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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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600TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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THURSDAY

DECEMBER 6, 2012

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ROCKVILLE, MARYLAND

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The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 12:45 p.m., J. Sam Armijo, Chairman, presiding.

COMMITTEE MEMBERS:

J. SAM ARMIJO, Chairman

JOHN W. STETKAR, Vice Chairman

HAROLD B. RAY, Member-at-Large

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STEPHEN P. SCHULTZ, Member

WILLIAM J. SHACK, Member

JOHN D. SIEBER, Member

GORDON R. SKILLMAN, Member

NRC STAFF PRESENT:

CHRISTINA ANTONESCU, Designated Federal Official

SUSHIL BIRLA

MILTON CONCEPCION

JOHN COOK

IAN JUNG

MARK LOMBARD

ANDREW PERSINKO

JAMES SHEPHERD

MOHAMMED SHUAIBI

JOELLE STAREFOS

ALSO PRESENT:

DOUGLAS AMMERMAN

*Present via telephone

A G E N D A

P R O C E E D I N G S

(12:49:51 p.m.)

CHAIRMAN ARMIJO: All right. Good afternoon, and sorry for being a little late. The meeting will now come to order.

This is the first day of the 600th Meeting of the Advisory Committee on Reactor Safeguards. During today's meeting the Committee will consider the following; Design Specific Review Standard for Instrumentation and Control of the Babcock & Wilcox mPower Reactor Design; Spent Fuel Transportation Risk Assessment; Draft Regulatory Guide 4.22, Decommissioning Planning During Operations; Guidance on Treatment of Probabilistic Risk Assessment Uncertainties, and Preparation of ACRS Reports.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Ms. Christina Antonescu is the Designated Federal Official for the initial portion of the meeting.

We have received no written comments or requests to make oral statements from members of the public regarding today's sessions. There will be a phone bridge line. To preclude interruptions of the meeting the phone will be placed in a listen-in mode

during presentations and Committee discussion.

A transcript of portions of the meeting is being kept and it is requested that the speakers use one of the microphones, identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

At this time we will turn the lead for the discussion to Charlie Brown, and I think we're just about ready to go. Charlie.

MEMBER BROWN: Okay. All right. The purpose is I think as obvious as if you look at the title on this thing. I believe this is the first -- part of the first full chapter of the new Design Specific Review Specifications that we're getting to look at. Correct me if I'm wrong, okay? So, this is your first opportunity to see what somebody's thoughts were. And I'm not so sure how applicable it is to other disciplines, but we'll go with the flow.

This is on, obviously, Instrumentation and Control, and I will now -- just to get ongoing with it, I'm going to introduce Mo Shuaibi. Have I got that right this time? He would like to make an introductory comment, and then he will pass it on and get things started. Okay?

MR. SHUAIBI: Thank you. My name is

Mohammed Shuaibi. I'm the Acting Director of the Division of Engineering in the Office of New Reactors. And I'm just going to say very few things, and then turn it over to what we all want to get to, I'm sure.

I thank you for the time today. We did have a very good ACRS Subcommittee meeting. It was obvious to us that you had reviewed the material, and we do appreciate it. We had some really good comments from that meeting.

We did commit to give you a list of the IOUs from that meeting, and we provided that to you through Christina, I believe.

What we have here is, in fact, the first chapter, full chapter of the DSRS for the mPower review. It is a collection of our lessons learned from the previous reviews in this area, digital I&C review. And really what we've done here is captured what we need to do for the mPower design in a way that makes sure that our review is focused on safety, is better safety and is more efficient to the way that we do the review.

We appreciate your time. We appreciate any comments that you may have, and with that I'll just turn it over to Milton Concepcion to start the presentation.

MR. CONCEPCION: Good afternoon. Again, my name is Milton Concepcion. I'm in the I&C, Instrumentation and Controls Branch. I'm here with Mr. Ian Jung, the Chief of I&C2, and Sushil Birla, which is our Senior Level Advisor in the Office of Research.

Go right ahead and start with the objective. As mentioned, we are here to formally present a draft Chapter 7 of Design Specific Review Standard for mPower. We're also here to collect feedback and answer any questions that this Committee might have.

Matter of fact, we had a very productive meeting on November 16th of this year. We went over every section of Chapter 7 of the DSRS, and we discussed a lot of issues, or concerns, or observations associated with the content of Chapter 7 that we are exploring and considering, and incorporating comments, as appropriate.

Going on to Slide 3, we have an agenda for today's meeting. I'm going to go ahead and start with the goals, and a little bit of background, followed by identifying some of the major license reviews that we capture as part of the licensing reviews that we've done over time, and then getting into the actual Chapter 7, provide you with a structure and some of

the key sections that we put together as part of this effort. Then summarize it and describe what our next steps are going to be.

Slide 4 I have Joelle Starefos from DARR, which is our Projects Office. She will briefly touch on the overall DSRS schedule, and where we, Chapter 7, fit in the overall scheme.

MS. STAREFOS: Good afternoon. Thank you, Milton. My name is Joelle Starefos. I'm the Senior Project Manager in the Office of New Reactors, and I'm the Lead Project Manager on the NRC's review of the mPower Design Certification.

I just wanted to take a few minutes to mention or discuss our strategy for how to issue this document. We are developing the draft. Much of the draft is complete, and is working its way through our concurrence process in our Office of General Counsel for no legal objection. Our intent is to get no legal objection on the majority if not all of this document before we go for public comment.

We intended to send this out in December of this year, and we plan -- we're actually going to delay that a little bit. The reason for that is that DOE has made a funding decision in the last couple of weeks that provided an extensive amount of money

available to vendors for Small Modular Reactors, and mPower was the sole selection for that. So, they're now negotiating their schedule and plans with DOE. We're trying to optimize our issuance and make sure that we are including and putting out the best product, so we will probably delay until after the first of the year. In fact, we're meeting today with my management to discuss the actual date, so it's a little premature to share with you what those are, but we're close.

Once that draft for inter use and comment is issued, then we'll go ahead and send that to the ACRS and hopefully queue up a few meetings for areas that may be of interest, like we're doing here with I&C.

We're going to go ahead and have a 90-day public comment period on this. It is kind of a long public comment, but we chose to do that because we think it's a pretty voluminous document, and we want to give members of the public and stakeholders plenty of opportunity to comment on the entire document.

Once the public comment period ends, we'll be resolving the public comments and revising the document, as appropriate. And then we'll have -- continue our opportunities to meet with ACRS. And

prior to the final document being issued, we're going to go ahead and communicate that to OMB for the Congressional Review Act review, and then issue the final mPower DSRS.

Right now, we are still determining when that final will be issued. We expect that it will be no later than just immediately following the Acceptance Review period to insure that the items that are identified during the Acceptance Review are appropriately scoped within that final document.

That's all I have. Are there any questions?

MEMBER BROWN: Yes. I forgot to ask, to make sure. This is not just the I&C. This is the overall DSRS.

MS. STAREFOS: Yes, sir. That's correct. That's the entire DSRS. It encompasses Chapters 1-19, and it parallels all the sections of the SRP. In many cases we are going to point back to the SRP because it's sufficient for the review of the mPower document. But in about 150 cases we've changed that document to issue a specific DSRS.

MEMBER BROWN: Okay, thank you.

MR. CONCEPCION: Okay. So, going over to Slide 5, as far as the goals for Chapter 7, we wanted

to enhance the focus of staff reviews by providing clear guidance to reviewers on how they can address high-order issues such as redundancy, independence, determinism, et cetera. And we also wanted to improve the efficiency of the reviews by incorporating the relevant lessons learned that we've collected over time in the review of I&C systems.

And, also, we see this opportunity as beneficial for the Applicant, in this case B&W, to have an understanding of the expectations regarding the review for I&C systems, and the level of detail that we expect them to provide in the applications of that. We have the information we need to perform the reviews.

Moving on to Slide 6, this is a little bit of background. As I said, we gained sufficient experience in the review of I&C systems over the past couple of years. Some of these reviews, as you probably know, have been really challenging ranging for a lack of level of design detail, to applicants struggling with demonstrating safety on the I&C systems. And, as you know, this has an impact on schedules and resources, which is of concern to our management. So, we took those lessons learned and we decided to develop a list that we could implement in

the development of this DSRS. Some of those lessons learned are -- you guys are very familiar with; for example, those fundamental design principles that we've been hearing for the past four or five years now.

Slide 7, we took those lessons learned and decided to use system engineering principles, which include integrated hazards, design principles in other attributes to enhance the review activities, and enhance the guidance for the reviewers.

So, we took the existing information from the SRP and reorganized it, and to the extent practical reorganized it to have this kind of framework that we intend to use for mPower. We expect that this particular framework will enhance the review process and facilitate a much more -- review process for both the applicant and the reviewer.

VICE CHAIR STETKAR: Milton, before you leave this.

MR. CONCEPCION: Yes.

VICE CHAIR STETKAR: We've discussed this a bit in the Subcommittee meeting. I know that there's an initiative for the Small Modular Design reviews to better risk-inform that review process. We've had some presentations about structuring the degree of review

based on risk-significance of systems, essentially ranking systems. We had -- the reason I bring it up here is that a good fraction of the DSRS is traditional safety-related. And, clearly, you're going to do a certain level of review for that portion of the DSRS.

For the non-safety-related portion there are words in the guidance that talk about important to safety. And I was curious whether you thought more about how you'll treat that, because that's -- those are the prime candidates for developing some sort of risk informed ranking at least in terms of your review effort of those portions of the non-safety.

MR. CONCEPCION: Yes. This is part of the feedback we received back on the 16th, and we're looking back at how the systems are going to be classified with this new risk-informed structure. And then we're going to make decisions as to what kind of -- what level of review is going to be applied to those systems that will not be the traditional safety-related systems. And we will have coordination with Chapter 19 to make sure that for whatever classification we apply the guidance as appropriate for that particular matter.

VICE CHAIR STETKAR: Will that be folded

into this document, or is it more of an overarching type review issue?

MR. JUNG: It's more overarching, and the Chapter 19 actually revised DSRS. Chapter 19 actually has a lot of language related digital system, PRA modeling.

VICE CHAIR STETKAR: We haven't seen that part. I don't believe we have. Thanks.

MR. JUNG: So, it's more integrated in such a way that Chapter 19 actually covers a broader set of systems and areas. We don't want to single out a Chapter 7 --

VICE CHAIR STETKAR: Yes, I was just curious how all that was going to fit together.

MR. JUNG: It is more integrated.

VICE CHAIR STETKAR: So it will be under 19.

MR. JUNG: It's a lot more integrated. Our interface with Chapter 19 has been getting stronger.

VICE CHAIR STETKAR: Thank you.

MEMBER SKILLMAN: When you communicate this will use the concept of system engineering principles. To what are you using the current 10 CFR 50, and Appendix A, the General Design Criteria, and those common touchstones that the industry uses for design?

MR. CONCEPCION: This is a process for Part 52, so these new applicants are coming under Part 52 as part of Small -- did I get that correct, Joelle?

MS. STAREFOS: Yes, that is correct. But let me also add, all of the GDCs are clearly applicable to these reviews.

MR. CONCEPCION: Yes.

MS. STAREFOS: And we've gone back and looked at the applicability of all of the requirements. In fact, in some cases in Part 52 there are some extended requirements, such as the PRA and things of that nature, so from a Part 52 perspective all of the requirements that you see with the large Light Waters, plus any new ones will be applicable. And in many cases in these DSRSs you'll see the specific reference to the General Design Criteria to Regulatory Guidance, NUREGs, things that we've used for years.

MEMBER SKILLMAN: Okay. Let me just go a little bit further here. Joelle, when you pointed to the slide, and this is I think number 4.

MS. STAREFOS: Okay.

MEMBER SKILLMAN: And you mentioned because of the availability of money, you're back to looking at the entire schedule, and you are actually looking

at all 19 chapters. Should we think of that as the DSRS for those 19 chapters or all 19 chapters of what is the Design Certification?

MS. STAREFOS: I think you'll find that 19 chapters of the DSRS will parallel the Standard Review Plan, and similarly you'll find that the application or design DCD or FSAR, whatever they choose to call it, will come along those same lines with their application details.

In many cases, and I'll take this opportunity to correct that Chapter 19, we went ahead and instead of issuing that as a DSRS for Small, focused on a specific Small Modular Reactor, we went ahead and updated the Standard Review Plan because we felt like the lessons learned were significant in that area, and we wanted to gain that knowledge across all designs that we reviewed using Chapter 19.

So, in some cases specifically for mPower we will refer back to Chapter 19 as being the scope of our review. But, of course, that will be the new Chapter 19 which is -- many of the sections are already out for public comment as we speak, and others will be coming out soon. We expect all of those will be issued in a timely manner so that they will be beyond the six months, or before the six months, kind

of that lock down period that 52.47(a)(9) talks about the six months to compare against your SRP.

MEMBER SKILLMAN: Okay.

MS. STAREFOS: So, that was kind of our focus, is to make sure all of that guidance was out before then. So, many of these new SRP updates are being incorporated into the SRP.

MEMBER SKILLMAN: Okay, thank you.

MR. CONCEPCION: So, this is a list of lessons learned, and this is not a comprehensive list. We came up with additional information. We grouped them into these six major areas where we said okay, we're going to take the information from the SRP and incorporate these lessons learned, and with changes in the format and structure develop this DSRS. So, what I'm going to do is I'm going to go through some of these lessons learned and identify what exactly we did to address the particular issue that's identified.

So, like I said before, this DSRS is focused on those fundamental design principles that have been preached to us in previous ACRS meetings over the past four or five years. So, we took that to heart and we definitely set on a path to take the guidance, take the information and in the SRP reformat is so that those fundamental design principles are

obvious to the reviewer as well as the applicant. Those fundamental design principles are redundancy, independence, determinism, defense-in-depth and diversity, and the one that is not necessarily a regulatory requirement but simplicity, which is also added as an appendix to the DSRS.

So, that takes care of those first two lessons learned. In addition, the structure of the DSRS puts those fundamental design principles on top supplemented by what we consider functional and design characteristics that I&C systems must exhibit. And those are consistent with IEEE 603-1991, which is our regulatory requirement.

In addition, we took what we consider redundant and repetitive information from the SRP and we put it aside, because right now the SRP is -- it provides a system by system approach, so the majority of the regulatory requirements are repeated on those different sections. And what we expect with this new structure is for applicants to address those regulatory requirements in a single location. So, for each system we expect applicants to provide information addressing independence, redundancy, defense-in-depth and diversity in a single location rather than scattered in different sections of the

application.

In the case of DAC, we understand that DAC is policy, and that we understand that it can be used in an application, but what we're doing is we're providing the reviewer with information that allows him or her to ask for the detailed design information that a reviewer would need to address all of the safety issues without reliance on DAC.

And there is language in the DSRS that alludes to functional block diagrams, for example. Appendix A, which is I&C System Architecture allows the reviewer to look for those high-level functional block diagrams and low-level block diagrams to have an understanding and complement the design descriptions in those Section 7.1 and 7.2 of the DSRS. So, we have confidence that we can get the design level information we need to close safety issues without reliance on DAC.

MEMBER BROWN: Yes, it's really Appendix B, the architecture --

MR. CONCEPCION: Appendix B, I'm sorry. Yes, Appendix A is hazard analysis. Okay.

We introduced simplicity and hazard analysis as part of the guidance, and not on this slide is also the I&C architecture. Those are the

three appendices. That is new review guidance that we intend to test as part of this pilot.

And, also, as part of our last lesson learned we tried to make sure that we covered all of the regulatory requirements for I&C systems contained in the SRP today and move those into the DSRS. So, we developed a table in Section 7.0 that maps all of the regulatory requirements and how we're addressing those in the DSRS.

As part of our November 16 th meeting we collected significant feedback regarding the coordination and review responsibilities that are documented in that table, and we're going back and addressing that in the next couple of months.

So, the next slide, the lefthand side shows the existing SRP structure, and on the right side the DSRS Chapter 7, I guess what I want to say is that we made sure that we didn't lose significant guidance from the SRP into the DSRS. We have information, we developed matrices and tables, and all that kind of information to show that relevant guidance was not lost or somehow not translated into the DSRS.

So, 7.0 and 7.1 of the SRP is contained in Section 7.0 of the DSRS, and as you go down to some of

those sections you see that 7.1 of the DSRS addresses all of the systems that we would consider within the scope of safety-related systems in the DSRS.

Now, we're going to go back, like I mentioned before, going -- insure that the coordination with Chapter 19 is there for those systems that will not be safety-related but important in safety. That is something that we will capture in the next revision of the DSRS.

MEMBER BROWN: In the Subcommittee meeting, I just want to state one thing you didn't say it in this case, when you talked about capturing all your previous guidance, Reg Guide, BTPs, et cetera, you made the statement that you captured somewhere in the neighborhood of 90 to 95 percent of the relevant, stuff that wasn't redundant. In other words, you shaved -- obviously dumped stuff that was redundant, you didn't need to repeat. Is that -- you still stand -- that's in the transcript.

MR. CONCEPCION: Yes, absolutely. Yes, we do.

MEMBER BROWN: So, you still -- okay. So, my understanding is that stays the same, that statement is valid. So, that's just a feeling, one of our concerns when we went into this is how are we not

going to lose all of the history that we've had of designing these systems that have been built into the review plan for reviewers to use in terms of their overall reviews of the applicant's design applications. So, that's kind of an important point to keep in mind.

MR. CONCEPCION: Yes. And, also, we're not just talking about the different sections of the SRP, we're talking about the Branch Technical Positions, as well as the Interim Staff Guidance that apply to I&C that we also considered and incorporated in the different sections of the DSRS, as appropriate. Okay.

