performance during normal conditions of transport. But the most important thing is that little figure at the bottom. So, as many people have said to us in the past, okay, we were using surrogate fuel assemblies. You know? It wasn't spent fuel. We don't have a railcar that's Sandia, and at PNNL, is taking the data that we just showed you, developing the models, making sure we can validate those models with that data. And then we're taking the data such as what Rose presented from what they'll be doing on the Sister Rods, and coming up with the mechanical properties of actual spent fuel, plugging those into the models, taking into account different cradle designs, different cask designs, and putting that all together to say, okay, when we do a

real shipment, what do we expect? The hypothesis being not much is going to change over what we just saw. So if you just throw up the last slide, I don't have anything to say to it other than a list of references that if you're interested in the details, please let me know, or these are available from Department of Energy.

Thank you. [Applause].

CHRIS BAJWA: Thank you, Brady. Our next speaker is Marc Richter. He has 32 years of experience in nuclear energy, including 24 years with Constellation Energy, and its predecessor. He is currently the Project Manager of Decommissioning -- Dry Storage Vendor Task Force, and Materials in Aging and quality issues. So, he does not have time to do anything else. He earned a Bachelor and Master of Applied Sciences from the University of Delaware, and a Doctorate of Material Science Engineering from Johns Hopkins, and a Master's of Administration from the University of Baltimore. Marc. [Applause] .

MARC RICHTER: Thank you for the introduction. First off, I would like to thanks NRC for inviting me to speak at this year's Reg Con, and providing us an opportunity to share with this group sort of a unique activity that we're in the midst of undertaking relative to the transportation of used nuclear fuel. The transportation of used fuel has been I'm going to suggest maybe on the back burner for a number of decades until very recently. I think it has been moved much closer to the forefront of the national discussion, at least as it relates to nuclear energy within the past several years we have a bow wave of nuclear power plants that have announced their intention to decommission ahead of the expiration of their license or are already in the process of doing that.

Along with that, immediately comes the question, what are we going to do with the used fuel? Certainly there's many entities out there that would love to have that fuel removed from their decommissioning site out of the neighborhood. There are other entities out their backyard. And you have other entities out there that would just like to cause general mischief to this industry because they just don't like us for no particular reason. So, you have to deal with a pretty broad spectrum of interests and motivations when you start talking about used fuel and its transportation.

In the context of plants that are shutting down and the competitive environment that they're in now, you hear a lot of discussion about total value proposition, and presenting to the marketplace and presenting to the community at large, just what is that in terms of nuclear? You can conclude that must be megawatts, capacity, bridge stability, fuel security, things like that that enhance the overall quality of life and the security of our electric grid. But it's really more than that. And that's what we refer to when we talk about the back-end. The back-end activities really haven't gotten a lot of glory over the years, but they are certainly as impactful to the total value proposition as a healthy, safe operating plant. We have been accumulating funds for a long time in a decommissioning trust fund. We have used fuel activity in place now with a consolidated interim storage facilities that may offer possibilities, hopefully in the relatively near future as to provide a place where we can move the used fuel, at least on an interim basis.

Define interim, I'm not sure. That could be 100 years or a million. That depends on your perspective. With that said, the ability to manage the used fuel that's aging. The ability to transport it and do it efficiently and safely really has a lot of potential impact when the overall value proposition for nuclear. That could be in a good way or a bad way. If we can't do it safely and we do it inefficiently, that will add further fuel to the fire to the groups that are opposed to nuclear, and throw that up as another impediment. This is just one more a position that we want to be in. So, what NEI hopes to do, in part with the tabletop exercise, which I'll describe, is to really demonstrate not just to the industry community, but to the public at large and other stakeholders, whether it be politicians, community groups, tribal groups, that there really is a pretty good understanding within the industry of what it's going to take to do this. It has been done before. There's a pretty long and very unexciting history of moving used fuel in this country for the last 50 or 60 years, primarily Navy fuel. And you don't have activity that just flies under the radar screen.

So the tabletop exercise itself is going to be held at Prairie Island Nuclear Power Plant. They very generously have offered their facility as a host site, a large meeting or conference area to physically conduct a tabletop. The tabletop will really not literally be one table, but it will be a collection of assembly of individuals from all of the involved stakeholders. The licensees, the fuel transport and shipping companies, public utility commissions, tribal representatives, local law enforcement, emergency management personnel, and there's a long list of others that we're working on developing to participate either as active and engaged stakeholders in the process or simply as observers. And what we hope to do on the table top is to demonstrate through dialogue and visual aids, such as some PowerPoint slides, photographs, some video clips, the actual discussions, the decision-making, the thinking that goes in to initiating the move of used fuel. That would go from the first thought that the owner has, I want to move fuel. To the point that it is resting safely in the consolidated interim storage facility at the other end of its journey. A couple of things that I wanted to point out relative to this particular exercise, there are some assumptions that we had to make going on. This exercise is going to demonstrate a private shipment model that would be closely aligned with what we see with the two consolidated facilities that are in the licensing process now. Department of Energy will not be participating.

We've invited them. For reasons related to budget and appropriated funds and so forth, they're not in a position to support it now, but they will be participated as interested observers. One of the other things that we into the scenario where we can demonstrate and exercise some of the various aspects that the fuel would encounter on its journey. So, rather than just selecting one location, we have created a virtual power plant, which would represent all of the physical attributes of cold and dark, near water, Kewaunee. We will overlay in the Kewaunee physical location, some of the stakeholder issues that Prairie Island is experiencing with tribal communities in the area to create this broad spectrum of challenges. The shipment itself, if you look at a map, three modes of transportation may not be the most direct or efficient. We will choose a route that exercises the ability or demonstrates the ability, rather, to move it over land by heavy haul trucking, by barge over water, and then also by rail. The rail head at the other end of its journey is going to be conveniently located somewhere near the border of New Mexico and Texas, near the town of Hobbs.

That was clearly chosen for reasons as well as it relates relatively conveniently to both of the consolidated interim storage facilities. Other things that we would like to address as part of this table top exercise is providing the side discussion or a side presentation where we step through and review the Price Anderson requirements and applicability to transportation of used fuel. We will step through what we believe the NRC requirements that are applicable here, Part 71 and Part 72, and have some hopefully meaningful discussion about process and how the industry will be ready to meet those requirements. On the back end of all of this, we will be videoing the Table Top, and hopefully we can produce two products from the raw video. One being a short production that can be shared with communities, tribes, other stakeholders that gives a -- pardon the pun -- a big picture of what transporting used fuel is all about to increase understanding and hopefully create a level of comfort and assurance that yes, the industry does have their arms wrapped around this and can demonstrate a good understanding of what it takes to move fuel to allay some of the unfounded fears that the anti-groups kind of stoke out there in the communities. And then the other video we hope to put together is more of a how-to video that goes into greater detail about process, the rules and regulations, the interfaces that need to take place between the private entities, the state and local governments, emergency responders and so forth. That would be designed to meet the needs of the specific companies that are involved in moving the fuel.

And also, subsequent to the completion of the exercise, NEI, with the help of many of our industry members, is going to be putting together two written documents. One will take the form of an NEI guidance document that is more or less a how-to in terms of what it would take to move fuel. It would basically replicate the processes that we've laid out in the Table Top scenario. And the other written product that will be put together along with the guidance document as a white paper, which may ultimately take the form of a topical report that presents in a coherent way a case where we can take advantage of some of the good information that's come out of recent research and test results from the DEMO cask as it relates to thermal performance and thermal modeling, and how we might be able to leverage those good results to make transportation of used fuel more efficient and ultimately safer. Because that is the greatest goal of all in the end, if we can do it more efficiently, maintain the high level of safety that the industry has enjoyed through the decades, then that will be a big achievement and a big plus for the industry. So with that, I've concluded. [Applause] .