So, this is another slide that shows the structure of Chapter 7. On the lefthand side, that's the introduction overview, the middle column shows 7.1 and the different sections. I will get into some more detail in the next few slides. And then 7.2, which are the design and functional characteristics out of IEEE 603 that we also rolled into the DSRS Section 7.2.

And not shown on this slide is Appendix A, Appendix B, and Appendix C, which will be used in conjunction with a review of the fundamental design principles.

Okay. So, now getting into the details of the DSRS, Section 7.0 provides an introduction and

overview of the review process. That's where we identify the review scope, objectives, review interfaces and review process for I&C. That's where we also identify all of the applicable regulatory requirements to I&C systems, and where in the DSRS we address those regulatory requirements.

Going into 7.1, that's the section of the fundamental design principles. This section covers areas such as the system design basis, independence including physical independence, electrical independence, communications independence, and functional independence, all consistent with IEEE 603. In addition, we cover redundancy, determinism, and diversity and defense-in-depth.

Just want to mention that Appendices A, B, and C, like I said, will be used in the review of those principles, and they complement the review of the fundamental design principles.

This is an overview of Section 7.2. Again, it's out of IEEE 603. Those are the functional and design --

MEMBER SKILLMAN: Go back one slide for just a second.

MR. CONCEPCION: Yes, sir.

MEMBER SKILLMAN: John, relative to your

comment a minute ago on the risk-informed, how that's being brought in, there is a statement in 7.1 which you probably remember that says, "This is being done on the traditional deterministic basis right now."

VICE CHAIR STETKAR: There is but there's a bit of -- the Staff may be able to do this better. There are areas -- it's certainly applicable within the context of the safety-related dotted line around things. And I understand the reasons for doing that. However, there are statements in here -- remember this applies to any digital --

MEMBER SKILLMAN: Exactly.

VICE CHAIR STETKAR: -- systems within the plant that says --

MEMBER BROWN: But really apply to any systems in reality. This really applies to any systems.

VICE CHAIR STETKAR: In the plant.

MEMBER SKILLMAN: Yes, not just digital. Am I correct in that? This is not digital only. This is for --

MR. CONCEPCION: I&C systems.

VICE CHAIR STETKAR: It's I&C.

MEMBER SKILLMAN: I&C systems.

VICE CHAIR STETKAR: But, I mean, there are

statements in there that says that it really applies to safety-related and important safety systems.

MEMBER BROWN: Right.

VICE CHAIR STETKAR: And the question is where does that level of effort of review extend out into that gray area from safety-related to not so important to safety?

MEMBER BROWN: Okay. I just wanted to make sure --

VICE CHAIR STETKAR: Because certainly the staff will do some level of review of everything, but tailoring the level of effort from what's characterized, I think it's in a footnote or something.

MEMBER BROWN: No, it's right in the second paragraph under "Level of Review." I just --

vICE CHAIR STETKAR: That was the whole concern about understanding where that effort --

MR. CONCEPCION: Yes, the applicability of the DSRS today is for safety systems. And we stated in 7.0 that it could be applied to non-safety systems. But there is a four -- four different categories of systems now with this risk-informed approach. And we want to make sure we factor that --

vICE CHAIR STETKAR: In theory, don't get

too close to 50.69, but in principle there's a graded approach.

MR. CONCEPCION: Yes. And we want to make sure that we provide the reviewer with information so that he understands what level of review will be applicable to --

vICE CHAIR STETKAR: That's the important part. That's right.

MR. CONCEPCION: We understand that, yes. Okay. One point that I want to mention here, there is an asterisk -- oh, I'm sorry. I guess, 7.2, yes, system characteristics.

There is an asterisk on 7.2.1, quality. This section is under development and is -- we're on a -- we're tasked with evaluating the use of Branch Technical Position 7-14, which is used for software —-- reviews of software development processes in I&C systems. So, that section is still in the works and not available today for public review and comment, but it will be in the next couple of months.

Now we are into Appendix A, which is hazard analysis. This is new guidance that we provide the reviewer to review I&C hazard analysis. The guidance focuses on hazards contributed from I&C systems, for example, through compromise of redundancy

or independence, or diversity and defense-in-depth, or complexity. And guides the reviewer to evaluate the adequacy of hazard controls for each hazard or contributory hazard identified in the applicant's analysis at earlier phases in the development process.

So, what we want is to make sure that that the reviewer understands how those hazards have been addressed by the applicant as the applicant identifies them, and what compensatory measures are -- will be in place to address those.

MEMBER SKILLMAN: How broad has the effort been to identify the appropriate hazards? Can you speak specifically to operating experience, and particularly to European operating experience where designers have been using digital I&C for many, many years?

MR. CONCEPCION: Sushil, do you want to tackle that?

MR. BIRLA: The guidance that you see in Appendix A is about five pages, and it does not have that level of detail. But the Technical Basis to create the Appendix A is the Research Information Letter that Research is preparing and will be made available eventually to the public, and to the licensing offices.

And this Research Information Letter is collecting whatever information is available, existing knowledge, including any lessons learned anywhere. We are collaborating with IRSN France. We've been exchanging technical information with other regulators, UK, Sweden, Belgium, Finland. Whatever information is available is being incorporated in that. But no new investigation has been launched to learn more from operating experience. There is a lot more to learn, that's work in progress.

MR. JUNG: Let me just add a couple of more information. The Staff has been involved in a multinational design evaluation program for new reactors. The members of that working group under NEA including much of the European countries who are interested in nuclear reactors.

Through that framework digital I&C is one of actually the generic working group, and Dan Santos was supposed to be here. He's actually in China this week to have an in-depth digital I&C working group internationally, about 10 members. They're developing some of the common positions on digital I&C utilizing lessons learned and operating experience from different countries.

In addition, for EPR and some other

working groups, there is specific working groups under which digital I&C has been very active in sharing lessons learned among a list of regulators.

In addition, the International Electrotechnical Commission, IEC, is a European standard development organization that have been gathering operating experience, and they've been developing significant number of actually standards. The staff has been participating in the past and some of the key member groups are sharing some of the lessons learned.

So, it's an ongoing process, and at the same time a lot of the digital experience we had within U.S. plants, non-safety system obviously have many experience. Of course, none nuclear industry have a lot of lessons learned, so the goal of this hazard analysis is not to develop how to do the analysis, but instead it's more of a what staff should look for telling the industry applicant to -- what we are looking for is this, or you should be addressing these type of hazards.

Some of the guidance we already have developed since `90s actually has quite a bit of the types of hazards and failure modes. I know ACRS has spoken about failure modes, how comprehensive are

those? It's a work in progress, digital systems, of course, it's evolving in nature. That's why we are looking for more of an integrated look at the hazards, not because regulation says this, you have to address this. We are looking for a broader set of both internal hazards as well as external hazards, even human factors hazards, if somebody makes a mistake. So, there are some elements here that are relatively related to sort of PRA type here because that gives you sort of an integrated look at least what are the type of hazards. But at the same time what we are looking for is not the hazards to the nth degree. What we are looking for is really those hazards that can have an impact on safety functions that we are really concerned about. There are a lot of other measures and regulatory requirements and other standards available to demonstrate reliability or quality of certain components, and process. What we are looking for here is at the design certification stage, knowing that some of these designs may not be built 15, 20, 30 years down the road. What are the types of hazards we need to be concerned about. So, this is in my mind a reconfirmation of GDCs and Part 50.

The fundamental concerns associated with hazards are related to the fundamental design

principles, so we are reemphasizing that system engineering perspective. So, some of the lessons learned from European framework we are engaging. Is it sufficient? There are more ways to go, but we started more engaging in the European framework.

MEMBER SKILLMAN: Thank you.

MR. CONCEPCION: Okay, so slide 15 shows a synopsis of Appendix B, I&C System Architecture. We provide guidance for the reviewer to look at areas such as interfaces between I&C safety systems and non-safety interfaces. This is an opportunity for us to tell the reviewer you need to ask for those functional logic diagrams that would expand on the design information provided in some sections of the application, so we're giving the reviewer instructions to ask and look for that kind of information to support the review activities. And this is direct feedback that we received from ACRS, so we attempted to incorporate it in our guidance.

And the next slide is on simplicity. We're looking holistically at how simplicity was considered by the applicant in the design of the system. We looked at information from the Multinational Design Evaluation Program, common positions and also information from IAEA to develop this guidance, and it

is out there. What we want to make sure is that unwanted complexity is at least reviewed by the staff and evaluated as we go through and review these I&C systems. And like I said, it's consistent with guidance internationally, so we tried to incorporate it in our review standard.

VICE CHAIR STETKAR: I think we had some comments during the Subcommittee meeting --

MR. CONCEPCION: Absolutely, yes.

VICE CHAIR STETKAR: -- that in some cases -- I think you presented it correctly here, that unwanted complexity is what we're trying to avoid. In some cases, complexity -- there might be a net benefit to some sophisticated algorithms, for example. And that's okay, for functionality, you know. And as long as they're justified, that's okay.

MR. CONCEPCION: Absolutely.

MEMBER BROWN: Yes. I actually draw a little bit of a distinction between -- I agree with you. If you look at some of the algorithms that we saw for control functions and the other design centers we worked on, they're fairly interesting algorithms. They are not simple at all.

VICE CHAIR STETKAR: And there's a net --

MEMBER BROWN: And there's a net benefit —-

(Simultaneous speech.)

MEMBER BROWN: -- very critical control stuff. But the fundamental thought of what -- they way I have addressed, or the point I have been trying to make with simplicity is not necessarily the algorithms and the software which you need to be careful of, people can overdo the software goodies, as well. But to have the complexity in the design, in the hardware interface designs and other things like that. So, it's a balance. I mean, there's good, there's some not so good, and just want to make sure you don't do the not so good. And you're right, we did have that discussion in some detail, just to let everybody know.

MR. CONCEPCION: One of the key aspects is to make sure that those features do not impact other safety functions that need to be accomplished, so we made sure that we provided guidance to address that. Okay. So, in summary --

MEMBER BROWN: Before you go on to the summary, I thought I'd bring up -- we discussed -- this is all in the name of transparency and openness. Okay? You can believe that.

MR. CONCEPCION: Amen.

MEMBER BROWN: We discussed, and I'm going to -- my comments I'm trying to calibrate you on what

we -- what I said we were not going to talk about in the Subcommittee meeting, but something that I in subsequent review after the meeting when I was going through stuff, because I didn't understand a particular point. So, in preparation for this meeting I looked and said oh, okay, that's a different thought process, so I was going to bring that up. And I said I am not going to address, what was it?

PARTICIPANT: Where's Mo?

MEMBER BROWN: I didn't want to get -- oh, he left. He's not going to be here for the good stuff. Cyber security.

(Simultaneous speech.)

MEMBER BROWN: I'm not going to address it as cyber security. That's what we -- we've been down that road, and whether I agree or disagree we've made the comments in our letters. I'm not going to revisit it and that's it. However, okay, you all were very —-- in the way you all talked about it in our Subcommittee, presented certain things, and a few comments got me thinking. I went back and looked under Section 7.2.9, which is referred to -- and part of that, there's three areas, control of access, identification and repair. Control of access is an interesting thing called Section 5.9 of IEEE Standard

603-1991. It's pretty specific in terms of that you have to come up and meet the control access including parts of the generation station design, the safety system design, et cetera. It's very, very explicit.

When I went back and looked at what you all wrote here in the DSRS, you covered a number of points relative to digital systems. You talked about networks, maintenance, access, test points, things like that. Largely, that discussion is focused on internal functioning of the safety systems and their possible interconnections, and their information flow to main control room, et cetera, whatever.

What you didn't talk about was external access, control of the access to those buses that may be -- that connect to the external world. Now, forget the cyber security aspect of it. I'm not working 73.54, not working 73.1, I'm not working radiological sabotage.

PARTICIPANT: This quacks like a duck.

MEMBER BROWN: That's right, theft of nuclear material. Okay? This is -- which is covered in 73.1. And when you look at it, there's only one real aspect to that, is if you look at the design centers we've looked at up until now in the new plants, they almost all go into a bus. That bus goes to the main

control room and a few other locations, possibly the Technical Support Center, just depends on the design. Almost had a little thing that sent stuff out to the external world through a firewall of some kind.

That is a control of access that falls in my opinion under the purview of 603-1991. So, I wanted to bring it up. It hit me -- I don't want to surprise anybody with anything, but it is on my plate for further discussion with the Committee.

MR. JUNG: Charlie, thanks for the input. We'll look into it.

MEMBER BROWN: Okay.

MR. JUNG: But at the same time I'm going to -- that's why simplicity and hazards analysis we are going to really provide a global framework. That type of access from outside to the safety system and plant SA, that's one of the unnecessary connections of complexity.

MEMBER BROWN: Yes, for instance --

MR. JUNG: And the hazards -- how they're going to protect, this step is going to look for --

(Simultaneous speech.)

MEMBER BROWN: My favorite way is you don't have that. You throw that away and you send data to the main control room. Somebody wants to take a thumb

drive and download it and go to another -- an air gap, a giant air gap. Now, that's not perfect but it beats the hell out of having somebody being able to jigger with a firewall and trying to define what that looks like.

Anyway, I'm not so sure that I'm comfortable with just leaving it up to the haphazard, no pun intended, utilization of the hazard analysis because that could be -- you know, you can lose something as you go through designs in terms of how that's applied.

Anyway, it was an interesting -- it never occurred to me before because I -- my lack of real understanding, but it is a point of access and it should be able to be controlled by the architecture design whether you do it via no connection, whether you do it via some firewall, whether you do it -- but if you're going to do it. And here, to me, you ought to have some review guidelines for the reviewer to look at. Okay?

MR. JUNG: Okay.

MEMBER BROWN: Okay.

VICE CHAIR STETKAR: One of the things that you may want to look at, and I was just searching through the hazard analysis appendix, is perhaps

enhancing a bit of the guidance in there to at least bring a sensitivity to these issues, because it talks about external influences, but primarily from environmental factors, and things inside the plant.

MEMBER BROWN: Yes.

VICE CHAIR STETKAR: There is -- and Sushil is going to point me to it, but there is a section that says no unintended or undesirable communications pathways which could broadly be interpreted as part of that. But you could easily add something to at least draw attention to it.

Now, Charlie doesn't like that --

MEMBER BROWN: No, no, that --

vICE CHAIR STETKAR: -- you know, the hazard analysis part of it.

MEMBER BROWN: No, no, no, no. That's just fine, John.

VICE CHAIR STETKAR: But at least draw attention to it as looking for those types of threats.

MEMBER BROWN: I think you ought to double it up. I mean, you ought to cover it in terms of their technical review of an architecture, and then here's the analytical part of it that gets reflected as part of addressing those types of threats in the hazard analysis. I didn't even think about that. That's a

great thought. Now, Sushil can --

MR. BIRLA: Thank you for the highlighting. I want to assure you that the guidance for reviewing hazard analysis will not be haphazard.

MEMBER BROWN: Oh, I didn't -- don't take that the wrong way, Sushil. It was not meant that way.

MR. BIRLA: The Appendix A that you see in the DSRS is only five pages, because I mentioned earlier to support the judgment of the reviewer there is a Research Information Letter. We will review that with the ACRS I&C Subcommittee in June, and then we'll reinforce the point I made today, and we'll show you the additional detail.

There's always an issue that my colleagues point out between very general and abstract statements that have sweeping coverage, and specific examples that go to the level of detail that you expect. And the challenges that my colleagues remind me of, that when you start giving specific examples, the applicants and reviewers just focus on the specific examples and forget the generalization.

MEMBER BROWN: I agree with you, but you've got to guard against that.

MR. BIRLA: Right.

MEMBER BROWN: What I meant by haphazard

was -- poor choice of words, just to make sure I wasn't shooting arrows at you, was really the variation in reviewers and different people seeing things and time lapse for doing things. Things can get lost. That's what I mean. But if you put some more -- and I think John's suggestion of adding something in there to give you some idea of what you're -- some specificity or examples are useful, but you certainly don't want somebody to say this is the inclusive list of everything you have to look at.

MR. BIRLA: Exactly.

MEMBER BROWN: And that's a very critical problem that we run into.

MR. BIRLA: So, as Ian pointed out, in our existing guidance things are specific clause by clause this is what you review, and things could slip through the cracks. And the purpose of having the hazard analysis appendix is to give that overarching organizing framework to prevent something falling through the --

MR. JUNG: We understand, Charlie.

MEMBER BROWN: Okay.

MR. BIRLA: Thank you.

MR. CONCEPCION: Does that address your cyber security --

MEMBER BROWN: I don't have a cyber security issue. I'm making it very clear. I'm not -- this is not in the framework of the realm of -- I can -- the thing this does it allows the cyber security people to go work their magic knowing that they've got an architecture that will be -- and that's -- and you all -- that's stated in 5.9. I mean, you're supposed to aid the control of access in the plant design, in the system design, et cetera.

MR. CONCEPCION: We're definitely going to expand that section to cover these connections that are, in fact, being made by applicants to TSC or whatever it is.

MEMBER BROWN: Okay. One other thing, we had -- just before you get into the summary, we did —-- we had tons and tons of suggestions as I would like to phrase them --

MR. CONCEPCION: I have that as part of --

MEMBER BROWN: It was a very productive meeting that we had with them. And we agreed that they could resolve these after the public comment instead of trying to crank them in. And I didn't say it in the meeting, I would just suggest, if you're all going to be delayed, I don't know what -- if you're going -- not delayed, but if you're going to -- what's the

framework? Hold it up a little bit, please. When are you all going to send this out now for the first public comment? Is that still the same schedule?

MS. STAREFOS: No, and I haven't run the final -- actually, I have a meeting after this one with my management to get them on board with the date.

MEMBER BROWN: Okay.

MS. STAREFOS: But it will be after the first of the year.

MEMBER BROWN: Okay. All right.