CHRIS BAJWA: All right. Our last speaker in this session on Spent Fuel Transportation is Roy Pratt. Gail Pratt has been part of the Naval Nuclear Propulsion Program for 23 years in the reactor refuelling division. 16 years were spent on packaging for dry storage, shipping, and disposal. Three of the years refuelling and four on submarine refuelling.

So, Gil? [Applause]

GIL PRATT: I think I have the most slides this afternoon. There's a lot to read. We will all have access to those afterwards if you want to continue reading them. I'm just going to hit the high

points. Who are we? We are a joint agency within the Department of Energy and the Department of Navy.

Next slide. Here are the topics I'm going to cover today. I will start with a quick overview of who we are, and then move through some information about our spent fuel shipping program. So we are responsible for the nuclear all of the aircraft carriers and submarines in our fleet. That makes up almost half of the Navy's major combatants. We have training and research reactors as well. And for those reactors, we have a cradle to grave. That includes helping figuring out what the fleet needs are.

Research and development, design and fabrication, testing, installation, testing, operating training, maintenance, refuelling, decommissioning, and disposal. For all of those activities, we both develop, promote them, and regulate those activities. Okay. So, talking a little about our shipping practices. Next slide. Our mission requires us to ship new and used core components for national security. Next slide. Most notably for this discussion, all of our spent fuel from all the ships and training reactors goes to Idaho for examination, processing, and packaging for dry storage and repository disposal, hopefully. Next slide. We have shipped almost 900 spent fuel containers to Idaho over the past 60 years, and we're currently shipping from four shipyards shown here. This gives you an idea about how many states we pass through. We do go coast to coast in our shipments.

Next slide. So a little bit of information about the three general aspects for how we know our shipping is safe. Our first layer of protection is the fuel itself. It is designed to be inherently rugged due to being designed for operating for decades in warships and being able to handle battle conditions, survive them. Next slide. When we take that rugged fuel and put it inside of our shipping containers, here is some information about those containers. They do provide a formidable barrier for release of radioactive material or increase of materials following hypothetical conditions. Next slide. Third major element is that we take very good care of our railcars. We do monitor the progress of our shipments continuously. We conduct a lot of outreach with state and local response personnel, and we escort our shipments using Navy couriers. In the event of a shipping accident, the rubble fuel on the robust materials control the radio levels of the radioactive materials. Our couriers would focus on till first response.

Next slide. We do perform periodic shipping container accident exercises to familiarize state and local responders with our shipments and coordinate coordination and communication during accident response.

Next slide. We've conducted 11 exercises since 1996 along our typical shipping routes, held in New York in June of 2017. We're currently in early discussions for our next exercise, potentially in Missouri in mid to late 2020. Next slide. A wide variety of organizations participate in each exercise. Here are the state, county, and local organizations that participated in our last exercise up in New York.

Next slide. Our planning for each exercise takes quite a while as I'm sure NEI is experiencing. It takes us typically about a year at this point.

Next slide. The typical exercise involves railroad, local and state response to a simulated collision that derails one of our shipping container railcars.

Next slide. So, here I've got a few photos to kind of set the scene for our last exercise up in New York. What you can see on this slide, the simulated accident location was at an intersection that we're going to zoom in on in a little bit, and the actual exercise occurred three quarters of a mile away in a nearby rail yard. The simulated event was a dump truck colliding with our railcar as it crossed the intersection. Zooming in a little bit to give you a little better view of the intersection.

Next slide, ground level view of the intersection. Next slide. There's the zoomed in version of the rail yard.

And the next slide, this is the layout at the exercise. You can see what appears to be drawn in with PowerPoint or some other package, there you can see the bleachers are in green. The locomotive and railcar assist is in orange and blue. Railcar is the red circle. Truck is the red box in the bottom right. This was the arrangement during the exercise itself.

Next slide. I've got a couple of shots here showing the level of interest in our exercise. This was the spectator gallery, not including the direct participants. Next slide. Same, from another angle.

Next slide. Then I just have ten images here showing what the event looked like from various points of view as it unfolded. Here is the locomotive and our railcar approaching the railyard. There is the locomotive is stopped.

Next slide. Another shot of the railcar.

Next slide. Next slide. Next slide. Next. Next. Next. I think that was the last one.

Next. Okay. So, as you can see, there are a lot of different people involved. And with the number of response organizations involved and their various responsibilities, coordination and communications are complex challenges, which is a big reason we do these exercises, as I mentioned. The network of communications frightens me every time I look at it.

Next slide. Another current communication and coordination opportunity that we have is the movement of several different shipping containers through Boston New York to support one of our training and research reactors. There is no rail access to the site, so we have to use heavy haul from the nearest rail site. As with the exercises, we started planning with state and local officials about a year before the first shipment. Because the heavy haul transfer and the shipment are more disruptive than just passing through town on rail, we also engaged with residents directly. As you can see, we did door-to-door discussions. A local paper published an article about our first shipment. Next slide. So, a couple photos of that heavy haul. You'll notice

this is the same M-140 shipping container that was in the exercise. There you can see some coordination with local utilities to move those power lines, traffic lines.

Next slide. This photo which was taken by a local resident from her driveway shows why it was so important to build the trust of our residents that we do take the safety of our shipments very seriously.

Next slide. And lastly, since I've already showed you some photos of our M-140 container, I would be the fleet. That is on its custom railcar. Next slide, moving it around at the shipyard to prepare it for loading.

Next slide. That's a staging area before it goes into be loaded.

Next slide. And this is the first loaded shipment carrying en route to Idaho.

Last slide. That's it. Thank you.

[Applause] .

CHRIS BAJWA: That concludes this session.

We have about 20 little bit. Do we have any questions from the floor? Question?

Question for Bernie, and if you described this already, forgive me, I wasn't paying attention as closely as I should have been. To extend the period for the certificate of compliance, is that something that a CoC holder would do and say here is why I want ten years and here is why it is okay?

It would be part of the renewal request.

Is there anything special you would need for that extra five years that you're looking for? [Laughter]

The answer I really want to give you is no. But, what we would probably do is go back and look at the age of the documentation for the package. I've got a couple packages now that we have renewed that documentation isn't there. All they have letters asking for renewal. We want to make sure the documentation is doable, so we may request a consolidation off the top of my head.

Anybody else in the room? Robin, do we have anybody on the phone that would like to speak?

At this time, I'm seeing no questions, but as a reminder, that's star followed by one if you have a question or comment
Okay. Am I spoiling you guys with real long breaks?

I have a comment

Okay.

Not really a question, but a comment. I can't resist making it. This is Marc Richter with NEI. I spent ten or 15 minutes the public and other stakeholders that it can be done safely. And we need to do these things to allay fears and counter some of the emotion that's out there that would oppose what we're trying to do. Fine. I sit down and the gentleman to my right stands up at the podium and shows us an impressive set of slides that shows large used fuel containers crossing across the country on challenge here, and maybe it's not technical. To me it seems paradoxical that we even have to have a conversation about how we can do this commercially when it's been done for 50 or 60 years routinely across the heartland of America. Food for thought.

Excuse me. We do have a transportation, but rather the fuel itself and storage in dry cask storage. I would like to ask for all studies that have examined the question of if a canister is breached and the helium rushes out and air rushes in, whether there can be a fire and or hydrogen explosion, particularly if the passive current gets diminished. And what would happen if water were able to enter a canister? That would be all who have examined that risk. Both ones that say the risk is high and low. All that's a little bit outside the scope of this particular session. However, I think if you would like to have that kind of information, that you should contact the Agency for that information and make an official request. We can't provide that to you right here and right now.

Okay. Thank you.

And we do have another question or comment that came in from Donna Gilmore.

Please state your company.
Hi, Donna.

Hi there. Two things. Maybe shipping. Is it?

Can you answer that one?

Yes. Can't give you too much detail, but with the M-290, the fuel is sealed. The container is sealed and leak-tested before it goes. There are several understand your question correctly

But the difference of hardened fuel rods designed for the stems? And that's highway 10, I think was in an earlier photo. That had just been inspected a few months earlier and deemed safe. So, for NEI was able to do this by rail on a poorly rated rail system across the country, and try to compare it to military that's oranges and apples.
Point well taken.

And you have the high burn up fuel rods that we have no idea how brittle they are, because we can't open these canisters. And how you can even consider shipping high burnup fuel before inspecting it before the shipment seems very irresponsible. Thank you.

Okay. Thank you, Donna. Does anybody want to respond to that? Is there anything to respond to? Okay. We'll take that comment under consideration and put it in the record. Is there anybody else on the phone?

There are no further questions or comments at this time

How about in the room? Okay. Just like this morning, when we end a session early, we can't begin the next session and they are not able to get online until 3:30. Once again, you guys can, you know, have a little bit of a longer break, because unless we've got any other business, it's break. [Applause]

Please be back promptly at 3:30.

You have a chance to use your cell phones on that break. If they're still on, please turn them off or put them on pause. When you are making comments after the end of the presentations, please make sure that they are on topic and concise and precise so that we can finish on time today. I'm going to turn the meeting over now to Rod.

ROD McCULLUM: Welcome. To try to increase the probability that you will all stay, I will reveal the latest and greatest as far as what is happening in the White House and congress. But we will save all of that until the end, because we have more one of the reasons I'm less prepared as I normally like to be, is a lot of silliness has been happening around the other thing. You may have heard me say it before, but dry cask storage has gone from being an unanticipated solution to an unexpected problem to being one of the great industrial success stories of our time. And we have to my right, we have three gentleman who really own that success. Three gentlemen who have risen up through the business and made that happen. I think that they represent three highly competitive – and we're all going to be nice to each other right now -- but three highly competitive companies is very much a positive. They're all involved in two highly competitive interim storage projects, which I think is also a positive.

The competition helps drive innovation. If you buy a car or a smartphone or even fly on a newer industry, we need to innovate to survive. These gentleman have driven a lot of technology innovation, which has made the dry cask business very rapidly successful. But we also have to business models that are very innovative, too. But we're here to talk about in a lot of these sessions the regulatory framework. Brian, have we loaded cask 3,000 yet?

I'm going to say yes.

ROD McCULLUM: I think we have. You're going to verify that soon. So, what have we learned? A lot of innovation. We have had 3,000 casks loaded. They're all extremely safe. Now it's time to apply those lessons learned. Because what's happening right now downtown is very silly. We may or may not get help in terms of a final disposal solution in the near term. We may very well be consolidating these dry casks, and we certainly are going to be managing them for long periods know, I'm hoping that the spirit of innovation these gentleman can bring to this final session can help for us to think about how we can take the technological innovation and bring the same spirit into how we regulate something we now have a lot of experience with.

And maybe that can be a platform for some discussions tomorrow and going forward to future events. I'm not going to read their bios, primarily because I just saw them the first time seconds ago. I am going to introduce all three of these industry leaders. First is Prakash Narayanan. He is the Chief Technology Officer at Orano, and brings over 20 years of experience to that position. I am looking forward to seeing Prakash's vision for the future. [Applause].

PRAKASH NARAYANAN: Thank you, Rod. Good afternoon. It's an honor and a privilege to present at this wonderful conference and provide our perspective on what spent fuel management is about. If I let Rod McCullum speak for ten more minutes, he probably would have covered much of my presentation. So, thank you, Rod. So, when Rod approached me about this new type of session in a Regulatory Conference, talking about a vision and talking about crystal ball, and trying to figure out. And you know, it's very difficult to have that kind of vision in a presentation form, especially following Rod. I have seen some of his perspectives at the end of the dry storage conferences, and he has a couple of pictures and just tells a great story throughout. So, I'm the old-fashioned pipeline guy, so this should hopefully I have some interesting things to say. In the end of the presentation, things will come together. Here I present a small vision of what we think about spent fuel management. Next slide, please.

I'm going to try to frame my presentation through into two aspects, one on storage, and one on transportation. And of course, we all know that it's often talked about the 71, 72, 71, 72 type. So, it will all come together, at least from the storage side and I will try to tie in some perspectives on what ISF licensing could mean or ISF visioning could mean. But really, they are two different issues, and I think we have ways to make them, at least the way I see it. And I will have some good conclusion for what we all think of this. So, this picture is about the new system that we have, the metrics that made that possible. So yeah, perspective for me is basically an extrapolation of today's snapshot. A snapshot is viewed through the prism of all of these things, the changes that are happening. Extrapolate those things, changes are happening faster and in large numbers. And as an industry, again, we have been extremely fortunate to have some really skilled individuals and teams that have made these things possible faster and resolve issues quicker. Particularly, guidance, I just mean guidance in general. But again, directed towards the regulatory compliance, but mostly guidances that have, again, shaped all of these changes and helped us resolve complex issues faster. From licensing amendments from a storage perspective.

Again, my vision on what future license amendments could look like, and also how the license amendments processing could be more efficient, or what can be done in order to make them much more efficient and make them much more lasting than the frequent amendments that we are currently experiencing. I have to tie in aging management to storage. How we have in a short time resolve that issue, moving towards something more standardized. The picture will become clearer as I talk about aging. Transportation. There are prospective changes. We are entering a new timeframe with respect to transportation. My perspective on what's been changed so far, and then again, regulatory guidance, transportation guidances are much more mature and structured. And licensing in general, what kind of licensing vision that we have that will tie this 72, 71, 72 together. Next slide.

Okay. So, when we look at this picture, this is again intended to be a general picture of the general licensing, Single list to single holder. Specific holder, and the CoC holder, which is us, and then the general licensing, and on site storage. We have made something that were not originally anticipated 15, 20 years ago, even ten years ago. From a CISF perspective, how do we see ourselves in there where a licensee, if you look at it, typically average one type of fuel, maybe one type of system, maybe two type of systems. But it's typically one type of fuel. And then us work together and try to make that work. You go to CIS perspective, and you are looking at several fuel types. It's possible that there may be a BWRBSC next to a PWRBSC. It opens up possibilities. Again, the goal is to make it simpler. The goal is to TN is concerned. And the emphasis on loading and operations. We all know that after the loading, dry storage remains uneventful. So, when you compare it to the reactor side, loading and operations are mostly one system. So, handling fuel constantly, and it's not just one cask per loading. Probably several per loading. So the emphasis on loading and operations, and TN support during loading and operations has greatly increased. And then the reality, which is early shut approach to licensing has significantly changed due to this possibility of this early shut down that has started becoming a bigger reality. Same thing in aging management. I talk aging management, because I know that three or four years ago, this was more about renewal, right? We have gone through this renewal licensing period. TN has crossed the licensing. We have a CoC. That's one piece of the puzzle; there are several aspects. We got some great guidance from the NRC on the MAPS document or the renewal documents, there are other pieces where I think the industry also has to come up with several other guidances regarding inspections, baseline inspections, acceptance criteria, standardized acceptance criteria and stuff like that. The emphasis is going the phenomenon and all of the other things that drive the renewal innovations. Here we talk about innovation. And that is true. I think a tremendous amount of innovation has occurred. If I take to take an example in the nuclear industry, just like Newton said, inertia, innovation is the one that will bring the inertia. That's what is happening. With the high capacity store. We are going into high capacity systems. We're definitely not at the time of 30 or 40 for smaller fuel assemblies, but that's an innovation. And same thing with Holtec, too. Things have been implemented in terms of making systems better, making systems more efficient and effective. And the same thing with the system, too. The matrix is truly innovation. Everybody is actually fuel, high heat loads, advanced methods, DOE, NRC, industry, everybody is contributing to this growing innovation, whether it be technology, whether it be process, whether it be guidances. I think there's no option. What it has done, as you may have noticed, it's actually resulted in

enhanced margins. So, I would say that even though we're looking at high heat loads, even though we're looking at high burnup fuel, it's a combination of materials, combinations of phenomena, combined with passive systems, we are still looking at enhanced margins. As I said, complex issues have been resolved. I can give you an example. ISGA, as we went through versions, there is an excellent example of innovation in regards to resolving this extremely complex issue. I mean, again, a lot of people have worked on it. My perspective is that there has been innovation in every aspect in what we do. We have made significant progress in the industry. Next slide, please.