VICE CHAIR STETKAR: But on that time scale, I think it's --

MEMBER BROWN: Oh, no, I'm not -- I was--

vICE CHAIR STETKAR: It would just throw too many monkey wrenches into the --

MEMBER BROWN: No, I'm not -- I wasn't suggesting that. I was just mulling over in my mind if it was going to be six months, then I would have made an observation or suggestion can you do something with certain ones if we felt they were more higher level ones.

MS. STAREFOS: Right.

MEMBER BROWN: If it's only a month or so, then it's not -- it would throw too many monkey wrenches into the gears.

MS. STAREFOS: Certainly, if we choose to address any comments, you know, we would certainly put this amongst them. I don't want to speak for Milton, but I think that he would agree that we would put this amongst the ones that we would attempt to --

MR. CONCEPCION: We definitely are looking into these comments.

MEMBER BROWN: Okay. No, no, I --

MS. STAREFOS: Yes.

MR. CONCEPCION: And we will incorporate all of them.

MEMBER BROWN: In one way, shape, or other. We're looking forward to that, and you all have committed to at least allowing us to review that again.

MR. CONCEPCION: Absolutely.

MEMBER BROWN: So, we can see what we've done. All right, now you can go on. That's the only other wrinkle I came up with that's post meeting. And I wanted to make sure I didn't surprise you with anything on it.

MR. CONCEPCION: Great.

MEMBER BROWN: So, you can fire away.

MR. CONCEPCION: Okay. Well, you stole my thunder because I brought the comments and

observations, and I was going to talk about that.

MEMBER BROWN: Go ahead.

MR. CONCEPCION: But you did.

MEMBER BROWN: Go ahead, you've got plenty of time.

MR. CONCEPCION: Yes, I guess. We came up with three major areas as our take-aways from our November 16th meeting. And we provided a draft version to you for review, and we're taking these observations and comments and incorporating them as appropriate in the DSRS. And, hopefully, the next time around you see the incorporation of them with the addition of this additional comment that you just had, which we will add to the list.

MEMBER BROWN: Okay.

MR. CONCEPCION: I guess in summary, the DSRS is in draft mode. We're really pleased with the way it came out, and we can't wait to just have the application come in and test it to see if it really works the way we expect it.

So, I guess in terms of next steps we're going to continue --

vICE CHAIR STETKAR: I'm sorry, Milton. Before you leave that one --

MR. CONCEPCION: Yes.

VICE CHAIR STETKAR: -- it's worth -- before you go to the next steps, for the benefit of the rest of the Committee who didn't attend the Subcommittee meeting, I wanted to ask Joelle something because something you mentioned earlier regarding Chapter 19 and rather than having a lot of that detail replicated for each specific design, you decided to pull it up into the SRP.

Although this particular chapter, and I wanted to keep this up here, says mPower TM DSRS Chapter 7, as best as I can tell there's very little mPower Design-Specific, if any, information in that chapter of the review plan. And, therefore, this is essentially a template for any of the Small Modular Reactors coming down the tube. It's in my mind very, very similar to that sort of overarching Chapter 19 in a sense, unless I'm misinterpreting something. We had some of this discussion in the Subcommittee meeting, but I wanted the rest of the Committee to have the benefit from this, that although it's listed as mPower, it's not very specifically focused on details of that particular design or architecture.

MS. STAREFOS: Let me address a couple of aspects of what we were trying to do here, and this sort of came to be placed in the DSRS.

There was a need following the Large Light Water reviews to incorporate our lessons learned, and to try to really enhance our guidance document. When this was initially identified we thought a pilot program would be an appropriate approach. At the same time, we were hearing from the Commission that they would like to see some design-specific development during pre-application, and ultimately resulted in us having a plan for each of the reactor designs, mPower being the first one in the queue. They have been very active with us pre-application. We approached them and asked if they would be interested in working to pilot this.

When we started to think a little bit about how to incorporate it and where to put all of this, it didn't seem appropriate to try to change a Standard Review Plan that applies not only to NRO and our New Reactor reviews, but also to NRR and a lot of the changes and new potential digital I&C reviews that they're doing, so we thought we would keep the scope as narrow as possible. And it was a good fit to put in the DSRS, as far as kind of a pilot opportunity.

Whether we choose to expand that to other SMRs, whether we choose to move that after the implementation experience that we have with one or

more of these reviews, then I think that the staff would certainly be discussing on a broader level whether or not those lessons learned would be important to share back into the SRP at some point. But I would presume to know that answer at this stage because we really don't have the experience of implementation with this very different and unique approach.

VICE CHAIR STETKAR: And I think we appreciate, we had some of that discussion in the Subcommittee meeting --

MS. STAREFOS: Yes.

VICE CHAIR STETKAR: -- but for the other members who didn't have the benefit of that discussion, it's a bit of a subtlety here.

MS. STAREFOS: Yes. This is a very unique piece.

VICE CHAIR STETKAR: And I want to make sure everyone understood it. Thanks.

MR. JUNG: Just -- the SRP update is on the agency's agenda. We are at a planning stage for Chapter 7 SRP as a whole. This DSRS development we are doing is part of the consideration how we could utilize this effort to make the SRP more consistent and improved. So, that's the agenda. But there are new

approaches here. There are certain elements of the guidance here, one example, like ISG-4, certain elements we decided not to, given the design-specific nature of -- that really don't have certain complexities that we have seen in other designs, that we don't really need the guidance for.

Other than that, broadly speaking these diagrams would -- especially new designs coming in, I don't see why anybody would deviate from this. I just want to show visually. This is the current guidance that includes current reactors ISGs on top of the SRP. This is a new DSRS. This is sufficient. You can see why this is so enticing as a manager, is I can give th is to my staff, newest members coming in for new reactors perspective, this is equivalent to that, and may be better in some places, in fact.

This one, in February meeting actually I explained to you certain words, independence showed up 225 times, a lot of them, repetition of the same guidance. But this one has one several page section on independence. This guides you to the right regulatory guides and understand better. It tells you specifically how to do it better so you can see the knowledge management perspective why this is a lot better. Is this perfect? We'll continue to update as

we go. That's why we are doing pilot, we will learn lessons from this, we'll improve that. So, it's to make this -- the benefit out of this and apply to a lot of other areas, so we'll communicate --

MEMBER BROWN: Well, from -- just to echo that. There's a template, like you say, you don't have all of ISG-4. Some of the concepts you have in ISG-4 are embodied in here. They're just not written in the manner in which you wrote them in ISG-4. And this is a personal opinion, not a Committee opinion, personal opinion, this is a good template for spring boarding this in for even large power reactor, large reactor designs because it covers the elements, and you design it in a -- and you design from a top down -- I mean, when you go design a house you don't go build it pipe by pipe and design it pipe by pipe. You design what I want it to look like. You've got to have a roof, you've got to have rooms, where do you want the rooms, how many doors do you want to go into the rooms, h ow many lights do you want in the rooms, et cetera, et cetera. And then you go design your systems to accommodate that within the rules of the National Electric Code, or whatever other codes you probably use. And this does it from the principles down, and then includes all the other stuff in terms of what you

do with the individual systems, and the piece parts within those fundamentals. So, it's a nice -- I like it because it obviously gets that point across in terms of the architecture, which is a very, very critical piece of these I&C systems in terms of its performance and safety. So, anyway, that's my two cents. You have another slide, right?

MR. CONCEPCION: Okay.

VICE CHAIR STETKAR: I just wanted to interrupt it there because the next slide is more specific on where they go with this particular document.

MR. CONCEPCION: This is the last slide. I'm not going to spend a lot of time on this, it's just that we want to maintain that engagement with B&W as the applicant. We will continue our interactions with ACRS. We will come back and present final version and address any questions you might have at the time, and continue our path to incorporating comments, feedback from the public as the document goes out for formal review and comment. And wait until next year so that we get the application to start implementing it which should be really interesting.

MEMBER BROWN: To give you an idea of the stack of paper, that was 500 pages roughly down to

about 130. And for somebody who's not been in the commercial civilian power plant world of implementation, I was able to read this and then walk through the table where all the requirements are mapped into various parts of it. And I just can't see any way that this approach gives the reviewer a leg up, particularly people you're bringing in new because you're always -- you want to keep bringing in new folks. So, I just think it's a -- I want to compliment the staff right at this point that I thought they did a very, very good job pulling this stuff, and taking the lessons from all the four different Design Centers and cranking it in, so there's a few kudos.

Before I leave this, I guess you want to do your next steps, and then we can --

MR. CONCEPCION: I think I'm done.

MEMBER BROWN: You're done? Okay. Do we have anybody on the bridge line that we know of?

PARTICIPANT: Dennis was listening in.

CHAIRMAN ARMIJO: Originally, there were three people on the bridge line, at least when we opened it up.

MEMBER BROWN: Could we go get it opened up, Christina? Who does that? Hello, are you still there?

MEMBER BLEY: Is it open? Hello.

MEMBER BROWN: Yes. Okay, does anyone have any comments from the bridge line?

(No response.)

MEMBER BROWN: Okay. Dennis, did you have anything you wanted to say on the bridge line?

MEMBER BLEY: I'm here. I think there are some other people on the bridge line. No, I agree with most of the things that were said here, and I like where they've gone, and nothing new here from the Subcommittee meeting.

MEMBER BROWN: Okay. One more shot for anybody else that's on the public comment, on the bridge line? Hearing nothing, I will -- is there anybody out in the audience?

(No response.)

MEMBER BROWN: Okay. I think we're done. I turn this back over to you, Mr. Chairman.

CHAIRMAN ARMIJO: Okay.

MEMBER POWERS: Mr. Chairman?

CHAIRMAN ARMIJO: Yes, sir.

MEMBER POWERS: A question. Are we writing something on this?

MEMBER BROWN: Yes, we have a letter.

MEMBER POWERS: Well, I think the opening

comment spoke to preaching, and I think that any comparison between Mr. Brown and a man of the cloth reflects such a catastrophic misunderstanding it deserves comment in anything we write.

CHAIRMAN ARMIJO: We could expand on that.

(Laughter.)

VICE CHAIR STETKAR: There will be fire and brimstone out there.

CHAIRMAN ARMIJO: Well, first of all, I'd like to thank the Staff for doing this. I think it's amazing that you've got your review plan down to a workable, readable document that pretty critical people feel is something that will work. So, I'm happy to see that. Maybe the Staff can -- in our letter we might make a comment that might be a best practice that staff should take a look at for other applications beyond -- not just Small Modular Reactors.

MEMBER BROWN: We'll have an opportunity to discuss those thought processes.

CHAIRMAN ARMIJO: Yes. And with that, thank you very much. We're finished with this presentation. We're way ahead of schedule, well not really, about 35 minutes ahead of schedule. I hate to waste time, but I'm not sure we can accomplish anything in 30 minutes.

MEMBER SHACK: We tried this morning and we sure didn't --

CHAIRMAN ARMIJO: Well, we tried --

MEMBER SHACK: We did, we're oh for two.

(Laughter.)

CHAIRMAN ARMIJO: We tried two things and both failed, so that's 100 percent. But we do have a lot of letters to write, and it might be useful to have a -- well, we have a 15-minute break scheduled.

MEMBER BROWN: AT 2:15.

CHAIRMAN ARMIJO: At 2:15. Can we take the break early and start the Spent Fuel Transportation early? Restart at 2:15.

VICE CHAIR STETKAR: We have to be careful about -- this is a full Committee meeting.

MEMBER SHACK: Yes, I think we can look at the letter at 2:15.

CHAIRMAN ARMIJO: Yes, we'll reconvene at 2:15, take a quick look at one of Mike's letters. Okay, 2:15, please be back.

(Whereupon, the proceedings went off the record at 1:55:58 p.m., and went back on the record at 2:31:37 p.m.)

CHAIRMAN ARMIJO: Okay. It's all your's, Mike.

MEMBER RYAN: Okay, great. Thanks very much. Thank you for your patience with our scheduling today. We had a large Commission briefing, so we're catching up.

MEMBER POWERS: Mike?

MEMBER RYAN: Yes?

MEMBER POWERS: I will recuse myself from this session.

MEMBER RYAN: Yes, sir.

MEMBER POWERS: Because of organizational conflict of interest with at least one of the principles.

MEMBER RYAN: All right. Thank you very much. So, let the record show that Dr. Powers is recusing himself from this session because of an organizational conflict of interest. Thank you, sir.

On September 18th, 2012, the Subcommittee on Radiation Protection and Nuclear Materials was briefed by representatives of NRC SFST staff on Spent Fuel Transportation Risk Assessment, NUREG-2125. I'm sorry, NUREG-2125, studies of radiological impacts of spent nuclear fuel shipments under routine and accident conditions for a range of road and railroads in urban areas across the country.

With that short and accurate introduction,

we will now proceed to the meeting. I call upon Mark Lombard, Director of SFST, NMSS to being. Welcome.

MR. LOMBARD: Thank you all. Thank you, appreciate it. I haven't been before you since I moved over to NMSS from NRO, so I'm in a different capacity now. You might remember I was in the Division of Safety Systems Risk Assessment over there, so now I'm Director of SFST.

So, thank you for the Subcommittee's review of the report and the Subcommittee meeting today. We really appreciate your input on -- this is an important report to us, and it's the fourth in a series. Fourth revision that's been conducted of this study over the last 35 years, and your expertise and feedback is really key to us.

It's an important report to us as we move forward. You may or may not know that DOE is getting ready over the next probably three to five week time frame to issue their response to the Blue Ribbon Commission Recommendations, and we suspect that as that occurs there will be some more interest in transportation risks, so this is kind of a key time of things all to be coming together for us.

In that report, from what we know so far, it looks like they're going to look at a phased

approach, might be an interim consolidated storage facility of a relatively small size that will be pursued in a short time frame, short in regulatory space anyway. And then a second phase, a little bit larger interim consolidated storage facility, and then eventually a repository. So, again, the transportation study we think is going to get a lot of interest as those things move forward.

If you look at slide 3, and I think it's funny, you know, being a person who was trained on the old overhead projector, we still call them slides, and I get stuck in that myself, but page 3 here. We really had the A-Team that helped us out on this review. And you look at the folks from Sandia National Lab, and Dr. Ammerman, Carlos Lopez, and Dr. Ruth Weiner, just really the A-Team. They've done a lot of good work for us over the years, and also on this particular project. Dr. Ruth Weiner I'm very familiar with because she does all the RADTRAN work that we use for transportation risk studies and consequence studies. And, again, they really are the A-Team that helped us out on the development of this revision of the SAFTR report.

When you look at our internal review team, Dr. Gordon Bjorkman works -- the top three folks, Dr.

Gordon Bjorkman, Chris Bajwa and Dr. Einzinger all work in Spent Fuel Storage and Transportation Division, recognize they're experts in their field. Matter of fact, Chris Bajwa was so recognized that he's over at IAEA now for a three to five-year stint on their fellowship, and the other two, Dr. Bjorkman and Dr. Einzinger are still with us in SFST. And Dr. Anita Gray, a recognized expert in her field in Health Physics, again did a lot of really good work for us internally.

Oak Ridge National Labs, we had a peer review team, there again top shelf experts in their field with Matt Feldman and Dr. Parks. They were the two leads from that standpoint but are also supported by a few others there at Oak Ridge National Labs. But I give a lot of the credit to our Project Manager, John Cook, and he will take you now into the technical details, and answer any questions you may have.

MR. COOK: Thank you, Mark. I'll be providing some brief introductory remarks on the background of SFTRA, and then we will turn to a more detailed presentation of results and analyses that are being completed, and also some modifications we either have or intend to make to the report before it's published.

Under the first item, the Final Environmental Statement, the NUREG-0170 contained NRC's first Spent Fuel Transportation Risk Assessment, and based on that assessment the NRC concluded that its regulations in Part 71 were adequate to protect public health and safety during spent fuel transport. But they also stated that transport should be subject to close and continued review.

And as you can see, in about a 10-12 year period, or I should say cycle, we have repeated the examination of spent fuel shipment risk estimates. And with the addition of the current, these assessments now span some 35 years.

One of the primary mission or primary goals for SFTRA is to provide an updated technical basis to reconfirm the Commission's conclusion that the regulations are, indeed, adequate to protect public health and safety. And such a reaffirmation if, of course, found to be technically justified helps to reassure the public, particularly before any large spent-fuel shipping campaigns. And when the study began back in 2006, it did, indeed, appear that large spent-fuel shipping campaigns might be on the horizon. But as it has turned out at present, no spent fuel shipping campaigns are imminent; however, we believe

that SFTRA's results would be generally applicable to any future spent fuel shipment transportation activities.

And with that, I think I'm going to --

MEMBER REMPKE: Before you go --

MR. COOK: Sure.

MEMBER REMPKE: You have to excuse me, I'm not an expert in spent fuel transportation. When I was looking at this document that was sent out to us, I was curious on how you came up with what sequences, what initiating events, and what phenomena to consider in your analysis. I'm a thermal hydraulics background where we do phenomena importance, ranking tables. Did the experts that you were mentioning in your earlier slide, did they get together in a room for several days and say well, we're going to consider high-burnup fuel, we're going to consider new cladding, we're going to consider a lot of phenomena, and that's what was incorporated into the models and analysis? How did you come up with what to look at it in your evaluations?

MR. COOK: We'll get to more detail on those questions in just a second.

MEMBER REMPKE: Okay, you can --

MR. COOK: But briefly, we looked at spent

fuel shipment -- spent fuel casks that are currently satisfied, and that's sort of defines the types of fuel loads that you're going to have. And we then also considered the typical accident statistics that regular freight packages, and these packages would move in in terms of what might be initiating events for accidents. It's a combination of those two things which together when analyzed bring us to the risk consequences and results.

MEMBER REMPKE: So, for like new cladding and high-burnup fuel, are those things incorporated somewhere in this approach?