Looking at guidance and thoughts, 72.48 guidance is a decent example of some changes that we have made, changes that are there. And again, a culmination of effort in terms of effectively addressing the methodology. MAPS, from a TN perspective, we got there before it with us done, but I'm extremely happy that this will definitely reduce the workload for the staff for the NRC as they deal with a flood of renewal applications in the future. From TN standpoint, we still have a few CoCs, and we view this as a good example of a cook book that if done effectively will improve our licensing throughputs and make it more efficient.

Examples of, again, how we can innovate with very good data. In the amendment 16 pilot, I know Don had a presentation today, and we have resolved all of the items except maybe one or two, but Don will inform us how the contents are displaced in the CoC. It will definitely help us in the future. When we look at how the amendments in the future are going to be structured. The big challenge, at least from my standpoint is moving to conformed, we are looking at passive systems. Once loaded, the casks and the contents cannot change. The severity, the heat load, the systems all going down, criticality, concerns of the system are going down. And really very limited number of design basis functions. Limited number of design basis limits. The problem that has to be resolved is actually not very big. It's small, and it's actually becoming better over time. I think there are some components of where we can use this and determine we may be able to address it going forward in the future as we address aging.

Next slide, please. Looking at vision, in terms of TN, again, it's simpler. Design changes are becoming less and less. We are limiting design changes. It's going to content-specific. What we see is basically with the shutdown plans, looking at higher heat load, but less number of them. Looking at different combinations of how we load fuel. They are not going to have a new 18 by 18 fuel type or a completely new basket design. Looking at incremental changes but mostly looking at content. And renewal considerations make it a little more complex, but renewal is associated with non-design basis, therefore, new amendments going forward are not going to challenge the design basis limits. The design basis limits are not going to be anymore stringent in the future. It will only be a combination that will change. When we do specifications, this may be an important consideration. For that, we need some guidance on a plan as to how to specify contents.

Next slide. License amendments. As I said, there is a cumulative impact as we go through, and the number of documents becomes complex to manage. That's what we need to consider when we look at changes. Next slide, please.

Aging management, licensing process is just the first step. There are inspection tools. There is technology. And we have management. Also, the action management where we need guidance, and TN is addressing all of that. That's what we call a comprehensive aging management. Right now, looking at post renewal considerations, we have to improve development procedures, preparing for baseline inspections, and developing the tools so that we can do the aging management comprehensively. Moving on to transportation -- next slide, please.

Almost the same. I guess the transportation has explained so much. I think transport is almost the same. Looking at early shutdown, higher heat load, high burnup contents, and also high capacity systems, and transportation is almost the same in terms of prospectives for changes. Guidance is almost the same thing, exception that I would say that it may become more important in terms of transportation. And we would need something on transport storage.

Content-specific has a big difference between storage and transport as we start loading shutdown plants, you can see there's a difference when people start loading for transport even during storage. And licensing those storage for transportation in the future becomes a challenge. It's only how the specific contents. So the design remains the same. It's the content. I would say as a process improvement, the biggest challenge will be how the contents are specified.

So in conclusion, at least from my perspective, I see that the transportation and storage direction is driven by licensing processing simplification. That's what I see. Technology and innovation play a part, but innovation in terms of how contents are specified and how transport is managed. I think everybody is doing a great job improving operations.

Aging management, we crossed the first hurdle. We have to do the other part jointly. And CSIF, if we take care of these things, the last part becomes the easiest. We should be able to manage it much more easily because we have all the right steps in place. With that, that is my presentation.

Thank you, Prakash. My instructions are that you are to hold all of your questions until the end. Be thinking of those questions while Stefan makes his way to the podium. Prakash, your teal bullets had very interesting points. It wrote down those that you alluded to a number of times. I think there will be opportunities tomorrow to further explore what we learned about the margins and how they can help us manage getting the contents in, getting it faster, and getting it on the road. But we have an equally qualified and a man with an equally impressive title, Stefan Anton.

So, Stefan?

STEFAN ANTON: Good afternoon. At this point in time, we are probably having some repetitions in my presentation that are of additional value. I am probably maybe competing for the shortest presentation. We'll see about this. It may hold some benefits. I'm just going to go and focus on the licensing in the industry and on the safety of this. So, just go to the next slide, please.

My first point is talking about the licensing efficiency, and I know we have already talked about that a couple of times. I hope I have some additional things in there. First, market, although we have mentioned, the licensing efficiency is linked to safety. It has a safety nexus. I think we all understand that, but I think we should repeat that more often. The licensing efficiency is not just for convenience of the users as vendors. In the end, probably the easiest way to characterize that, is that at any given time there's a limited amount of resources in our area at your area.

So, if we can remove clutter, if we can improve the efficiency, there will be in the end more resources available that can focus on the important safety issues. So, again, we all understand impression why we're actually doing this. Going forward, of course, it's very important that we continue that, because there are the demands on efficiency and safety will definitely be increasing in both storage and transportation. We are going for consolidated storage that will be decommissioning. We hope there will be transportation with all its complications that we have there. So, there is a need to not stop where we actually are, but to go ahead and to make further graded approach, and the pilot project. I didn't intend to repeat all of this. We are very happy that this is happening. We fully support this, of course. And we hope that it's in the end, will result in increased efficiency. We will hope for the 37.5% and not the 2.5%. It will also affect us whether it scores one way or the other, but, so we'll see how that comes out. But then, substantial reduction in the size of our certificates, I think there is still more work to do from our perspective. I still see, and it's probably -- I could probably give some examples, but it's more a gut feel than anything else. I'm a very technical, focused person, and I still see that I believe that even if we are successful in the graded approach as it's being done now, that there is still more things that can be done, and probably that needs to be done to meet all the challenges that we are facing in the future. So, overall, the improvements, they are just an ongoing process. It's not that we -- it's not from -- and probably you've heard that sentence before.

But the improving efficiency, it's a journey, not just a destination. So, going forward, I would expect the additional pilots or projects that continue to go in that direction to simplify are the use of topical reports. That has traditionally not been used to any significant extent in the dry storage area, because it was always considered that it takes a long time to get a methodology approved to a topical report, therefore the licensing requirements would be moving much faster in order to get through to something. But I think in our case, we've come to the conclusion, and as I said, we've already brought up the idea to come up with topical reports to basically get certain methodologies approved, which then in the end, would simplify all certificates, because hopefully the certificate would say he has the criteria. There's the topical report that you can go forward with. Now, I can't get into any details yet, but I just thought in that context, I might share that. It's probably in another area where we may in the future can find further improvements in the efficiency. So that's basically, that's my first subject there. And if you go to the next slide,

Again, in innovation, we've already heard now a couple of times that competition is good for innovation, but it's also safety concerns. And they should be doing that in that respect. We, of course, we consider ourselves as an innovation company. We have done so much over the years. Some of the examples of the past is our underground system to improve the safety of the

security of the system -- we have OUN our manufacturing facilities. So, we combine engineering, licensing, and manufacturing, which gives us a really very good opportunity, a very good basis to introduce the innovations. Initially, I also wanted to mention, innovation is also a safety focus, but we have already mentioned that it's not -- we do that to improve the safety of the systems. And address issues that we have in the industry.