MR. COOK: We have a discussion of high-burnup fuel in here.

MEMBER REMPKE: Okay.

MR. COOK: But, again, the burnup that's been analyzed in this report, the extent to which the particular casks we've selected for the study are currently certified for.

MEMBER REMPKE: Okay.

MR. COOK: So, that's the limitation that we have on high-burnup.

MEMBER REMPKE: Okay.

MR. COOK: Okay?

MEMBER REMPKE: Thank you.

MR. COOK: But with that, I'd like to turn for more detailed analysis to Doug, if you could please pick up the basic --

MR. AMMERMAN: So, there's really two different aspects of a Transportation Risk Assessment. What happens if there's not an accident, routine conditions. You have a cask that is emitting some amount of radiation going down the road in the public sphere, so the people are somewhat concerned about. So, this report describes the doses that will accumulate to various types of people. And I'll get into that in more detail in a later slide.

And then under accident conditions, now what happens if there's an accident. And we used deterministic fine element analysis to say what would happen to the cask under different types of accidents. And found out that almost all accidents don't significantly damage the cask. As a matter of fact, almost all accidents are below the requirements that are stipulated in 10 CFR 71, Part 73, Subpart 73. And casks that have demonstrated, the casks survived that event.

There is another set of accidents that are more severe than regulatory accidents, but still don't cause any damage to the cask. And we looked at those,

and that is really one of the big differences in this study, is that the early studies, 0170 and the modal study assumed that any accident that was more severe than the regulatory accident would result in release of radioactive material. In other words, if the casks had zero margin of safety against the design basis. Obviously, that's not true, and that's one of the biggest reasons why this study shows such a marked reduction in risk.

The initiating events, like John described a little bit ago, were the initiating events for accidents that occur for all freight now. And there's not been enough spent fuel shipments that we can just say let's look at the accident history for spent fuel shipment. So, we look at the accident history for all large trucks. Are all large trucks the same? Not necessarily, but that's the best data that we have.

MEMBER SHACK: But do they take special precautions for spent fuel shipments? I mean, are there warning trucks in front, warning trucks in back, and escorts?

MR. AMMERMAN: In urban areas there are police escorts. There is not warning trucks, and it's not like a large load, you know, where you have warning, there's a large load coming. There's not that

for spent fuel shipments. And the escorters were to —- - as a security issue, not as a safety issue.

MEMBER BANERJEE: So, if a cask gets into a fire, is there a length of the fire that it can be exposed to without severe damage?

MR. AMMERMAN: Yes, there is. And the regulatory fire is a 30-minute fully-engulfing fire, which fully-engulfing means that the cask is right in the same location as the fire, and the fire is the way around it, and the cask is suspended above the fire so that there's no protection from the ground either. We analyzed fires up to 3-hours in duration for the rail casks, and found that at that duration there still is no seal failure so that the cask can survive up to a 3-hour fire. Fires longer than three hours are really not credible. I mean, a fully-engulfing fire longer than three hours is not a credible event.

MEMBER BANERJEE: These are all truck transports.

MR. AMMERMAN: The 3-hour fire was rail transport.

MEMBER BANERJEE: Yes, because rail transport potentially you could get longer fires.

MR. AMMERMAN: The accident history for rail shows some fires that are very long, but

typically they're not very long all in the same location. So, it's a traveling fire, you know, you have this tank car full of material that's burning, and it ignites the one next to it, and that one burns, and the one next to it, so you have a traveling fire.

MEMBER BANERJEE: That's a good explanation.

MR. AMMERMAN: And the cask doesn't go with the fire. It stays in one place.

MEMBER SIEBER: But on the other hand, you did analyze tunnel fires for rail casks.

MR. AMMERMAN: Yes.

MEMBER SIEBER: And those are pretty severe.

MR. AMMERMAN: Right. Yes, we did look at -- well, the NRC has looked in great detail at the Baltimore Tunnel fire, the Caldecott Tunnel fire, and the Newhall Pass Tunnel fire which just happened a couple of years ago, and what the response of the cask would be to those environments, and we included some of that information in this report.

VICE CHAIR STETKAR: I want to challenge you on the -- you use the word "credible", and one of my pet things is I don't know what that words means, so I always people to define it for me. Does that mean

it's not possible, or is the frequency so low that you've looked at it and dismissed it for some other reasons?

MR. AMMERMAN: It's the second one, that we've looked at it and the frequency is so low that we said that it's -- the risk that would be accumulated by adding it into the accident basis would not be incremented because the probability that you're multiplying by to get risk is so small.

MEMBER REMPKE: When you say "frequency," isn't that dependent on how many shipments occur? It's not really a frequency you've looked at, at all. Correct?

MR. AMMERMAN: All of the study is on a per-shipment basis, exactly. And that's because this is not a study for any particular action. It's a generic study, and any given action -- I mean, in order to do a true frequency you'd have to have a shipping model.

MEMBER REMPKE: Right, and a location that you're shipping to.

MR. AMMERMAN: Right. Since there is no shipping model, then we can't do a true frequency. I mean, we could speculate and say well, we think that there's going to be 100 shipments per year, just

multiply everything by 100 and you have the right answer, or somebody else could speculate there's going to be 10,000 shipments per year. If you want to have a accident per year instead of accident per shipment, just multiply by the shipment, number of shipments.

MEMBER SHACK: But just to come back to Sanjoy's question, I mean, as I recall, I mean, your most severe fire was a railroad tank car where all the fuel gathered in a pool, and you sat the thing in the middle of the pool. Right?

MR. AMMERMAN: Exactly.

MEMBER SHACK: So, that's his --

MR. AMMERMAN: Yes.

MEMBER BANERJEE: It depends, you know, what the -- I can't also easily think of a fire that would burn for longer than three hours but, you know, in many of these situations if the pool forms, say it's a flammable liquid, not a liquified gas but a flammable liquid, then you could conceive of the pool being fed and actually it being a pool fire. Right?

MR. AMMERMAN: Right.

MEMBER BANERJEE: Which this tank is in. But it's hard to think if a pool which would keep getting fed for more than three hours. I guess you've looked at this in great detail. Right? Somebody has.

MR. AMMERMAN: Yes. The NRC sponsored a separate study just looking at fire statistics, or the history of fire accidents for both truck and rail accidents, and the essential outcome of that was that there are very few, if any, that even meet the 30-minute fire accident engulfing in one -- co-located and engulfing fire that lasts -- that's a hot fire that lasts for 30 minutes.

MEMBER BANERJEE: There have been storage farm fires which have lasted longer than this.

MR. AMMERMAN: As a matter of fact, that's one of the incidences that we did not look at. I mean, a person could postulate a train goes off the track and there's this big tank there, you know, a storage tank there, and the cask goes flying into the storage tank, punches a hole in the side of it, you've got 10 billion gallons of gasoline that comes out. And that is an accident that could happen.

MEMBER BANERJEE: You could think of scenarios.

MR. AMMERMAN: Exactly, exactly.

MEMBER SIEBER: Did you consider multiple nuclear fuel shipments on a single train?

MR. AMMERMAN: Yes.

MEMBER SIEBER: Okay.

MR. AMMERMAN: As a matter of fact, that's -- the train accident is a database that we used as a per-car, not per-train.

MEMBER SIEBER: Okay. So, you just multiply.

MR. AMMERMAN: Yes, exactly.

MEMBER SIEBER: Okay.

MEMBER BLEY: So, the last sub bullet there under --

MEMBER BANERJEE: What's the most vulnerable part if the fire lasts for a long time, what starts to go --

MR. AMMERMAN: There are actually three things that are vulnerable in a cask. If you have a lead shielded cask, you can melt the lead, and then when lead melts it expands. And, typically, you don't have a break in the cask so the lead can't become liquid and flow out. And our structural analysis shows that from impacts you don't get a failure in the cask wall, so that the lead won't flow out. But it will expand, so it expands the cavity that it's in, and then when it resolidifies it shrinks back down, and you only end up with a shining path because there will be a gap where there's no lead. We considered that accident.

The second failure is the seal of the cask, either elastomer or a metal seal, and those will fail -- when they get to some temperature, they'll fail. It depends on what kind of seal they are. For elastomer it's something around 500 C or 400 C, maybe, for a metal seal it's a little bit higher.

And then, thirdly, you have the cladding itself on the spent fuel. And if you get the cladding hot enough, it will rupture. So, really, in some of the casks you have two barriers to release, the cladding and then the cask body itself. And the other ones that we studied that have inner welded canister, you have three barriers to release. And heat -- there's no way that heat can fail that welded canister. And we looked at for deliberate events, and how you could fail that canister by heating the cask, and it just -- it's not a credible event. You can't even do it on purpose much less in an accident.

So, essentially, the outcome of the accident analysis, that last bullet there, you take the accident probability times a severity fraction determined by event trees and the consequence that produces, by the consequence and that gives you the collective dose risk which is the output parameter that we use for most of this study, is collective dose

risk.

RADTRAN VI was the code that was used to do that multiplication and calculation of all of the severity fractions and the consequences. And that's a similar approach that was used in two of the previous three risk studies. The original one, NUREG-0170, RADTRAN was written to do that study, RADTRAN I. The modal study didn't carry this study as far as consequence. It only looked at what's the probability of cask failure. And then NUREG/CR-6672 used RADTRAN V to do its risk study.

MEMBER BANERJEE: You've actually exposed real casks to real fires. Right?

MR. AMMERMAN: Yes, we have.

MEMBER BANERJEE: This is not a calculation, this is reality.

MR. AMMERMAN: This study is based on calculation, but it's calculation that's informed by tests. We didn't do any tests for this study. And, as a matter of fact, none of the casks that are in this study have ever been exposed to a long duration fire. The certification of them was done by analysis.

MEMBER BANERJEE: So, if I understand the process, then you exposed casks to fires, and then you certify or validated your calculation procedures based

on these measurements and applied it to somewhat different designs.

MR. AMMERMAN: Exactly.

MEMBER BANERJEE: What's the closest design which is to what is being analyzed that has been exposed to fires in terms of let's say size, geometry?

MR. AMMERMAN: In the report we talk about a calorimeter test that we did which was roughly the same size as a rail cask. It wasn't nearly the same thermal mass. It was a relatively thin wall, it was only a 1-inch wall as opposed to casks that have 8, 10-inch walls, so it had very little thermal mass. So, it heated up relatively quickly, and didn't cool the fire as much as a rail cask does. But that was a benchmark exercise that was -- so we had a lot of data on that calorimeter, and were able to compare the analysis code that we used in this study to the results from that fire test. But in addition to that, there have been some long duration fires on casks, not recently. In the mid-1970s as part of a program at Sandia, we did a real accident sequence. We took a rail car with a real cask on it and smashed it into a concrete wall, massive concrete wall, 600,000 pounds of concrete backed by several tons of -- many tons of dirt, and then took that damaged cask from the impact

and put in a fire and burned it for an hour and a half. The results from that test were that the cask essentially remained leak tight.

The Germans have done a test where they put a cask into a fire that had a propane tank next to it and let the fire both heat the cask and heat the propane tank, and the propane tank eventually BLEVE-ed, exploded, so I don't know if in Germany they don't have the same safety precautions on propane tankers that we have here that prevent that BLEVE or if they purposely defeated that, a rupture disk on the tank so that it would explode as opposed to vent.

But, anyway, the propane tank exploded and blew the cask out of the fire, so it was a good thing. You always ought to ship with a propane tank next to you so it can blow you out of the fire.

MEMBER REMPKE: In some of these tests after the tests were performed, was there any oxidation observed on the casks?

MR. AMMERMAN: I have a slide on that later on, and we'll get to that. Okay?

MEMBER REMPKE: Okay.

MEMBER BANERJEE: So, your point is that the analysis tools are fairly well validated.

MR. AMMERMAN: Yes.

MEMBER BANERJEE: Based on experiments.

MR. AMMERMAN: Yes.

MEMBER BANERJEE: And there's a lot of margin, I presume, to take account of uncertainties in these calculations.

MR. AMMERMAN: There is some margin. And, actually, in the slide that I'm talking about, also talks about that a little bit. That there is --

MEMBER BANERJEE: It can wait. Go ahead.

MR. AMMERMAN: Okay. So, this study compared to those previous studies use certified casks, which John mentioned earlier, and so we had the real geometry and all of the margin of safety that cask designers put into their casks beyond the regulations. So, that was one of the big differences.

We used updated accident event trees instead of relying on the historical data from the 1970s that the previous studies have used. Detailed 3D fine element analysis of the thermal event and more detailed fine element analysis of the impact events than had been performed in previous studies. And that's just because computers have gotten more powerful and --

MEMBER BANERJEE: Are these standard sort of finite element like ANSIS or something?

MR. AMMERMAN: Actually, both of these -- both the structural and thermal analyses performed in this were done with Sandia-developed codes. The structural analysis was done with the PRONTO code, no, PRESTO code, which is a relatively new code. The thermal analyses were done with a coupled code that's called CAFÉ, which couples a fire model with a commercial off-the-shelf P-THERMAL heat transfer code, so the coupling part is a unique Sandia code but the thermal analysis itself is done with a commercial code. But the impact analysis, the PRESTO code is very similar to ABAQUS explicit or LS-DYNA, which are commercial codes.

Another change in this study is that we looked at an accident type that had been neglected in previous study, and that's -- the accident doesn't damage the cask but it causes it to sit there for a long period of time, so you -- while that cask is sitting there, it's emitting its radiation and people are getting dose.

The casks selected were the Holtec HI-STAR 100 which is a all-steel bodied cask. It's transported with an inner welded canister. The NAC-STC, which is a lead-shielded, the gamma shielding is lead rail cask, and it can be transported either with a welded

canister or with directly loaded fuel, the GA-4 truck cask which has DU shielding for the gamma shielding. So, with these three casks we have all the gamma shielding types, steel, lead and DU, rail and truck transport, canisters and direct loaded, three different vendors, so designs from essentially the whole community.

CHAIRMAN ARMIJO: Is your truck cask bolted or welded canister?

MR. AMMERMAN: It's a bolted lead, so it doesn't have a welded canister.

CHAIRMAN ARMIJO: Okay.

MR. AMMERMAN: And these are the types of casks that would be used in any future large-scale transportation campaigns. Now, maybe not future 300 years from now when we might be actually transporting something, but future at the time we start --

MEMBER BANERJEE: How big are these casks?

MR. AMMERMAN: The rail casks are about -- the cask by -- they have an impact limit on the end which makes them bigger still, but the cask body itself is about 8-feet in diameter and 17-feet long, with the impact limiter it goes out to about 10-1/2 feet in diameter, and maybe 22-feet long.

MEMBER BANERJEE: So, it's like a

container.

MR. AMMERMAN: They're big, yes.

CHAIRMAN ARMIJO: How many tons?

MR. AMMERMAN: The rail casks weigh about 120 tons, so they're substantial. The truck cask, of course, it's a legal weight truck so it's 55,000 pounds. And the rail casks hold up to 26 PWR assemblies, and I think 68 BWRs. Now, since we did this study they've upped that capacity a little bit on some of the casks. The truck cask can hold four PWR assemblies.

MEMBER SCHULTZ: And you said this is the whole population of manufactured types?

MR. AMMERMAN: Not quite. We're missing -- TransNuclear is one of the cask vendors, that we did not use one of their casks.

MEMBER SCHULTZ: Okay.

MEMBER BANERJEE: Are these the guys in Utah, or what?

MR. AMMERMAN: TransNuclear?

MEMBER BANERJEE: Yes.

MR. AMMERMAN: No, they're here.

MEMBER SCHULTZ: The reason for not choosing them, or was it unavailability, or --

MR. AMMERMAN: No, we could have used them.

They have essentially three different casks that they -- transport casks they use. TN-68, which is a all-steel without a canister cask, so it's a direct loaded cask. The reason that we didn't choose that one was because we already had an all-steel cask, and we said -- I mean, we could have switched and done the all-steel as the bolted -- as the direct loaded cask, and the lead cask as the canister cask, but the advantage of doing it the way we did is that we had -- the lead cask could be both ways, so we had a bigger spectrum by only looking at three casks. The TN-68 cask cannot be shipped as a canister cask, it can only be direct loaded.

They have two canister transportation casks, one for BWR fuel, one for PWR fuel. They're the NP-187 and NP-197. And those casks really look very much like the NAC cask that we looked at. They're 24 assemblies instead of 26 assemblies. It's essentially the same type of cask.

CHAIRMAN ARMIJO: But all basically the same materials --

MR. AMMERMAN: Basically the same materials, yes.

CHAIRMAN ARMIJO: And carbon steels, as well?

MR. AMMERMAN: The all-steel casks have carbon steels. The steel lead casks can have stainless steel.

CHAIRMAN ARMIJO: And the canisters inside are --

MR. AMMERMAN: The canisters are all stainless steel.

CHAIRMAN ARMIJO: Okay.

MEMBER SCHULTZ: So, I didn't quite catch it when you described all the different types. Is there any one that's left out of the set that would be covered by the review that is done here?

MR. AMMERMAN: No.

MEMBER SCHULTZ: They would all be -- encompassed means that it will cover the parameters of all the population --

MR. AMMERMAN: That's right. You could take the results from this and apply it to any cask that's out there.

MEMBER SCHULTZ: Okay, great. Thank you.

MR. AMMERMAN: Yes. We look at four originations and four destinations for spent fuel. The destinations were Hanford, Skull Valley, Deaf Smith, and Oak Ridge National Labs. The origins were Kewaunee Power Plant, Maine Yankee Power Plant, Indian Point

Power Plant, and Idaho National Lab.

These routes include a tremendous portion of the country. I mean, you look at the two examples that we've shown here and you see we've covered most of the country, and including the highly urbanized East Coast corridor, the Maine Yankee route, Maine Yankee to Oak Ridge.

When we don't have an accident what affects the dose that people get? How long they're exposed, which is a function of how fast the vehicles are going, how many times it stops and how long it stops, and how often it stops for inspections. How many people are exposed? A factor of the population as the traffic density and how many people there are per vehicle.

The dose that each individual gets influenced by the shielding that's provided by where they are, so RADTRAN assumes that you have no shielding for rural people, that they're essentially outside, 13 percent for suburban, so that your typical wood frame house provides 13 percent reduction in dose, and 98 percent for urban. So, your typical concrete building is going to be a pretty good shield for radiation.

And then also the distance from the cask

is going to affect the dose, so both traveling down the highway, we look at a range from 30 meters up to 800 meters. People, of course, at 800 meters are going to get much lower dose than those at 30 meters, and the same is true at a stop.

And what's the result from our routine transport analysis? That big blue pie is background dose that the people that are exposed during the transportation to additional dose would get from background. The tiny little sliver in there is the additional dose that they accumulate because we did a spent fuel transportation passed them.

And who gets that dose? You can see there that most -- the largest fraction of it is the inspectors. They get almost half of the total dose of anybody from the shipment.

MEMBER SKILLMAN: What is the time calculated from Maine Yankee to Oak Ridge?

MR. AMMERMAN: Yes, I think it's almost 11 hours, 10.8 hours, 10.6 hours, something like that.

MEMBER SKILLMAN: Thank you.

CHAIRMAN ARMIJO: So, these are the inspectors that check the cask before it leaves?

(Simultaneous speech.)

MEMBER SKILLMAN: I just did that last week

and I'll tell you, 11 --

MR. AMMERMAN: It took you longer than that, huh?

MEMBER SKILLMAN: Well, yes. In a tractor trailer you'd have to be averaging about 80 miles an hour.

MR. AMMERMAN: Actually, I think it's the -- the time that we got for that is assuming an average speed of 60 miles an hour, 68 miles an hour maybe.

MEMBER SKILLMAN: It's probably about 750, so 11 is probably pretty close, but that presumes that the driver has the hammer down the whole way.

MR. AMMERMAN: Yes, exactly.

VICE CHAIR STETKAR: And you've got somebody out in front clearing people out of the way, too.

MEMBER SKILLMAN: All right, thank you. That's close enough. Thanks.

MR. AMMERMAN: So, the people who are most concerned really are the residents near routes. I don't want this spent fuel going by my house. And you can see that they get very little dose. The fraction of dose that they get is extremely small.

MEMBER BANERJEE: Are they worried if they

have an accident or something?

MR. AMMERMAN: Also that, yes. And we'll get to the accident risk later on in the presentation.

MEMBER BANERJEE: This is just routine.

MR. AMMERMAN: This is just routine transport, right. Of course, everybody is worried about accidents. Thank you for that great lead-in, by the way.

Here's what happens in an accident. This is a 120-mile per hour impact onto a rigid target of the steel lead steel cask. You get some loss of shielding from the lead slump. You see that the lead slides down, you have a little bit of a gap up there in the top of the cask, right here is a gap. But if you look down here at the closure, it's still in good shape. There is no leak path through the closure to the outside. And what happens in this accident, let's watch that one more time.

MEMBER BANERJEE: What are we seeing exactly?

CHAIRMAN ARMIJO: Dropping the cask.

MR. AMMERMAN: So, you're seeing the cask getting crushed. This is the impact that I was talking about, the part that's in red at the bottom and blue at the top. It's actually made up of two different

materials. The red part is redwood and the yellow part is balsa wood. Same thing up on the top, the blue is the redwood and the green is the balsa wood. The orange part here is the spent fuel contents, and in our analysis we didn't model the individual rods. We just smeared all the contents inside the package. The read layer here is the inner shell. This is actually the containment boundary of this cask, this layer and lids. The dark blue is the lead column, the light blue is the outer shell of the cask, and in the impact analysis we did not consider the neutron shield. We just added a mass of it onto that outer shell.

MEMBER SKILLMAN: And the lead slump is really the flow rate of the lead of a high strain --

MR. AMMERMAN: Exactly, yes.

MEMBER SKILLMAN: Okay.

MEMBER REMPKE: So, this is a stainless steel or a carbon steel --

MR. AMMERMAN: This is stainless steel, so the -- these materials are stainless steel. The maximum strain in this analysis I think occurs right here, and it's about 40 percent of true plastic strain. Stainless steel is good for about 100 percent, so that's actually quite a ways from failing.

MEMBER BROWN: Has anybody postulated a

terrorist with an RPG firing it into the side of it?

MR. AMMERMAN: Yes, and this study -- this specifically did not look at terrorist acts. This is only an accident study, not a sabotage study, partly because we wanted it to be able to go out for public comment. And if you include sabotage stuff, then it becomes safeguards information.

MEMBER BROWN: Have you done that?

MR. AMMERMAN: It's been done.

MEMBER BROWN: Satisfactorily, without any detail?

CHAIRMAN ARMIJO: We can't talk about results, I don't think.

MR. AMMERMAN: You can cause damage to a cask with an RPG.

MEMBER BROWN: Okay.

MR. AMMERMAN: And then, of course, you get into this whole armor/anti-armor argument, and do you want to make casks RPG-proof? Probably not.

MEMBER BROWN: I just asked the question out of -- when I looked at the generalized event, just it's --

MR. AMMERMAN: This is the same cask subjected to a side impact at 90 miles per hour, and this is the only orientation that produces a leak path

in any analysis that we did. And at 90 miles per hour, and 120 miles per hour we got essentially the same result. And you can see right here that we have a gap through the lid. Lids don't come off, they're still attached, but you can get material out. However, if this orange fuel region is in a welded canister, again no failure, no loss of containment.

CHAIRMAN ARMIJO: What's the condition of the fuel inside this cask, it's all broken up. Right?

MR. AMMERMAN: It's all broken up, yes. It's in bad shape.

CHAIRMAN ARMIJO: Yes, I can imagine.

MR. AMMERMAN: Yes.

CHAIRMAN ARMIJO: How do you go about getting a 90-mile an hour rail side impact?

MR. AMMERMAN: You can't.

CHAIRMAN ARMIJO: Okay, that helps. You have to work at it, I guess.

MR. AMMERMAN: You have to work at it. As a matter of fact, one in a billion accidents is what we calculated could be this. And that's probably conservative. At 60 miles per hour there is no leak path, so the gaps here don't exist at 60 miles per hour, but our risk assessment assumed that if it impacted at any speed greater than 50 miles per hour

into hard rock which is 5 percent of the route wayside surface has hard rock, maybe covered by soil but it's there, we could get a release.

MEMBER BANERJEE: So, these would be what, derailments of some sort?

MR. AMMERMAN: Exactly.

MEMBER BANERJEE: Yes, that's the only way.

MR. AMMERMAN: That's right, yes. I suppose you could postulate that it's a landslide occurs just as the train is going by and there's a big boulder that comes down.

MEMBER BANERJEE: I see.

MR. LOMBARD: At 60 miles an hour.

MEMBER SKILLMAN: Or a 45 mile an hour train that somehow hurls its payload onto an oncoming 45-mile an hour train.

MR. AMMERMAN: Yes, exactly.

MEMBER SKILLMAN: Or it goes off a bridge.

MEMBER BANERJEE: The Russian explosion when two trains were passing each other, the Transiberian.

MR. AMMERMAN: Yes. And, actually, the -- one of the other conservatisms that we have in this study is that we used the accident database that's for all trains, whereas spent fuel trains have operating

restrictions on them that says you're not going to go 90 miles an hour with a spent fuel train.

MEMBER SKILLMAN: Probably 35 or 40, or something.

MR. AMMERMAN: Yes, I don't remember off the top of my head what the current speed limit is. They just increased it. It had been --

(Coughing.)

MR. AMMERMAN: -- because that was what the test was. And they didn't realize well, except the test is for impact onto a rigid target, and we don't have rigid targets out there really. So they increased -- I think it may be 50 miles an hour now is the operational speed limit.

MEMBER SIEBER: In the 1960s it was 35-miles per hour, and only one cask per train, dedicated train, dedicated route.

MR. AMMERMAN: And then if we have a side impact at any recorded velocity, and an accident has ever happened onto any target besides hard rock, no release. So, it has to be side orientation, faster than 50 miles per hour in our assumption, and into hard rock in order to get release.

Similarly, we did finite element analyses of fire events, and the temperature of the flame

varies both spatially and temporally. You can see that at any given location on here you have cool spots that pop up, and then looking at just that one slice in time you can see that okay, it's cool here and it's hot here.

CHAIRMAN ARMIJO: At the bottom is it --

MR. AMMERMAN: This is actually the coldest part.

CHAIRMAN ARMIJO: It's sitting on the ground and --

MR. AMMERMAN: Yes.

MEMBER SIEBER: Lack of air.

MR. AMMERMAN: And this is the result that you get. And this is one that generated your question, Dr. Rempke, is that yes, you see here we've got temperatures 1,300 degrees. That's darned close to the melting temperature of stainless steel.

MEMBER REMPKE: Well, oxidation concerns, too, and whether it's carbon steel instead of stainless steel.

MR. AMMERMAN: And the way that this is modeled because it's a fluid-dynamics models that's putting up the fire, we don't include the skin that's on this impact limiter. We smear the skin into the properties, and so the outer surface is actually not

very conductive, which allows it to capture that temporally hot surface, the hot time that's there and not distribute that when it's not hot at that location. And especially at the corners based on that calorimeter test that we did, we know that the CAFÉ model, the thermal analysis model over-predicts the temperature so, in fact, that temperature is probably not as high as 1,300 degrees. How much it over-predicts I don't know for sure. Is it below 1,200? Probably not, it's probably above 1,200. But then the other issue is that that high temperature only occurs on the skin of the impact limiter, not on the cask body.

CHAIRMAN ARMIJO: Which doesn't give --

MR. AMMERMAN: So, the cask body itself, the peak temperature it sees is 1,100 degrees C. Even if you got rapid oxidation out here, it really is not going to affect anything very much, but any of the pool fire tests that we've done at Sandia we've never seen indication of that --

MEMBER REMPKE: Carbon steel as well as stainless steel?

MR. AMMERMAN: No, not --

MEMBER REMPKE: I have some furnaces at my lab and I get lots of oxidation.

MR. AMMERMAN: Right. You see, I did say of stainless steel, because yes, carbon steel you definitely get that. And actually we see that in our test stands which are made out of carbon steel very often, that they get --

MEMBER REMPKE: So, this goes back to my original question about a PIRT. I guess you -- the experts just don't think oxidation should be considered in your model that you use to analyze these things.

MR. AMMERMAN: Right.

MEMBER REMPKE: Because after you drop it, an oxide is going to behave different than a steel will.

MR. AMMERMAN: Yes, except that we don't ever have an impact after a fire. We only have a fire after an impact.

MEMBER REMPKE: Okay.

MR. AMMERMAN: The MacArthur Maze accident being an exception to that, and I'll talk about that, too.

CHAIRMAN ARMIJO: Which accident was that, Doug?

MR. AMMERMAN: MacArthur Maze. It was -- MacArthur Maze is the intersection of I-80 and I-580

that's just on the east side of the Bay Bridge in San Francisco, or actually in Oakland.

MEMBER RYAN: Doug, I don't want to rush you but we're on time so you're going to have to pick up the pace a little bit.

MR. AMMERMAN: Okay.

MEMBER SKILLMAN: Before you go, the image that you show there shows the impact limiters.

MR. AMMERMAN: Yes.

MEMBER SKILLMAN: Inside those impact limiters are redwood and balsa wood.

MR. AMMERMAN: Correct.

MEMBER SKILLMAN: So, how do they react to this high temperature?

MR. AMMERMAN: They char. And we --

MEMBER SKILLMAN: The impact limiters I've handled are in and of themselves structural members so the standoff from the actual cask is afforded by the rigidity of the redwood.

MR. AMMERMAN: True.

MEMBER SKILLMAN: And when you hike the clamps on it is the redwood that slightly compresses to afford some of that impact limitation, so now you cook them.

MR. AMMERMAN: Yes.

MEMBER SKILLMAN: So, talk about the temperature.

MR. AMMERMAN: Yes, so you -- and we see this in tests that we produce a char in the impact limiter, and that char front will move through it but it doesn't get all the way through the wood. The wood still provides some insulation. And most of that is because it's oxygen starved. It's in a region where there's not enough oxygen for it to burn, so it's only charring.

MEMBER SKILLMAN: Okay. That I can understand, thank you.

MR. AMMERMAN: Yes. So, for accidents the collected dose risks are very small, and I have a slide to show you how small. Two types of events have dose risks, one is involving release, that cask that I showed you the side impact, and one involved loss of shielding, can be from either a fire and lead melt or from an impact and lead slump. If you have inner welded canister there's no expectation of release in any of the impact or fire accidents analyzed. The collective dose from loss of lead shielding is comparable to that from release and both are very small. And these accidents occur with extremely low probability, ones that cause either loss of shielding

or release, less than one in a billion accidents.

VICE CHAIR STETKAR: What is your uncertainty on that. One in a billion is a really small number.

MR. AMMERMAN: It's a very small number, yes. And the uncertainty is large, I would say.

VICE CHAIR STETKAR: Okay.

MR. AMMERMAN: It could be one in one hundred million only.

VICE CHAIR STETKAR: Yes. I mean, did you actually try to actually quantify those uncertainties?

MR. AMMERMAN: In this study we didn't. In the previous study, 6672, we looked at that and in that study instead of having a deterministic result we have a horsehair of results, and looking at probabilistic. And the general comment of that was nobody could understand what those plots mean.

(Laughter.)

MEMBER POWERS: Yes, yes, nobody understands those plots. They are useless.

VICE CHAIR STETKAR: You've recused yourself, good try. You know, in some sense most people don't understand what one in a billion means.

MR. AMMERMAN: Exactly.

VICE CHAIR STETKAR: So, that --

MR. AMMERMAN: And I think extremely low probability is something that people understand, but now it's a question of do they believe you. So, really the -- a big part of this study is to get that plausibility --

vICE CHAIR STETKAR: That's why I asked about the uncertainty analysis in terms of rather than trying to precisely estimate less than one in a billion, how confident are we that it's less that one in a hundred million, or less than one in a million, or less than one in a thousand?

MR. AMMERMAN: I am very confident that it's less than --

vICE CHAIR STETKAR: You're sitting there. You answered my question.

MR. AMMERMAN: Yes.

VICE CHAIR STETKAR: You didn't really quantify that.

MR. AMMERMAN: Yes. Okay. So, here's the dose comparisons between the previous studies. This is the one that said transportation regulations are adequate and that amount of collective dose risk. Here's this study. We've dropped it by about eight orders of magnitude the expected risk.

CHAIRMAN ARMIJO: So, there is a lot of

margin from what was adequate?

MR. AMMERMAN: Exactly, exactly.

CHAIRMAN ARMIJO: Whether it's eight orders of magnitude or six orders of magnitude, who cares? Yes.

MR. AMMERMAN: So, SFTRA findings are that the collective dose risks from routine transportation are small and about four to five orders of magnitude less than the background dose that the same people see, very little variation in the risk depending on the route. And then we could have probably done this study with one example route because it didn't vary that much as a function of route.

If casks are -- if the fuel is a welded canister there's no possibility for radioactive material release, and only casks without inner welded canisters could release, and only then in exceptionally severe accidents. Very high likelihood that if there's an accident there would be no radiological impact, less than one in a billion chance the accident results in a release of radioactive material. And even if there were -- and this is actually one of the huge things in this study.

I told you about that very low probability, one in a billion, but even if the -- you

get that one in a billion the consequences are not that bad. The maximally exposed individual would not get a dose that would result in acute fatality.

MEMBER BANERJEE: How close would that individual be?

MR. AMMERMAN: He's 21 meters away.

MEMBER BANERJEE: And this exceptionally severe accident involves a fire, or is it just a big impact?

MR. AMMERMAN: It's an impact accident, fire never causes release.

MEMBER BANERJEE: So, this is the thing when it gets hit on the side.

MR. AMMERMAN: Yes, exactly.

MEMBER BANERJEE: There's a path out. How much is released?

MR. AMMERMAN: The total release I -- my recollection is it's less than 10 A2s, which is A2 is the quantity that you don't need to have a accident resistant package to transport. An A2 is the regulatory release from --

MEMBER BANERJEE: What is mainly released?

MR. AMMERMAN: You could have fission products, stuff like cesium, you could have noble gases like radon. You have some actonides, uranium and

the ingrowth of plutonium. So, we look at --

MEMBER BANERJEE: So, how is this -- is this sort of a volatile release, volatile material?

MR. AMMERMAN: Most of it's particulate, but it could be volatile. I mean, the radioactive gases like iodine that you think about for reactor accidents is all decayed away by the time you get to spent fuel transportation.

MEMBER BANERJEE: That's clear.

MR. AMMERMAN: But you do have cesium, and cesium can be volatile, but not in an impact-only accident. You need to have a fire accident in order to get the cesium volatilized.

MEMBER BANERJEE: If you had an impact and by any chance there was a fire associated with it, even if it's one in a billion, let's take a sort of a limiting scenario. Would you kill people around if that happened?

MR. AMMERMAN: No. Even if following this one in a billion impact accident you had a fire in addition to that severe accident, you still wouldn't kill anybody. You might --

MEMBER BANERJEE: So, this is going through a city or something.

MR. AMMERMAN: Yes.

MEMBER BANERJEE: And it somehow has a major crash.

MR. AMMERMAN: Yes.

MEMBER BANERJEE: You can imagine that everybody says that it will never happen, but invariably it happens.

MR. AMMERMAN: Yes.