Another of the canisters. We have been already working in our area. The main area of concern on the canister. I don't know if you are familiar with this. You may notice that it doesn't have any circumference welds anymore. The welds themselves are made in a different way, providing less heat input into the system. We developed the laser pinning system for the welds that we have already been using. And going forward, we are developing a new welding technologies. I have been told that we are working on what is called a hybrid laser welding system, which I personally don't even know what that is, but I have been told that it will even get better quality welds that have an external surface with a higher corrosion resistance, because it will contain already a different stress state in the surface of this. So, this is really all I wanted to talk about. I wanted to leave you with it. Thank you very much. [Applause].

ROD McCULLUM: Thank you,

Stefan. Another interesting presentation. Because Stefan asked that we do it, and I strongly believe in it, I'm going to repeat what he said, that licensing efficiency has a nexus to safety.

And I think that's something that we can explore. Stefan also talked about safety driving innovation, and he posed the question, are we there yet? And I don't believe any of these gentlemen think that we're there yet. Let me ask you guys, is there anybody in the audience who believes we're there yet in terms of licensing efficiency? Even on the NRC side? Okay. Good. We're the Vice President of engineering and licensing for NAC international, and he also got to that level of impressive title with a lot of experience, in his case, 28 years. So, George, welcome.

[Applause].

GEORGE CARVER: So I just want to say everything they said. It's all right there. Did anybody pay attention to director Dapas this morning? Did he not say these things? That's what I'm going to tell you. More of it from an NAC perspective. All right. So next slide.

I'm going to launch on pretty much the same thing. It's talking a whole lot about NAC's priorities and the future of the dry storage business. We had about five bullets here. It's going to sound a whole lot like what we had before. We're still focusing hard on the nuclear plant decommissioning dry storage technology. We're working on long term storage solutions, also.

Also involved in integrated waste management. We figured it was a shame to have this much transportation systems, I don't know if anybody knows, NAC has a pretty robust transportation business. We have a lot of shipments under our belt, and we're looking to leverage that into the

transportation and future of spent fuel coming off of the ISFSIs and going into the CISF. We're able to spread some of the wealth. We're in with a couple of international companies. I will slide deaths. Our systems are operated that way. We're still operating that way.

Our focus in the future will maintain that perspective. We still have to meet the nuclear power plant operational decommissioning fuel storage needs. Everybody knows this has been cranked up a knowledge over the past few years. By the way, this presentation I made two years ago, and I just tweaked it a little storage. This is kind of an evolving perspective over the last two years. You are talking about systems that were designed for -- or licensed for 20 years. They were designed for longer. Now approach in mind. You've got storage, long-term storage, potential transport, even longer-term storage. So, we will try and keep everything in perspective. As I said, MAGNASTOR is the pinnacle of this effort. The four points that are pushing us into the future, we're looking at -- everybody wants higher heat loads, but you can't have higher heat loads with the same shielding.

So, you have to balance your shielding. You have to balance your transport capacity. And you have to balance the ease of operation. So, we're trying to keep everything in perspective with the mag system as we forward in time. The take-away on this was, you know, everybody's trying to push over 40 kilowatts, 42 kilowatts, 18 month full removal. We have been able to decommission a couple of sites less than 30 kilowatts using some innovative fuel loading plans. It provides occupational safety. And it still gets the fuel out in a reasonable amount of time. So, that's what we're going to continue pushing at. Next slide, please.

Long-term at-site storage. NAC is internally active with licensing renewals. We are part of the wave coming up in 2019, 2020. We've got two certificates up there. One is the UMS, very older system. MPC, older still. But both have been implemented. The pictures on the side show some old Yankee plants, and at the bottom is the world's largest pad. We have other certificates at Duke and Arizona.

They will fall into the same certificate renewal. The details we have taken the TLAA, AG analysis. Lessons learned, going forward, there's been a lot of steps on the trails ahead of us. But with the help of the MAPS documents, the upper documents, the industry, and we've come up with proper TLAAs and aging management programs. We're pretty rock solid on what we think we're going to bring in here. Our submittal for this will be in the 2019, 2020 time frame. In support of that, we did complete an in-service inspection at Maine Yankee. I think Paul or Neil will do the presentation on the presubmittal service inspection. It's amazing how well-maintained these systems are. And then we had the inspection analysis. I think David Dunn and I can't remember who. But we're going to years down the road. It will learn from the efforts of UMS and MPC work. So, moving into the CISF, I said that NAC was part of the team. Our technology is part of the IPS and ISP submittal.

Acronyms are killing me. [Laughter]

Who put a slide up with all the acronyms? That was clever. But, in support of this, we're looking at longer-term storage, and we're looking at the development of material innovations, process innovations, and operations innovations that are going to support the longer term need for the spent fuel. If we get to a CISF, it's going to be there just 20 more years? 40 more years? 100 more years? I don't know. But we have to think that it has to have a life beyond where we're at right now. We were at 20 years. We thought not a problem. And here we are today. So, we're still looking farther out, looking to see what we can do process-wise and material-wise to make these more robust long-term systems. Next slide, please. I mentioned integrated waste management. We have a couple of projects we've worked on. We have taken the concept of spent fuel storage, and we looked at some high level waste solutions. The first high level waste solution we looked at was the west valley material.

We put those into concrete cask storage. It's not ventilated. Wasn't enough heat. It was nice and easy breezy, but it was really contaminated. So, it took a lot of effort and operational scheme of things to get the right equipment to keep people in a safe condition and keep the occupational hazards load.

We are under a DOE storage license, but we did get our 71 license for the transport of this material. On the right-hand side is a couple of new packages we've developed going into licensing soon. But it won't be with the NRC. They are going into another country. These are high-level waste packages.

These are brand new technologies. But again, it's going to leverage all of the knowledge and experience that we've had over spent fuel to solve other high-level waste issues. The most current dry storage for an indeterminate period of time. Almost 2,000 capsules can be stored on a single pad.

These are, for handling and thermal purposes, we have them segmented into pieces, packages going into a canister similar to what the fuel is in. Slightly different, but still the same. This is a DOE storage license. Very challenging thermal model on that, if anybody is familiar with the cesium strontium capsules. We are still pushing forth on the transportation side. We had two NAC operations for 15 years. We had another order for four units. Two of those have been completed. They're in operations. And we've got eight more in fabrication now. These are the same overpacks that would be used if we were to move Sheryl's canisters from Lackbar to wherever we're going to table top. These are the packages. These are being fabricated. They're proven technology.

They have been moving fuel in China for years with these packages. So, we're glad to have those out there. These also leverage some of the earliest high burnup fuel. I wouldn't say technology, but some of the earliest research in high burnup fuel technologies will get this license with the NRC. International alliance. We have -- we're trying to implement concrete cask storage everywhere we can. It's a great idea. I don't know if anybody is aware, but Japan, Taiwan, everybody likes to do it. They don't like to use metal casks. Metal casks are very expensive.

We're working with international entities in Korea, Taiwan, Japan, and China to get them the concrete casks and help them realize some of the efficiencies of this technology. So to recap, we are staying involved, heavily involved in spent fuel. We're picking up some high-level waste management effort. We want to remain flexible. We're very good at adapting to the spent fuel disposition. We're moving a little here and there and wherever it ends up landing, whether it's political based or regulatory based, we have other regulations we have to address. We're on it. Commercial and government entities. Dry spent fuel storage, again, once considered to be interim is now longer. Don't know how long. But we have to be cognizant of it. First step is getting license renewal. Next step is getting it developed. And we will implement effective aging management programs, design options that are going to support that. We're also looking at development of techniques and equipment that's going to be supportive of the CISF implementation.