MEMBER BANERJEE: Okay. So once it happens, what happens? That's the issue. I've seen chlorine tanks having -- leaking in the middle of Toronto.

MR. AMMERMAN: Yes, and that's -- I think that's one of the --

MEMBER BANERJEE: It happens all the time.

MR. AMMERMAN: -- strongest points that this study says, is that if that happens, nobody dies. We considered that and nobody dies.

CHAIRMAN ARMIJO: In the case of these casks that there's so much protection afforded by the inner welded canister, what are the quality controls on those welds? Are those machine welds that are made after it's loaded?

MR. AMMERMAN: Yes.

CHAIRMAN ARMIJO: Because nobody really wants to stand on top of it and --

(Laughter.)

CHAIRMAN ARMIJO: And then how are they inspected? Yes, if the inspectors get zapped the welders would be, so these are automatic -- these welding machines, and then somebody does a sonic inspection.

MR. AMMERMAN: Yes, they do a PT inspection.

MEMBER BANERJEE: So, you'd be prepared to say that under no circumstances, whatever happens, anybody would die even if the worst possible accident happened in the middle --

CHAIRMAN ARMIJO: Sanjoy, somebody is going to get burned to death, or --

(Simultaneous speech.)

CHAIRMAN ARMIJO: People will die in that accident from non-radiation.

MEMBER BANERJEE: But as you know, the tsunami has proven that you can kill 20,000 people and kill nobody --

CHAIRMAN ARMIJO: From radiation.

MEMBER BANERJEE: -- and that's two completely different impacts. So, all I'm asking is what happens. I think that's public perception. I mean, reality is reality.

MR. AMMERMAN: That is exactly the question

that the public wants the answer to.

MEMBER BANERJEE: Yes.

MR. AMMERMAN: And the answer to that is nobody dies. Nobody dies due to the radioactive nature of the cargo. People can die from other reasons --

(Simultaneous speech.)

MEMBER REMPKE: So, I hate to ask in terms of the cleanup, is there -- I mean, you said particulates are getting out. Right?

MR. AMMERMAN: They could, yes. And there have been studies of economic impact of this. And actually RADTRAN has an economic model in it that will calculate that. It depends on, of course, what's your cleanup standard. What are you going to clean up down to? And I don't know the answer to that question, but it's a calculable number.

MEMBER REMPKE: You don't remember if it's significant or insignificant?

MR. AMMERMAN: Actually, in this study we didn't calculate it.

CHAIRMAN ARMIJO: It wouldn't wipe out a city.

MR. AMMERMAN: No, no.

CHAIRMAN ARMIJO: Okay.

MR. AMMERMAN: I mean, our biggest release

is -- I believe the number is seven times what you could transport -- I mean, you could have seven A2s transporting in a UPS truck. You've got seven boxes that have an A2 each in them that are not accident resistant. Perfectly legitimate transportation, no big deal.

MEMBER RYAN: Okay, press on.

MR. AMMERMAN: I think the important conclusion on this one is the bottom one. No changes are needed to the regulations for spent fuel transportation because the risks are lower than what was already deemed to be adequate.

After the Subcommittee was kind enough to review this for us a couple of months ago, we've made some changes to this report, so if you guys looked at the draft report, these changes were not in what you've seen but they are currently in the version of the report that is going to be published. We've added the probability for the Baltimore Tunnel fire and the MacArthur Maze fire and looked at what the increase of the dose risk would be, and it's about a 4 percent increase if we include those from what we have in the current study, so it doesn't significantly change the answer.

We had a question in the Subcommittee

review about what happens if it's caught in rush hour and you've got somebody stuck behind it and next to it the whole time? Actually, the routine transport results we assume that there is a car next to that truck the whole distance along the whole route. There's always a car next to it adjacent to the cask, and also a car immediately following the cask for the entire route.

We added potential criticality section. The probability of seal failure due to severe accidents is four times 10 to the minus 10. The probability that you have water present following a severe accident, and that means this is how often is there water along the wayside, and it's about 1 percent, nine times 10 to the minus 3. The probability then the water is sufficiently deep and the cask is fully immersed, there's no data on that so this is a Doug estimate, is 1 times 10 to the minus 3. And you could argue whether that number is right or not.

Combining all those, the probability that you get water and leakage following a severe impact is 4 times 10 to the minus 15, only for the rail lead cask without a welded canister. If you have a welded canister you can't get water inside. And even then you're not assured criticality. You still have to have

the fuel configured in the right configuration for criticality to occur. And, again, if there's an inner welded canister there's no possible criticality --

CHAIRMAN ARMIJO: What about the bolted?

MR. AMMERMAN: This is for the bolted. That calculation, 4 times 10 to the minus 15 is for the bolted cask.

MEMBER SHACK: And the question is whether it's got an inner canister or not.

MR. AMMERMAN: Yes, if you have an inner canister then it's 4 times 10 to the minus infinity.

CHAIRMAN ARMIJO: Yes, but if you didn't have an inner canister and you did fully immerse it, just make it one, would it make any difference?

MR. AMMERMAN: Well, the probability of that event is essentially 10 to the minus 12, right. Given an accident, one in a trillion accidents would be a possibility --

CHAIRMAN ARMIJO: Yes, so it's very low.

MR. AMMERMAN: Yes. So, I -- the bottom line is that criticality I don't think is a credible -- there you have what I'm defining as credible, 10 to the minus 15 is credible, or is not credible.

We added text about the MEI, used to say it would be non-fatal and now we changed it to would

not cause an acute fatality, and you saw that in a previous slide. And we make reference now to the Plain Language Public Summary in the Executive Summary so that somebody who just looks at this and says oh, this is going to be too hard for me to read, I'm not going to get through this, they have that glimmer of hope there in the Executive Summary that says oh, I can just look at this Plain Language Summary and understand it. We added this --

MEMBER REMPKE: Just curiosity, is the Plain Language Summary in a separate document, or they're both in --

MR. AMMERMAN: It's part of the appendices that are of this document.

MEMBER REMPKE: Okay, sorry, I missed that part.

MR. AMMERMAN: It's Appendix F of this document.

MEMBER REMPKE: Okay.

MR. AMMERMAN: And we added this figure or a rendition of this figure, it's actually a vertical version of it instead of a horizontal one, to that Plain Language Summary. And this is actually the summary of SFTRA on one slide. This pie chart is the set of all transportation. The blue part is routine

transport, the sliver is you had an accident, about one accident every thousand trips. The red is the sum of all accidents. This tiny green sliver on here is the accidents that are more severe than the regulatory accident.

MEMBER SKILLMAN: Is it independent of what the cargo is, or just with radioactive cargo?

MR. AMMERMAN: This is just for steel lead steel cask, the only one we could get release out of. The steel lead steel rail cask, that's what this is for. It's going to be about that for any spent fuel cask, that is --

MEMBER SKILLMAN: So, does the blue ball on the left include tractor trailers hauling pineapples and telephone poles --

MR. AMMERMAN: Yes.

MEMBER SKILLMAN: -- and railroad ties?

MR. AMMERMAN: That accident rate is the —-- yes, it's all --

MEMBER SKILLMAN: Tractor trailer --

MR. AMMERMAN: All tractor trailer traffic.

MEMBER SKILLMAN: All tractor trailer traffic.

MR. AMMERMAN: All tractor trailer traffic, yes.

MEMBER SKILLMAN: And the accidents with those.

MR. AMMERMAN: Yes.

MEMBER SKILLMAN: Okay, thank you.

MR. AMMERMAN: Yes. And then of that small part of the accident space that is more severe than the regulatory accident, that's this green ball, a very, very thin sliver of that can result in loss of shielding or release.

The overall probability of release or loss of shielding is less than one in a trillion per shipment, so every trillion shipments you might get an accident that causes release.

MEMBER BANERJEE: Is there a particular cask which causes that?

MR. AMMERMAN: This was for that steel lead steel cask that we looked at. Steel lead steel cask--

MEMBER RYAN: I'm just curious. How long would it take to have a trillion shipments at the current rate of shipping? Let's see, longer than the life of the planet earth?

MR. AMMERMAN: What's a trillion divided by zero?

MEMBER BANERJEE: Unfortunately, in the one in a trillion, the one could be the first one.

MR. AMMERMAN: It could be. It could be. That's right.

MEMBER RYAN: Or the last one.

MEMBER BANERJEE: The last one you don't worry.

MEMBER SCHULTZ: Well, in terms of communication what this says is that in the next thousand accidents, once the program gets started full-time for the thousand truck accidents, one is going to be spent fuel transportation canister. And that's --

MR. AMMERMAN: No.

MEMBER SCHULTZ: The blue ball.

MR. AMMERMAN: What it says is that in the next thousand trips of spent fuel casks, one will have an accident. And that accident rate is based on all transport. It's the same accident rate as everything, so the same thing is true hauling pineapples, one in a thousand shipments of pineapples you've have an accident.

MEMBER SCHULTZ: So, this might be a nice presentation for what you've done, but you also need to explain why the results that we do in 2012 are so much different than the report that was published by experts in 2000.

MR. AMMERMAN: It's --

MEMBER SCHULTZ: Because the bar is a million times different. Now, that's really going to be hard to explain to the public.

MR. AMMERMAN: And the biggest reason for -- there's two reasons for that, actually. One is, we have improved event trees, but the biggest reason for that --

MEMBER SCHULTZ: So far you haven't made anything clear to the public.

(Simultaneous speech.)

VICE CHAIR STETKAR: Because those really smart people thought about all of that.

MEMBER SCHULTZ: Yes, I'm not asking for an answer. I think it's a --

MR. AMMERMAN: No, but the real answer is because this study used generic casks, no factor of safety. This study used real casks with an inherent factor of safety against the regulatory.

MEMBER BANERJEE: Is the answer more clearly that you have better casks?

MR. AMMERMAN: No, we -- the casks are actually about the same.

MEMBER SCHULTZ: The analysis was different.

MR. AMMERMAN: We have better analysis.

MEMBER RYAN: The analysis included the better casks.

MEMBER BANERJEE: That's not a very --

(Simultaneous speech.)

VICE CHAIR STETKAR: It's that real tiny number that says 4 times 10 to the minus 10.

MEMBER BANERJEE: So, the analysis -- I mean, what was wrong with the previous analysis?

MR. AMMERMAN: We made an assumption that the casks were -- did not have design margin.

MEMBER BANERJEE: What does that mean?

MR. AMMERMAN: That means that the casks did not have -- just met the regulatory requirements. They didn't --

MEMBER BANERJEE: Were there thicker walls, thinner walls?

MR. AMMERMAN: Yes.

MEMBER BANERJEE: What's the physical reason?

MR. AMMERMAN: They were --

MEMBER BANERJEE: Better welds?

MR. AMMERMAN: Actually, the biggest difference was in the impact limiters. The energy absorber that we put, that sacrificial energy absorber

that people put --

MEMBER BANERJEE: You put something additional then?

MR. AMMERMAN: Something better, yes. We had --

MEMBER BANERJEE: What was that something better?

MR. AMMERMAN: The -- we actually analyzed the real impact limiters. The cask designers put this impact limiter to limit the acceleration that the cask sees during the regulatory accident, the 9 meter drop onto a rigid target. And partially because of people like Gordon who ask difficult questions of them, they have -- they built a lot of design margin into that impact limiter so that they say if I make this impact limiter so that it -- if I drop this cask from 9 meters and 10 centimeters, it's going to fail, Gordon is going to let me get a license. So, they put in a lot of margin of safety into their impact limiter design.

MEMBER BANERJEE: So, this was a new design?

MR. AMMERMAN: Accounted for that margin of safety in this study because we were using real casks. In the previous study we did not.

CHAIRMAN ARMIJO: Say yes. The answer is yes.

(Laughter.)

MEMBER BANERJEE: I think the problem I'm having is that there isn't a physical change. It's just sharpening your pencil. I am very suspicious about --

MEMBER SHACK: Well, you can think of it as a physical change. I mean, if you had an impact limiter that acted like the old impact limiter --

MEMBER BANERJEE: So, I think you have to say it, there was a physical change.

MEMBER SHACK: Yes, but it wasn't a real--

PARTICIPANT: The old analysis was with a cask that didn't exist.

MEMBER RYAN: Yes, the old analysis was done on a fictitious cask that didn't have all the nice features of the cask itself.

MEMBER BANERJEE: Analysis, I mean, we always know that analysis is wrong to begin with, so you start as I'm analytical, I know. The only thing you believe is experiment at the end. Right? Unless you've tuned your analysis.

MR. AMMERMAN: Yes. And, actually, I'm an experimentalist.

MEMBER BANERJEE: Yes. I do both.

MR. AMMERMAN: And I'll argue that everybody in this room believes the experiment except me, the guy who did it. I know where the holes in the experiment are, too.

MEMBER BANERJEE: Yes, but unfortunately I have to go, but you know, you have to give a more clear answer.

CHAIRMAN ARMIJO: How about yes?

MEMBER RAY: A more clear answer would have been yes. Why didn't you just say yes to start with?

(Laughter.)

MEMBER RYAN: Okay. We're really kind of getting short on time, so we need to wrap up in the next two minutes.

MR. AMMERMAN: This is the last slide.

MEMBER RYAN: Good.

MR. COOK: The last slide, just a few statements about where we see the path forward from here, and that is, we do intend to make further improvements to the draft particularly regarding the presentation of risk, including the pie slide that you just saw. We may need to tweak the text a little bit to reflect that.

We would like to improve the treatment of

the census data in the study. It currently uses 2000 data. We're trying to get 2010 data, but the hang up there depends on whether the Department of Energy can get the code that develops those kind of calculation estimates for the routes back up on line within a reasonable time frame. They tell us that's reasonably near term, but there's no schedule yet so we're looking to see what we might be able to do there.

And the last thing is we're looking at the side impact at 70 miles an hour. Essentially, if we find there is no release at that impact velocity, then the estimated dose results, estimates of population consequence that you've seen so far would, in fact, be reduced further.

So, we do intend to look to those items there and any comments that we might receive in addition to those, and look to publish in the middle of 2013. So, that pretty much concludes our presentation.

MEMBER RYAN: Any further questions for the presenters?

CHAIRMAN ARMIJO: I just have a comment, that so much of what you've presented relies on the integrity of those welded canisters, a good part of it. And somewhere along the line, I don't know if it's

in the text or something, it tells you about these are really great welds, they're highly ductile, they've been tested, they're inspected after fabrication so that you don't get into situations where somebody can say well, how good are those welds? Did you consider that? And I'm sure you did, but I just -- in talking to the public you make a big deal out about how good those welded canisters are, and they are important. So, just urge you to kind of beef that up, if it isn't already beefed up enough.

MR. AMMERMAN: Okay.

MEMBER RYAN: The question, Sam, for the Committee I think is do we write a letter at this stage, or do we want to see a further follow-up in a few months on this and write one letter, or what do you want to do?

CHAIRMAN ARMIJO: As far as I'm concerned we could write a letter.

MEMBER RYAN: Now, okay.

CHAIRMAN ARMIJO: It's just a matter of workload to get it done. I don't think there's need for any further work.

MEMBER RYAN: Okay, great. I just wanted to -- because they are doing some follow-ups on certain things. I just want to know if you wanted to address

that later, or comment on it now and just look at it when it comes along and see if we want to write another letter, or what.

MEMBER SHACK: Well, I think that's a Committee decision.

CHAIRMAN ARMIJO: That's a Committee decision.

MEMBER SHACK: We look at the letter that we have and then decide whether we --

MEMBER RYAN: Okay, all right.

MEMBER SHACK: -- want to --

MEMBER RYAN: All right. Fair enough.

MEMBER SHACK: -- send the draft and we'll tell them to come back or what.

MEMBER RYAN: Okay.

MEMBER SHACK: That's up to us.

MEMBER RYAN: All right. I just wanted to bring that up.

MR. LOMBARD: I was going to suggest if you had time to talk about the extended storage transportation issue on Aging Management Programs, but you're tight on time, so --

MEMBER RYAN: We're done.

CHAIRMAN ARMIJO: No, no, no. Let's just finish this up and move on to our next topic.

MEMBER RYAN: All right. Well, I guess we'll thank our presenters and we'll take up the subject of a letter and letter writing. Correct?

CHAIRMAN ARMIJO: Okay. Yes, sir.

MEMBER RYAN: Okay. Thank you, gentlemen, appreciate it very much.

CHAIRMAN ARMIJO: Thank you, good job. Okay. We can take a break of about -- we're behind schedule.

VICE CHAIR STETKAR: A minute and 12 seconds.

(Laughter.)

CHAIRMAN ARMIJO: That's right. We do have that other presentation, geez. Five minutes.

(Whereupon, the proceedings went off the record at 3:45:12 p.m., and went back on the record at 3:53:40 p.m.)

CHAIRMAN ARMIJO: People were given five minutes. Let's just go ahead, we have a quorum.

MEMBER RYAN: Jim, welcome.

CHAIRMAN ARMIJO: All right. Let's -- Mike, we're in session.

MEMBER RYAN: We here to hear the presentation on the Decommissioning Planning Guidance, Reg Guide 4.22. Without further ado, I'll turn it over

to Jim Shepherd for the presentation.

MR. SHEPHERD: Thank the Committee for spending their afternoon. We've got a brief slide of 60 presentations, a briefer presentation than 60 slides I did two days ago for the Subcommittee.

This project really began with the License Termination Rule in 1997 in which we converted from concentration-based to dose-based criteria for license termination, and introduced the idea of ALARA, if you will, a restatement of it minimizing the introduction of contamination throughout the site.

The Commission asked us to review that rule in about 2001-2002, which we did. In SECY-03-0069 among other things we recommended rulemaking to prevent what we call legacy sites, those that lack the resources to remediate to license termination criteria.

We approached it from two bases, one to strengthen financial assurance requirements, basically making it stronger for us in case of bankruptcy or other financial distress. And, secondly, to require licensees to have a better understanding of the environmental condition of their site so that they could put aside enough money to remediate. And the Commission approved that rulemaking effort.

We started out with a couple of day workshop which we had a couple of hundred people, I guess, from across the industry. We had briefings with the Committee. One of the issues that came out of that was that groundwater monitoring should be a prime consideration.

We had a draft rule prepared to go forward when Braidwood happened. The Executive Director formed the Liquid Release Lessons Learned Task Force. We decided to hold the rule until the completion of that Task Force to insure that we didn't create some kind of an artificial conflict at that point.

In fact, we assisted the Task Force in some of the questions that they raised, one of which, what is significant contamination? In 50.75(g) it says, "Record significant contamination." And this has come up in a number of places. Significant briefly stated means it's going to cost you money to clean up in order to terminate your license.

We had a number of interactions with the Committee, got some very good recommendations, further developed the rule. This is the rough schedule. The draft rule went out for comment in January of `08. We also issued a version of the guidance at that time. We issued an updated version of the guidance about a year

later. The final rule was published on June the 11th, 2011 with an effective date of next week. In December a year ago, we issued DG-4014 for public comment. In July we issued a revision to it based on the comments from December, and held a public meeting and a webinar. And, as I said, the effective date of the rule is next week, and we hope we will have the final guidance on the street by the end of this year.

So, what did the rule itself say? 20.1501(a) is licensees shall make surveys to determine the condition of the site. We added the phrase "including the subsurface." Prior to this rule, the subsurface had been an implicit consideration. A number of licensees who knew they had leakage on the subsurface were already monitoring, but we wanted to make it explicit.

Radiation protection programs, we said that you need to consider real potential areas where you might have contamination in your radiation protection program. We did not make any changes to the 20.1101. So, what does the guidance say? The guidance says look where there might reasonably be stuff. You may not have looked there before, but you need to look there now. Areas that are not readily accessible, first question I ask is are they really inaccessible

or are they just inconvenient? If they're truly inaccessible, then you need to address where a reasonable surrogate location would be. Subsurface is explicit. It doesn't mean that everybody has to go drilling holes. It means you have to consider do I have a reasonable expectation that I have leaked radiation into the groundwater, or into the subsurface around my facility?

We also found that in the same time frame, NEI was working on their Groundwater Protection Initiative which applies to the nuclear power plants that comprise roughly one-half of 1 percent of the licensed community. Their objectives are very much the same as our's, and indeed meet the intent of this regulation.

Regulation says keep records. This actually goes all the way back to the 1989 GAO audit where they felt that NRC did not have requirements for records retention that was adequate. Again, significant residual radioactivity, you're going to have to pay to clean it up in order to terminate your license.

It can also serve as the basis for final status survey plans. Licensee comes in and said I want to consider this 400 acres of my site to be unaffected

or Class 3 so it doesn't cost me a lot to survey. If you have done surveys and got the records, if you have those, that helps.

The details for the financial assurance are actually in a separate guidance document, NUREG-1757, the consolidated Decommissioning Guidance, Volume 3, Record Keeping and Financial. A revision for that was issued in February this year.

Licensees should after they do these surveys make a reasonable estimate of what it would cost to clean that up to unrestricted release criteria, 25 millirem. And then they should arrange to have that money available at the time they need it to remediate the site, if they decide not to remediate in the shorter term.

For the reactors under the formula, of course, they never have to actually have more money than the value in the formula, but what we say is - in 50.75, it says "at or about five years prior to shutdown do a cost estimate." We mean do one that you really think is reasonable. 50.82 says "within two years of permanent shutdown you must cost your actual decommissioning plan." Again, they don't have to have the money, but they do have to say where they're going to get the money if the expected cost exceeds the

formula value. Non-reactors have to do much more frequent updates. They need to include the potential cost.

As I said, the guidance has been out. From the December year ago version we got comments from six groups that covered fairly well the industry. Because there were a large number of comments, I grouped them, and I'll talk a little bit more in a moment on how I responded to these.

One group said we're really good licensees. We've never had a problem. You should exempt us from the rule. No.

(Laughter.)

MR. SHEPHERD: Record how good you are, stay friendly with your banker. Some said just because we have fluid processes doesn't mean we should have to think about where we might leak. At the first NEI Groundwater Initiative conference they had an EPRI expert on concrete that said if you spill stuff on a concrete floor, it's going to go through. Concrete is a porous media. So, if you spill enough over enough time it's going to leak. You're going to have to check.

One of the common complaints was well, you didn't tell us how many samples to take and where in

order to comply with the rule. No, I didn't. No, I'm not going to. That's what you guys get paid to do.

Okay. The question of well, how do I decide how many samples I need to take. So, I added several tables, more appendices to better explain the concept of risk-based analysis. Most of that information came out of Volume 1 of NUREG-1757, the Consolidated Decommissioning Guidance that was published initially in 2002.

The guide says use available sources of information to compare what you measure with whether you have to do something or not. We have things like screening values that we said if we someone has screening value concentrations we assume that a dose calculation would be less than 25 millirem. You don't have to do it. If you measure concentrations in those values, you don't expect you'd have to do anything either.

Table 2 to Appendix B to Part 20, nominally 50 millirem for effluent absorption. If you have numbers in that range, you might actually have to clean up to meet 25 millirem at the time of license termination, but it depends. If you're looking at tritium and you've got 50,000 picocuries per liter, and your license runs out in 20 years, you probably

1 don't have to do anything at all. If you've got cobalt
2 and you want to terminate your license at the end of
3 next year, you probably do. So, again, it's a site-
4 specific basis.
5 A couple of comments that we didn't talk
6 about the restricted release option in saying how we
7 should come up with the funding. Restricted release is
8 not a planning point during operations. Restricted
9 release is an alternative if you can't get to
10 unrestricted release. Among other things, you have to
11 meet a number of criteria, such as demonstrating that
12 you've removed everything you can from the site and it
13 would either be exorbitantly expensive, or result in
14 environmental harm to take any more off. You have to
15 have submitted a decommissioning plan or license
16 termination plan that shows how you incorporated
17 public opinion in determining what your institutional
18 controls should be. You have to establish the
19 institutional controls, set up banking to fund the
20 institutional control. These are not things that
21 happen during operations.
22 If we take to the logical point beginning
23 if someone came in and said yes, I want to run for 20
24 years. And, oh, by the way, I plan to crap up this
25 site so bad I can never clean it up, probably wouldn't

get a license.

In the December draft a year ago based on an internal comment, I had about a page-long comparison between the NEI Voluntary Initiative and the Decommissioning Planning Rule showing how the pieces matched. A comment we got on that was it appeared to incorporate the Voluntary Initiative into the regulatory framework, which the Commission has clearly told us not to do. So, I removed that comparison and simply said this is one method acceptable to meet the rule.

So, we plan to go here today, receive what comments you may have on the guidance document, revise it as necessary, and since we know we're not going to get very many, complete publication by the end of the month in order to be as close as we reasonably can to the effective date of the regulation.

In the meantime, we are working to develop some enforcement guidance. The purpose of this rule is not saying inspectors write violations. There's not an immediate health and safety hazard. We are looking at preventing legacy sites from occurring in the future. We had a discussion with NEI Tuesday, we think at the end of a year or so we should sit down collectively and say here are the pieces that work, here are the

pieces that didn't, and make whatever changes seem appropriate at that time.

The Enforcement Guidance document is in the process of being reviewed. We hope it will be out by the end of the year. That's controlled by the Office of Enforcement. I don't have a specific date for it.

That basically is the presentation I had, so if you have any questions, I will --

MR. PERSINKO: Let me just say -- this is Drew Persinko, Division of Waste Management. You meant enforcement discretion, didn't you?

MR. SHEPHERD: What did I say?

MR. PERSINKO: Guidance.

MR. SHEPHERD: Well, EGM is Enforcement Guidance Memo.

MR. PERSINKO: Right, but --

MR. SHEPHERD: But, yes, the purpose is enforcement discretion.

MR. PERSINKO: It's to put enforcement discretion to allow licensees time to modify their programs, as necessary, to meet the rule and guidance.

MEMBER RYAN: Mr. Chairman, I might note that this has been an activity that's been ongoing for quite a long time, and Jim and his team gave us a lot

of detail about how this has been ongoing. And it's come to, I think, a good conclusion. My recommendation out of the Subcommittee is that we just produce an Ed-gram for this work and send it on.

CHAIRMAN ARMIJO: Which says we do not want to review it, or we --

MEMBER RYAN: No, that says during the 600th meeting of the Advisory Committee on Reactor Safeguards, December 6-7, the Committee considered the draft final regulatory guide, "Decommissioning Planning During Operations." The Committee has no objection to the Staff's proposal to issue this Reg Guide as final. No response to this memorandum is required.

CHAIRMAN ARMIJO: Yes, it's what the Committee members may want to do. I think the problem is we've just had a Subcommittee meeting, and then a full Committee meeting the same week. They've got a deadline of getting their thing out in December. We've got a lot of letters to write, and whether there's a lot of issues, and those are the things we've got to think about.

VICE CHAIR STETKAR: We discussed that in our letter --

(Simultaneous speech.)

VICE CHAIR STETKAR: -- I think the format and the words.

MEMBER RYAN: That's why I'm suggesting this, to help with the workload.

CHAIRMAN ARMIJO: Well, you know, I think it's up to the members to discuss that, but --

vICE CHAIR STETKAR: More relevant is does anybody have anything for Jim?

MEMBER POWERS: It seems to me the expeditious thing is to do what Mike says, but because you've had a Subcommittee meeting, and because you've had a full Committee presentation, I think you have no choice but to produce a Committee letter that may say no more than what the proposed Hackett-gram would say, but I think you've got to send it out from the Committee itself.

CHAIRMAN ARMIJO: Well --

vICE CHAIR STETKAR: Why don't we settle that later?

MEMBER RAY: I guess I have one question at this point. What is the -- what are we approving? We're certainly not rendering any judgment on whether the funding required is adequate.

CHAIRMAN ARMIJO: No.

MEMBER RAY: So, it seems to me like we

need to say something about what it is about this thing that we've looked at, because I'll tell you the funding isn't adequate, but that's beside the point. I just don't want us to imply that we've looked at that when we haven't.

VICE CHAIR STETKAR: Again, why don't we discuss that later.

MEMBER RAY: Well, I only raise it now, John, because perhaps the Staff would like to tell us what it is that they think we're buying off on here.

MR. SHEPHERD: In our opinion, we published the rule in June of 2011 that told licensees they need to strengthen their financial assurance instruments, that they need to better understand the radiological condition of their site, and they need to marry the two of those.

MEMBER RAY: Okay, the better understanding the radiological --

MR. SHEPHERD: Our guidance --

MEMBER RAY: -- conditions, that part I think is fine. I just object to us having any -- I'd rather explicitly say we haven't reviewed the financial provisions --

MR. SHEPHERD: This guide does not address the financial provisions. That guidance is in a NUREG

that's separate from this guide.

MEMBER RAY: Yes, all right. That's--

vICE CHAIR STETKAR: This is strictly on methods for monitoring, sampling --

MEMBER RAY: Well, that's all we've talked about. I just wanted to make sure it's all --

vICE CHAIR STETKAR: Reporting contamination.

MEMBER RAY: -- we're opining on.

MR. SHEPHERD: Yes, it is. No, we're not getting into whether the formula is adequate.

(Simultaneous speech.)

MEMBER RAY: I've fought that for years, I don't want to fight it here. I'm just telling you that it's not something I want to comment on. I've done it enough.

MEMBER RYAN: I share Harold's history.

MEMBER RAY: Huh?

MEMBER RYAN: I share your history on that.

MEMBER RAY: Yes. I mean, it's crazy, but nevertheless, just be focused on what we're talking about.

MR. SHEPHERD: No, the only comment on finances here is that the results of the sampling need to be factored into the cost estimate for the non-

reactors.

MEMBER RAY: Okay.

MEMBER BROWN: Have we ever done a decommissioning back to greenfield, the NRC?

VICE CHAIR STETKAR: Yes, Maine Yankee. What was the one in Oregon?

PARTICIPANT: Trojan.

MR. SHEPHERD: Trojan Plant. We've actually only terminated three licenses, Trojan, Fort St. Vrain, and Shoreham.

MEMBER BROWN: I'm not talking about -- I mean, actually taking the plant down to --

MEMBER RAY: He said back to greenfield.

MR. SHEPHERD: Well, Big Rock Point, for example, is absolute greenfield except for the ISFSI.

MEMBER RAY: Except for what?

MR. SHEPHERD: ISFSI.

(Simultaneous speech.)

PARTICIPANT: But Trojan isn't.

PARTICIPANT: That's really not greenfield.

MR. SHEPHERD: Trojan did not greenfield. Trojan left their -- the simple answer to that question is no, we have not.

MEMBER BROWN: The answer is no.

PARTICIPANT: The answer is no, keep it

simple.

VICE CHAIR STETKAR: And Zion won't be a greenfield --

(Simultaneous speech.)

MR. SHEPHERD: Right.

MEMBER BROWN: Interesting. Just an information question because we did it once, I mean, in Windsor.

MR. SHEPHERD: Rancho Seco would be --

MEMBER POWERS: You could convince DOE to take your fuel, which --

MEMBER BROWN: We convinced everybody to take our fuel. We don't want any of it.

CHAIRMAN ARMIJO: Well, you know, is there any comments from Committee members to Jim as far as his Reg Guide? I've got a sense that we have none, so you're free to go, Jim. We'll have to figure out what we do about this letter, because it's letter that we would not -- we're going to -- I don't know how we're going to get enough technical information there to suit future --

MEMBER RYAN: That was kind of the reason the Hackett-gram made sense to me.

CHAIRMAN ARMIJO: Well, we'll worry about that. I don't have a problem with a short letter.

MEMBER RYAN: That I can do.

MR. SHEPHERD: Our thanks again to the Committee.

CHAIRMAN ARMIJO: Thank you, much. Okay, we got through that. So, now we better get into preparation of ACRS reports. And here's what we've got. We've got --

VICE CHAIR STETKAR: Sam, the recorder.

CHAIRMAN ARMIJO: Yes.

VICE CHAIR STETKAR: Close the meeting, bang the gavel. There you go.

CHAIRMAN ARMIJO: Thank you much. The meeting is closed.

(Whereupon, the proceedings went off the record at 4:16 p.m.)

NRO Staff Initiative for the Licensing Review of Instrumentation and Controls (I&C) for the mPower™ Small Modular Reactor Design

Milton Concepcion, Sr. Digital I&C Engineer
Division of Engineering
Office of New Reactors

December 6, 2012

Objective

Provide a briefing to the ACRS full committee on the draft mPower™ Chapter 7 Design Specific Review Standard (DSRS)

Agenda

- DSRS Status and Schedule
- DSRS Chapter 7 Goals
- Background
- Incorporation of NRO Lessons Learned from LLWRs
- DSRS Chapter 7 Highlights
- Summary
- Next Steps

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DSRS Status and Schedule

Approximate Timeline for Finalizing the mPower Design Specific Review Standard (DSRS)

September 2012~	Draft mPower DSRS is completed and labeled *For Interim Use and Comment*
October 2012~	Internal Concurrence; OGC NLO obtained
December 2012~	Federal Register Notice FRN is prepared and mPower DSRS is issued for public comment • Document and Memo sent to **ACRS** • Document and Memo sent to CRGR
March 2013~	Public Comment Period Ends
March -August 2013~	Resolve Public Comments revise document as appropriate Prepare Final mPower DSRS Document • Opportunity to meet with **ACRS** • Notice sent to OMB for Congressional Review Act review
May 2013~	SRP Updates Finalized to Support mPower DC Review *(coincides with APOB schedule)*
September 2013~	Internal Concurrence; OGC NLO obtained **ACRS** letter received
November 2013~	Prepare FRN and issue final *mPower DSRS* • Document and Memo sent to **ACRS** • Document and Memo sent to CRGR

DSRS Chapter 7 Goals

Apply lessons learned in a timely manner to:

1. Enhance the safety focus of staff reviews,
2. Improve review efficiency.

Background

- Licensing reviews of I&C have been a significant challenge from the perspective of both safety demonstration and schedule/resources for all new large light water reactor design centers.
- I&C licensing certainty has been consistently expressed by industry as a high priority for new reactor reviews.
- Lessons learned were identified by NRO I&C staff and improvements were incorporated to support the DSRS Chapter 7 goals.

Background (continued)

- The DSRS Chapter 7 approach applies the concept of system engineering principles (under the current regulatory framework):
  - Design principles,
  - Simplicity attribute,
  - Integrated hazards.
- Structural changes enhanced the guidance for clarity and efficiency.