We continue to advance robust spent fuel transportation program. Everybody knows that it won't stay in storage forever. It's got to go somewhere. We can't leave transport behind, so we are actively pushing the transportation envelope. And my last bullet, we will continue to work with the regulator to develop more efficient and effective licensing processes. We're interested in leveraging current research activities. There is a lot this year, there's a lot of that here today. I'm looking forward to making that into part of a license amendment, into packaged efficiencies. That's all I got. Thank you.

ROD McCULLUM: Thank you, George. It was interesting to see in your talk and the others, the extent to which the decommissioning perspective is changing our view and the driving of innovation along with long-term storage. Also interesting that I guess this is a misery loves company thing.

But used fuel isn't the only waste form out there that needs a place to be stored and something that can be transported. So, I'll go ahead and take the podium just to call on you guys for questions. I will warn you in advance if you don't ask questions, I will start requesting questions. Hopefully you can fill up the time.

JOHN MCKIRGAN: I'm John, Chief of the Licensing Branch. I want to thank everyone. I really enjoyed those talks. Some interesting points. One of the points that I didn't see that I was kind of expecting is how risk informing would work in the future of CoC licensing? And I wondered if the panel could offer their views on how risk could come into play here.

Don't all go at once.

STEFAN ANTON: Well, this is Stefan. I kind of tried to cover that with my last point saying we need more pilots. And how that really would look like, I'm not quite sure. It depends on how far we can take things.

PRAKASH NARAYANAN: We definitely, as the industry, and probably everybody will agree, our certificates are still too long, even if they are reduced by 37.5%. So, how that can be reduced would probably be Orano went as far as they could under the current framework. So, we would have to probably sit together and first think what else can we actually do there? But I agree that there is probably still areas presentation, and I will elaborate. I think with contents, that's where we have the biggest. We the field is maybe the one that provides the additional information.

For transportation, same thing. If the -- for example, if the fuel aged 20 plus years, you have all the documents, I'm thinking maybe a grandfather amendment would basically say for these 100 casks on site, this is the document, maybe five pages, 20 pages, whatever that is. Specifying contents in much more bigger picture, not necessarily after you make a few measurements based on aging management, I think as we progress with age, I believe that there's a good efficiency on managing documents.

Other questions?

I have another -- I would have another comment after thinking about this. Is that okay?

ROD McCULLUM: That's okay.

STEFAN ANTON: I have also been, as many of you know, been working in the wet storage criticality area, and I remember seeing tech specs of nuclear plans, and they say that the reactivity of your spent fuel pod has to be .95, and of burnups or things like this. It's bolt on to the ultimate requirement, which is .95. From a throttle perspective would be a temperature, and from a shielding perspective would be a dose rate. Many of the other things that we have in there, basically are just indirectly related to this, so maybe -- and that was probably the idea with the topical report that we would then be able to reduce the tech spec entries to requirements that are fulfilled through an approved methodology.

Yeah. Instead of hashing it out with every tech spec, you have a topical report. It's risk informed topical.

STEFAN ANTON: There would be one methodology that might be used in many of our amendments and certificates being used, but the methodology is only approved once, and then I don't have to revisit it.

Right. And I think you get back to the heart of John's question. The risk informing only has to happen once. You don't have to keep proving it over and over again.

STEFAN ANTON: Yes. That's also true.

All right. Paul, you have a question?

PAUL PLANTE: Yeah. Being a little pessimistic about the future. I would like to ask a two-part question. Are any of you working on in situ repair technologies on the sites? And if you are, would you care to elaborate a little bit on what you're working on?

Are you talking about repairs of canisters? Or any specific area?

Canisters. Concrete, we can all do that. I'm really talking about canisters
So our perspective, and we have said this. It's nothing new. We have said it before. If there would ever be an issue with a canister, our approach would be to put the canister into another canister. The technology for that, we don't need new technology for that. We make a larger canister and basically lift it up into our transfer cask, and transfer to a new canister, weld it again. We might be using a different material on this. So, that would be our first line of or first idea of approach. And as I've said, we've mentioned that before, that we would rather do that than try to repair a canister on site.

Same thing here. In Idaho there's actually a canister in canister solution licensed. So, there's a standby material for the second canister

I'll add, the technical requirements for doing in situ repair is incredible. I think they have not even tried to tackle with their inspection, scope, anything like a repair. And in the pure term of a repair. It is very difficult.

Sounds like transfer is winning out over repair on all three fronts there. I know you have that capability already. And let's say, and I don't think he's anywhere close to this. But say Paul needs transfer capability at some point in the future, what would be involved in you guys being able to mobilize that? And what regulatory barriers would you see to that? Getting to our theme of efficiency? What regulatory challenges would you foresee for you to mobilize that?

Paul already has it.

Oh!

Paul already has a canister to put one in.

He's got the canister. And you've got the know-how. But in terms of actually making a transfer into his extra canister, the stand-by canister, are there things you need? Are there regulatory challenges to actually performing that operation?

I say we take an amendment to have it in that form. But the heat load wouldn't be a big deal. It would require another shielded vessel so you could do the stack

As a licensee, it's not a licensed configuration. So, we have got to get over that hurdle if we were to be able to use it. I will take that back to what Stefan said I should repeat that licensing

has a nexus to safety. There you are trying to do something that is necessary for safety, and yet you need a license amendment. So, if that process is efficient, that's no problem.

If that process is somewhat less than efficient, now all of the sudden, regulatory process becomes something that's not exactly safety. Is a faulted canister really a safety issue to the point.

There could be an argument that suggests you do nothing, then

I'm not sure about if it's license configuration. Assuming you are in renewal, I'm sure it will be approved if there is a corrective action to address that. The corrective action is to produce the large additional confinement, I think it's a learning part of the program. We should not be looking at it as a hurdle or something. I believe that it is possible. But that's just me.

STEFAN ANTON: I also wouldn't think this is a challenge in the licensing area. It doesn't seem to be anything -- of course, it would depend on many things, but I don't see anything special on getting to license

I think some of us who have seen the work wouldn't use the word "quick" in terms of the need. That's where the risk informed argument comes in. And there are limits without first going back to the regulator. We have 72.48 processes that have to be employed. And certain things will trip those triggers. Right?

Right.

And if necessary, they all file exception requests and have tools available to speed things up if need be.

So we have the know how. We have the capability. We have multiple ways of attack here.

I think so, yes.

All right. Any other questions out there from the audience? Of course, regulators first. He asked a question already. I defer to the industry side for a change

I just wanted to ask each of the three of you how things are going with AMID? Is it rolled out to your users? Are they entering information? Are you populating the database? That's an important element of a number of renewed licenses and CoCs.

I can defer. He's about the only person that's gone into the inspection process at this point. The Yankees. And you have been putting those in, David?

Yeah.

It's up and running, but also would have to defer to my licensing manager to -- [Off mic]

it. You know, that there are a few entries.

John?

Thanks. I wanted to follow up.

Committees, and if they represent an opportunity for further enhancements as the NRC looks to adopt or endorse certain codes and standards. Are you guys finding the codes are responsive to your needs? And is there an efficiency to be gained there in getting some of the issues that you have resolved through the committee and then bringing that consensus standard back to the NRC for consideration?

GEORGE CARVER: From what I have gathered in the development, we have the ability to get out there. And we have some criteria now to go out and do an inspection.

So, I think from that perspective, it's been helpful to us. There is no other place to look for that type of criteria in the industry.

STEFAN ANTON: Yeah, I don't have any further comments on that. I have not been directly involved in these.

I think it's a great help. I would say that code committees are very good, and I believe have a much better improvement or ground for improvement.

JOHN MCKIRGAN: Can I have a follow-up?

ROD MCCULLUM: You sure can, John.

JOHN MCKIRGAN: What is the timing of that process, and how quickly are they able to address your issues as you see them? Because in terms of an efficiency mechanism, how quickly can they respond and get things endorsed as you see changes needed?

GEORGE CARVER: I'll take a shot at this. It has taken a few years to get where we are right now with the ASBI section 11 for the development of where we are right now for visual inspections on the cans. If I push them any farther, I don't think they are a nimble organization. So, it could take more time if we try to get into different areas. If you want some type of repair to a vessel, an in situ vessel.

STEFAN ANTON: I can only offer from the commercial time frames that we work under. And so, I'm not quite sure from that too late.

Susanne. I'm just going to offer a comment from the panelist members. So aging management and what happens with canisters that remain in service for many years, it's not selling any new canisters for you.

So, it's not part of your big business, if you will. But it is something that all of your clients have to keep and live with for many, many years. I would encourage all of you to participate in the code cases, to participate in EPRI ESCP and all the things that come with aging management and the other big processes that the industry and the users have to live with for many years.

ROD McCULLUM: Given that wasn't a question, you're under no obligation to understand it. But if you want to say anything.

STEFAN ANTON: Understood.

ROD McCULLUM: It does bring to mind a question that I was thinking of asking that I will ask plants. So, you're not just a supplier, you're also the customer. How has that perspective informed what you see as the needs going forward for in licensing efficiency and innovation?

STEFAN ANTON: Probably we see things from both sides at the same time. That might have in beginning of the process there. So, I'm definitely there will be other things coming up.

ROD McCULLUM: And your perspective is especially unique. You're creating some new sides. You want to move it to your interim storage facility. I would be very interested in seeing how that informs things going forward and how that maybe drives some more innovation there. And of course, your two competitors are involved in a similarly vertically integrated project. So any other questions? Meraj? Yes.

MERAJ RAHIMI: Meraj with USNRC. I was trying to take some nuggets from the presentation in terms of what's on the horizon in terms of our perspective from regulatory perspective. What are the -- which design envelopes are you pushing?

And what we should be looking at, you know, the challenges coming in. So, I guess to repeat, Prakash mentioned the content specification, that is from you point of view coming in. But the variety, and it goes back to more, maybe, if we can come up with a process in terms of focus on the safety parameters as opposed to really having, like a 300-page tech spec that goes all the way from spacers that are in the inside diameter. I assume that that is where you see the future that you will come in with a lot of different, you know, fuel type. And I guess George mentioned that you guys are pushing beyond 40 kilowatts. This is what, you know, is in the horizon. Most of the vendors who have been pushing that, you know, the heat loads. And of course, I guess Stefan, you were talking about more process improvement on our side, I think that's what you were talking about.

But is there any other areas that sort of you want to give the regulators a head's up in this area? This is what is coming down, you know, in terms of, is there a cap at this point to the, you know,

payload capacity? You know, because we've gone through 37 or 39. Are you seeing even that keep going up?

STEFAN ANTON: I think with the systems that we have now, I would presume that we are reaching the limit there in what can be done in terms of weight. If you go any further, then I think your shooting performance of the systems will go down to the extent that it becomes problematic, to say the least. I also think the content specification is probably the one fine-tuning in that area, and without making it too complicated from a licensing perspective is probably what we are all looking for.

ROD McCULLUM: I appreciate your vision.

STEFAN ANTON: Do you agree?

ROD McCULLUM: I think we share that vision. Let me perhaps put a really too sharp a point on this contents discussion. I think one of you alluded to you want the 37% reduction as opposed to the 2% reduction in terms of efficiency. And I think Prakash, you said one or two issues were left? Yeah, those are big ones, and those are on the content side. I believe they're in the fuel qualification tables? Would you care to elaborate and maybe be blunt as to what you see the answer?

PRAKASH NARAYANAN: So a couple of things about the content. Yes, it is also fuel types, but coming to shutdown plans, the tough part is combinations and heat loads are unpredictable. When a plant shuts down, unplanned, the combination of heat loads is not something you can license before. So, you end up with a different reactor and you say oh, I need a new heat load zone or a family of heat loads. So, we end up having three or four every time you send an amendment. And it may be for the one reactor. Maybe the next one does not fall into this family that you have. What I was looking at is I'm not going to license something more than 50 kilowatts, but I know for any next system I don't need 50. I only need 42.5. But the location of my hardest also will lower. Criticality is not likely an issue. But it's an 18 month amendment cycle. If there's a way to predict the heat.

The second thing is the combination related to dose rate and source. I'm assuming if there is a way that I can very efficiency specify my contents from fundamental quantities such as heat loads, and not necessarily a derived quantity that is a sole. This is an example. That is the contention I have, I believe you may be specifying the safety requirements in terms of what really takes care of certain design function.

ROD McCULLUM: All right. Brian.

BRIAN GUTHERMAN: I don't have a question. I have a suggestion. On the Part 50 side, the power plants have what's called a core operating limits report. Now that report's reviewed and approved by the NRC, but what it does is it sets the boundaries for the new core design each cycle so the plants don't have to go to the NRC every time they want to update for the operating

cycle. Is there no analogy that we can take from that given that they are running reactors at pressure and we're talking about cans of spent fuel?

STEFAN ANTON: That's the idea with the topical report. It goes in that direction.

GEORGE CARVER: Steve Nesbitt isn't here, but we would be proud of us.

If I could change the topic just a little bit. I wanted to get the panel's perspective on any one of three topics. So, higher burnups, which industry has talked about the operating fleet has talked about running another cycling. ATF, accident tolerant fuels, what the implications are there for storage. And advanced reactor fuels. If you guys are connected with that industry to see what storage challenges the advanced reactor fuel designs would present. So, that's -- any one of those three would be great.

GEORGE CARVER: I'll do the high burnup. We struggle with high burnup fuel from the get-go. We heard today about cliff edge. It's 45.001. And I was joking earlier today, and I said who approved burning fuel beyond 45,000? Before we know it, the fuel did. If you went to beyond where we are now, I think you want to do a little more up-front research. Maybe it would be dove tailed with the events fuel, not where we're at now.

We're just coming out of the clouds on the high burnup fuel now. If we take another step out, are we going to open up another cliff edge that we're going to have to deal with again? If we did increase the burnup, do some of the work before we release it so the back end has a chance to deal with the fuel as it comes out of the pools.

ROD McCULLUM: Okay. Any other questions from the audience?

PRAKASH NARAYANAN: As far as the other fuels, we are getting involved. I believe we had a discussion more focused on criticality now, not yet on spent fuel side or in issue, I believe, in such a short duration, I think it will be the same effort.

ROD McCULLUM: All right. We have a session here that is supposed to end at 5:00. I'm under no requirement to make sure it goes all the way to 5:00. Oh, yes. Any questions on the phone?

Yes, we do have questions on the phone. Your line is open.

Hi. Gary. We're representing about 5,000 concerned citizens that live near the -- where we almost dropped a canister 18 feet. I heard a lot talked about pilot programs and resistance you get from the public sector. Sometimes that feels like we're just obstructions no matter what. But really, we have serious concerns about what would have happened if that canister dropped. What I'm suggesting with the pilot program, using sophisticated technology that you discussed today, but in simplistic terms, in layman terms where the general public could relate to the test, I'm going to suggest making a canister with the designs, drop it from 18 feet, but instead of having, you know, real fuel in there, have led-filled clouded material, and fill it with water

perhaps. So, you could see when it drops, are the welds going to hold? Even if it's not the same amount of weight. If it's 30 tons instead of 50 tons, it would be reassuring to the public. It would be straightforward. We could see how the stems hold up. It would cover a lot of ground that the public is realistically worried about.

That's something that, you know, we'll think about. I know that we do take your concerns seriously, because there is common cause here. You know, we want those plants safely decommissioned. We want to move on to the next lines of business.

And you want certain materials safely managed and out of your community. So, we're striving to that goal, and to the extent we always worth considering. I will ask George Carver a question. You alluded to the well-traveled light-weight truck cask, the LWT. What have you learned from your vast experience with that cask that you think can be informative to the full-sized rail casks? I believe we heard some of the concerns earlier.

The LWT has a very broad inventory of contents. I wish I would have seen a lot of that in the beginning where we had amendment 42 of 68. Amendment 68. So, I will poke at a couple of things. Each one of these amendments is almost an individual licensing action. And it takes a lot of effort to do that. So, it would be -- it would be good for us to be far more flexible in our contents for our transportation casks for this spent fuel for the larger casks.

And then I think the other thing is, we found out that when you move a cask, maybe three times a year, and then you start moving a cask 13 times a year, the wear and tear on the cask is a little bit different. So, looking at the operational aspects of the cask becomes more important. So, when you get into looking at mobilizing transportation system that's going to start moving fuel all across the country at what we would suspect to be a reasonable rate should be a robustly designed system, not just from a pure licensing perspective, but from an operability perspective. Every little nut, bolt, latch, name plate, everything has to be taken into consideration. It just takes know we have more on the phone?

Yeah. I will be George's phone a friend. We're at revision 68 of that certificate. I encourage people to look at the contents of what that CoC is. It is a certificate. We ship a variety of stuff in there, and there hasn't been a cataclysmic situation where somebody opened a cask and said what is wrong with the payload? That is one thing I would add to the question. We do that with the LWT. We have substantial material that is shipped.
Are there more from the phones?

Yes, our next question comes from Donna Gilmore.

Your line is open.

DONNA GILMORE: Hi. I'm hearing, I assume it was the vendors talking that it is not have thin walled canisters that you know can crack: We've got defective gasket shims. We've got Japan discontinuing aluminum baskets. You have no way to inspect the baskets inside. You have no

way to verify the fuel. It's not -- there is a 20-year design for something that needs to last replace these cans and not play this game that everybody in that room knows that what you're doing is a bad plan. As soon as you realize it, the sooner that you're going to be able to protect all of us. I just want to -- I know the NRC has a lot of NRC engineers that try and do their job, but the policy from the management are getting in their way. And the sooner you stop this, the better, you know? So you've got the older canisters. Maybe the NRC isn't the biggest risk right there in Maryland. Maybe the pentagon. Maybe New York City. You know these things are going to go at some point. You know you have criticality issues. You know that you have explosion issues from the hydrogen from the high burnup fuel if air gets in there. And we need to start facing it before it's too late for all of us. This should be a national security issue, and you're deceiving the elected officials. You're deceiving commissioners about the truth. And it's time for that to end. Accelerated time frame here where Holtec is having a major risk on our safety, and I have heard no solutions for any of these problems. That's all I have to say.

ROD MCCULLUM: Thank you, Donna. A lot you have said. You know, I think your concern simply highlights why we all need to be very good at our jobs. And being good at our jobs means we need to continue to innovate and to be efficient.

And I look around this room, and I see a bunch of people who are very dedicated to doing just that. And hopefully we can all see the day when final solutions are in place. Are there any other questions on the phone?

PHONE OPERATOR: I'm sorry. We do have more questions. Diane, your line is open.

DIANE D'ARRIGO: Hi. Thank you. It's Diane with Nuclear Information and Resource Service. I have a question about the concept of the centralized interim storage. Is the plan to bring all of the fuel to the sites? Or will newer packaged fuel move first? Will the oldest dry storage fuel move? If there is some kind of -- okay. That's what I wanted to know. The order of how the waste would move. I the site? And if there is any kind of plan to just move canisters that don't have issues first.

ROD McCULLUM: I think that the answer to that question is probably, it depends. I know it's industry policy.

Can you say who you are?

ROD McCULLUM: I'm the moderator of this panel. It is industry policy that fuel from shut-down plants should move first. It would make sense to move some of the easiest to move canisters first. But really that depends on a couple of things. Is it a Department of Energy or a private shipment? If it's private, that is certainly a business decision that the entities would have to make. I certainly think they'd want to take their least challenging canisters first, but there's all kinds of things and considerations that come into play. The key is that we want to take a reasonable approach to moving the fuel. Once you get beyond the shut-down plants, if it's a DOE shipment, there is a waste acceptance queue.

Utilities have contract rights, which means oldest fuel moves first, which is good in some ways, because it tends to be the cooler fuel, so the plants that have the older fuel, granted there's some fungability there. I think the key aspect to that is that it would be shut-down plant fuel first.

And you also asked, I mean the regulations Part 71 and Part 72 talk about what inspections would be required. And that's something that's being played out in the licensing processes at both interim storage facilities right now as far as what would be needed. I certainly wouldn't want to speak ahead of what's going to be decided in the licensing processes, only to mention that the

I had a clarification. So, I think you got it. But I wasn't asking which reactors, I wasn't asking about the order of the queue, I was talking about at a reactor site, which fuel -- is all that some of it would go, but some of it would stay?

ROD McCULLUM: I think for those sites that are going to move, the intention would be to move it all, because the benefit to the owner of the site in moving it is that once it's all gone that site can now be freed up for other uses, that that owner no longer has a nuclear facility that they have to manage. I think if you're going to start a shipping campaign from a shut-down plant site, you will be committed to moving it all.

In terms of which cask you move first and which cask you move last, obviously you're going to pick the ones that are least challenging first, I would assume. But again, that's business decisions that need to be made.

So those decisions, the public wouldn't have input on, because those would be something that the companies would decide?

ROD McCULLUM: No. Most shut-down plants have community engagement panels. I know at the plants you're not going to undertake things like that without it being fully visible to your community engagement panels.

Is there a plan to move waste from operating reactors as well?

ROD McCULLUM: Well, there is, but the shut-down to say that it's going to move in accordance with the queue as specified by contract, which is a bureaucratic answer. I think the reactor movement would be very much informed by the shut-down plant experience. And at an operating reactor, you're obviously not going to move all of the fuel off the site, because you're still producing. You still have some in the pools. You probably want of the pool first, which is the way the system was designed to work from day one, which is the fuel comes out of the pool and goes into a transport over pack, and then into disposal or storage.

In ways, that's easier, because you see everything in the pool, and you move from the pool and you can choose what you want to take out of the pool as opposed to what has already been put in the cask. But again, that's getting ahead of the game. The first is the shut-down plant fuel. I

would tell you if you're in a site with a community engagement panel, that's your point to engage on that. The regulator is obviously going to want to see some things before that leaves, and the regulators' processes are also fully public. I'm hoping that you will get an opportunity to engage in one of those processes soon.

So then, with regard to the Part 71 and 72, could you summarize very simply, are there any required tests that need to be done before the fuel is moved? Three vendors, for the record, are shaking their heads yes.

And could someone summarize what those tests are? Is it just way too -- I mean, generally?

ROD McCULLUM: In the interest of time, this is a very good line of inquiry, but that varies depending on whose license it is. As you have already heard, there's a lot of diversity in the licenses. I mean, you test? What kind of concept are you trying to test for before the fuel moves is what I'm trying to get at?

ROD McCULLUM: There has to be a visual inspection of the transport cask. Depending on what that finds that determines what you do next, right? They're shaking their heads yes again.

I don't want to cut off now. I was almost promising this session might end early, but I suspect that I might have more on the phones. I will look to my NRC colleagues for guidance on what to do? We have reached the end of the session here. I want to thank you all. This was very participatory, as usual. The reason I do this sort of thing is I always learn something new, and everyone involved has taught me a thing or two. I will figure out how to use that and enjoy your evening.

We'll see you tomorrow. [Applause]