Incorporation of NRO Lessons Learned from LLWRs

- Reorganize review guidance to separate design principles from specific system requirements
- Provide guidance on Fundamental Design Principles at system level
- Remove redundant and non-applicable information
- Eliminate the use of DAC
- Introduce Simplicity and Hazard Analysis in Review Guidance
- Ensure adequate coverage of regulatory requirements and applicable guidance

Review Guidance Structure

- Existing SRP Guidance
  - 7.0 Overall Review Process
  - 7.1 Introduction
  - 7.2 Reactor Trip System
  - 7.3 ESF Systems
  - 7.4 Safe Shutdown Systems
  - 7.5 Information Systems
  - 7.6 Interlock Systems
  - 7.7 Control Systems
  - 7.8 Diverse Systems
  - 7.9 Data Communication Systems
  - BTPs (7-1 to 7-21 & 8-5)
  - ISGs

- DSRS Chapter 7
  - 7.0 Overview of Review Process
  - 7.1 Fundamental Design Principles
    - Design Basis
    - Independence
    - Redundancy
    - Determinism
    - Diversity and Defense-in-Depth
  - 7.2 System Characteristics
  - Appendix A, Hazards Analysis
  - Appendix B, I&C System Architecture
  - Appendix C, Simplicity
  - Appendix D, References

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DSRS Chapter 7 Structure

Areas Of Review	7.0 – Introduction and Overview	7.1 – Fundamental Design Principles	7.2 – System Characteristics
	• Review objectives • Review interfaces • Review process • Mapping of regulatory requirement to DSRS location	• Safety system design basis • Independence • Redundancy • Determinism • Diversity / Defense-in-Depth	• Quality • Equipment qualification • Reliability, Integrity , and completion of protective action • Operating and maint. bypasses • Interlocks • Derivation of system inputs • Setpoints • Auxiliary features • Control of access, identification, and repair • Interaction between sense and command features and other systems • Multi-unit stations • Automatic and manual control • Displays and monitoring • Human factors considerations • Test and calibration

DSRS Chapter 7 Highlights

7.0 Introduction & Overview of Review Process

- Establishes differences between the SRP and DSRS.
- Provides DSRS review scope, objectives, review interfaces, and review process for I&C.
- DSRS Table 7-1 maps the regulatory requirements and guidance with review responsibilities.

DSRS Chapter 7 Highlights

7.1 Fundamental Design Principles*

- 7.1.1 Safety System Design Basis
- 7.1.2 Independence
- 7.1.3 Redundancy
- 7.1.4 Determinism
- 7.1.5 Diversity and Defense-in-Depth

* Appendices A, B, and C will support the review of the fundamental design principles.

mPower™ DSRS

7.2 System Characteristics

- 7.2.1 Quality*
- 7.2.2 Equipment Qualification
- 7.2.3 Reliability, Integrity, completion of protective action
- 7.2.4 Operating and maintenance bypasses
- 7.2.5 Interlocks
- 7.2.6 Derivation of system inputs
- 7.2.7 Setpoints
- 7.2.8 Auxiliary features
- 7.2.9 Control of access, identification, and repair
- 7.2.10 Interaction between sense and command features
- 7.2.11 Multi unit stations
- 7.2.12 Automatic and manual control
- 7.2.13 Displays and controls
- 7.2.14 Human Factors consideration
- 7.2.15 Capability for test and calibration

* Under Development

DSRS Chapter 7 Highlights

Appendix A – Hazard Analysis

- New guidance to review I&C hazard analysis.
- Supports early identification of issues (e.g., contributory hazards) from:
  - Compromise of redundancy,
  - Compromise of independence,
  - Compromise of diversity and defense-in-depth,
  - Compromise of determinism,
  - Complexity.
- Identifies commensurate hazard controls.
- Provides safety function focused organizing framework.

mPower™ DSRS

Appendix B – I&C System Architecture

- Architecture description will support review of fundamental design principles.
- Review areas:
  - Description of all I&C functions that are part of the design basis.
  - Interfaces between I&C safety systems.
  - Safety to nonsafety interfaces.
  - Signal flows and descriptions.
  - Simplified/functional logic diagrams.

DSRS Chapter 7 Highlights

Appendix C – Simplicity

- Staff will evaluate whether simplicity has been considered in the design of the digital I&C systems.
- Simplicity will be reviewed concurrent with each fundamental design principle.
- Key factors for simplicity:
  - Safety systems are designed for the required functions,
  - Simplified communications and system integration are implemented,
  - Support features and their effect on increased complexity (e.g., self-diagnostics) are described.

Summary

- The staff has implemented lessons learned and restructured existing guidance in the development of the mPower™ DSRS Chapter 7 to:
  - Ensure clear line-of-sight from regulatory requirements to review guidance,
  - Enhance staff review focus,
  - Improve review efficiency,
  - Leverage NRC staff's cross-organizational expertise.

Next Steps

- Issue draft DSRS for formal public comments.
- Continue ACRS interactions.
- Collect and resolve public comments.
- Continue pre-application interactions with B&W and other stakeholders.
- Issue final DSRS Chapter 7 to support the mPower™ application review.

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Spent Fuel Transportation Risk Assessment (SFTRA) Draft NUREG-2125

Presentation to the
Advisory Committee on Reactor Safeguards

December 6, 2012

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Agenda

Item	Topic	Presenter	Time
1	Opening Remarks and Objectives	Dr. Michael Ryan, ACRS	2:30 – 2:35 p.m.
2	Staff Opening	Mark Lombard, Director, SFST/NMSS	2:35 – 2:40 p.m.
3	Draft NUREG-2125 Background	John Cook, SFST/NMSS	2:40 – 2:50 p.m.
4	Draft NUREG-2125 Method and Results	Dr. Douglas Ammerman, SNL	2:50 – 3:25 p.m.
5	Committee Discussion	Dr. Ryan, ACRS	3:25 – 3:30 p.m.
6	Adjourn		3:30 p.m.

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SFTRA Research and Review Teams

- Sandia National Laboratory Research Team
  - Dr. Douglas Ammerman – principal investigator
  - Carlos Lopez – thermal analysis
  - Dr. Ruth Weiner – risk assessment
- NRC's Technical Review Team
  - Dr. Gordon Bjorkman – structural analysis
  - Chris Bajwa – thermal analysis
  - Dr. Robert Einziger – fuels, source term
  - Dr. Anita Gray – health physics
- Oak Ridge National Laboratories External Peer Review Team
  - Matt Feldman
  - Dr. Cecil Parks
- NRC Project Manager – John Cook

SFTRA Purpose and Goals

- Continuing review
  - Final Environmental Statement (NUREG-0170, 1977)
  - "Modal Study" (NUREG/CR-4829, 1987)
  - Reexamination of Spent Fuel Shipment Risk Estimates (NUREG/CR-6672, 2000)
- NRC's safety mission
  - Considering public comment, provide updated basis for NRC's safety regulations applicable to spent fuel transportation
- Outreach responsibilities
  - Reassure public regarding spent fuel shipments
    - Basic message: Risks are low, so safety is high
    - Improve public understanding and acceptance of spent fuel shipments
- Potential shipments
  - Significant issue when study began (2006) – much less so now
  - Method applicable to future shipments, may need to consider different casks, long-term aging of canisters, and high burn-up fuel
- SFTRA is a generic SNF transportation risk assessment and is not
  - Driven by any external requirement or commitment
  - An EIS or major federal action
  - Required for any licensing action, nor does it contain any regulatory proposals
  - An analysis of transport security

SFTRA Basic Methods

- Radiological impacts of spent nuclear fuel (SNF) shipments
  - Routine conditions
    - Determine doses to various populations from cask external radiation level during routine transport
  - Accident conditions
    - Perform finite element analysis to determine cask response to impact and thermal accident conditions
    - Almost all accidents do not significantly affect the cask; however extremely severe (and rare) impact or fire accidents might result in an increase in external radiation level or a release of material beyond that permitted by regulation.
    - The consequence of any external radiation level increase or release of material is calculated for the exposed population as collective dose in person-Sv.
    - National (for rail) and state (for road) accident statistics are used to estimate the probability of accidents on routes, and "event trees" developed by U.S. DOT are used to estimate the conditional probabilities (severity fraction) of accident conditions.
    - The accident probability x severity fraction x consequence products are aggregated for the route. Accident risk results are expressed in person-Sv per shipment (collective dose-risk).
- RADTRAN VI (see user guide, references) was used in SFTRA to calculate routine doses and accident dose risks for representative truck and rail shipment routes
- Approach similar to that in NUREG-0170 (RADTRAN I, 1975) and NUREG/CR-6672 (RADTRAN V, 2000)

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How does SFTRA differ from previous NRC SNF transport risk studies?

- SFTRA
  - utilized certified casks instead of generic casks.
  - used updated accident event trees instead of relying on accident data from the 1970s.
  - performed detailed 3D finite element analyses of the thermal events.
  - used more detailed finite element models for the impact events.
  - considered accidents that do not damage the cask (as long-duration stops).

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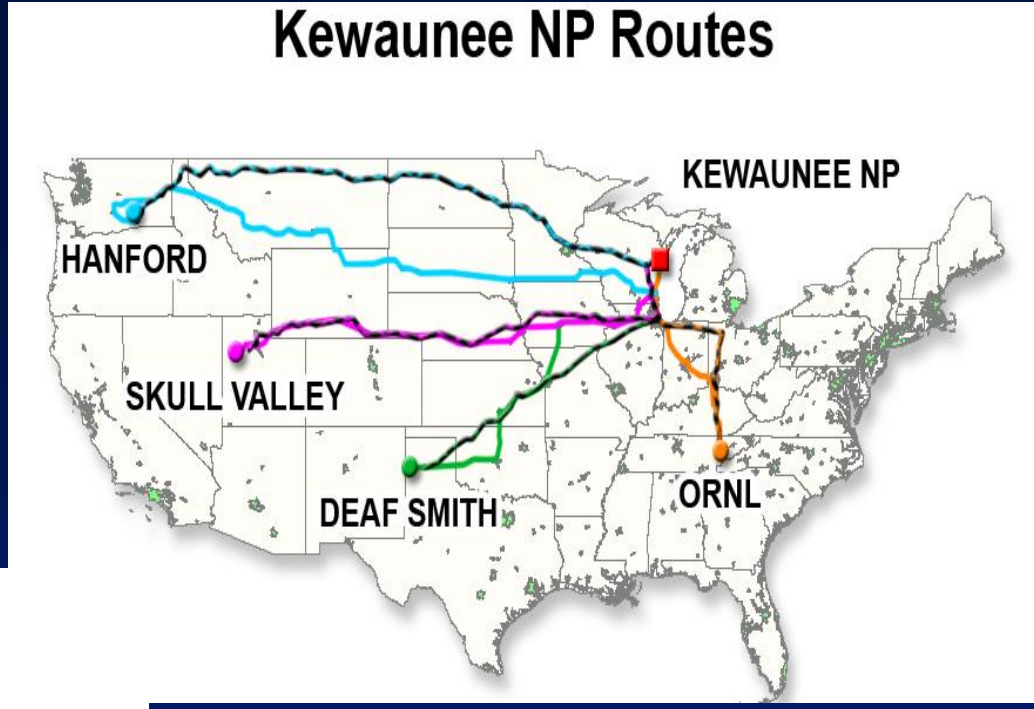
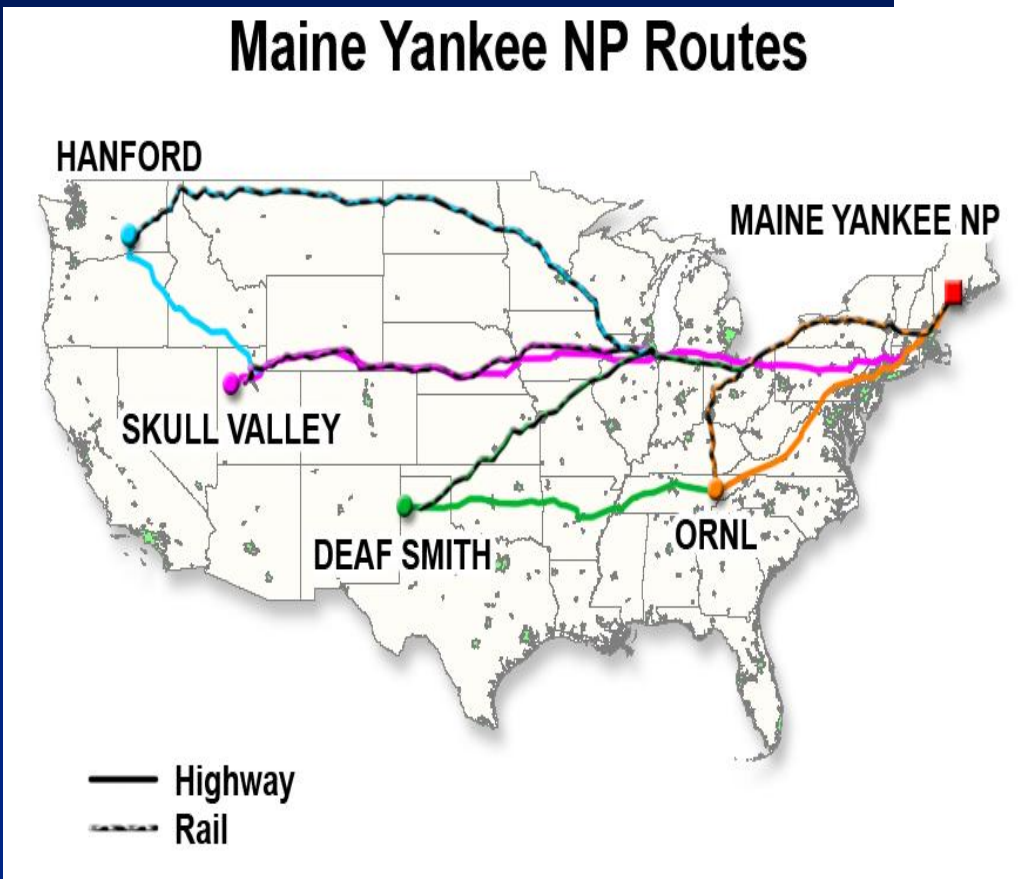
Casks selected

- The Holtec HI-STAR 100, a steel-shielded rail cask transported with an inner welded canister
- The NAC STC, a lead-shielded rail cask transported with direct loaded fuel or with an inner welded canister
- The GA-4, a DU shielded truck cask
- These selections encompassed all the gamma shielding types, both common modes of transport, the use of inner canisters, three different cask vendors, and modern casks that could be used in any future large-scale transportation campaign

Example Routes





These routes represent a variety of route lengths and populations. They include the eastern and western states, and cross-country routes.

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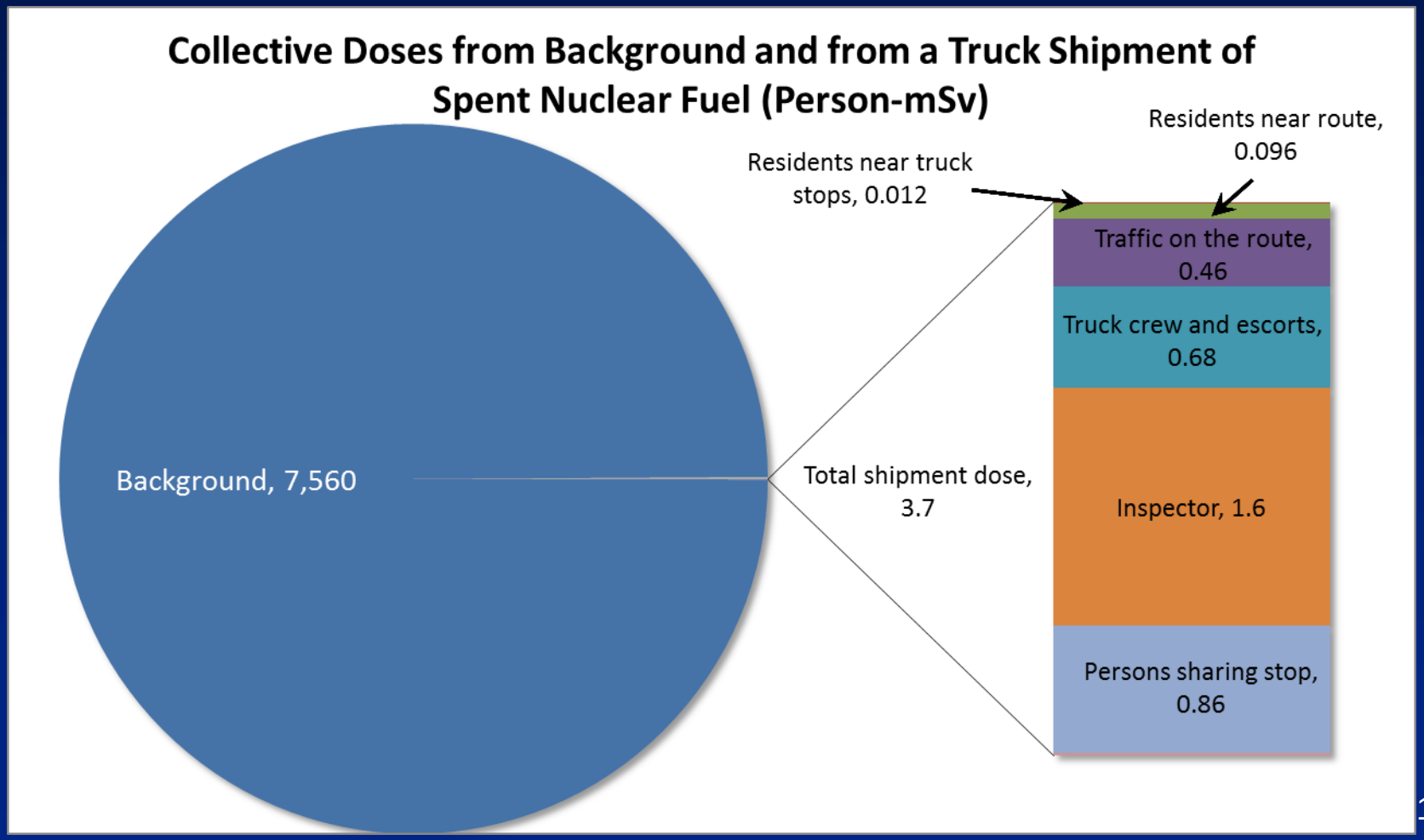
Factors affecting routine doses

- Exposure time
  - Speed of the vehicle
  - Stop times and number of stops
  - Number of inspections
- Number of people exposed
  - Population density
  - Traffic density
  - Number of people per vehicle
- Dose
  - Shielding provided by housing
    - 0% for rural, 13% for suburban, 98% for urban
  - Distance from cask at stops

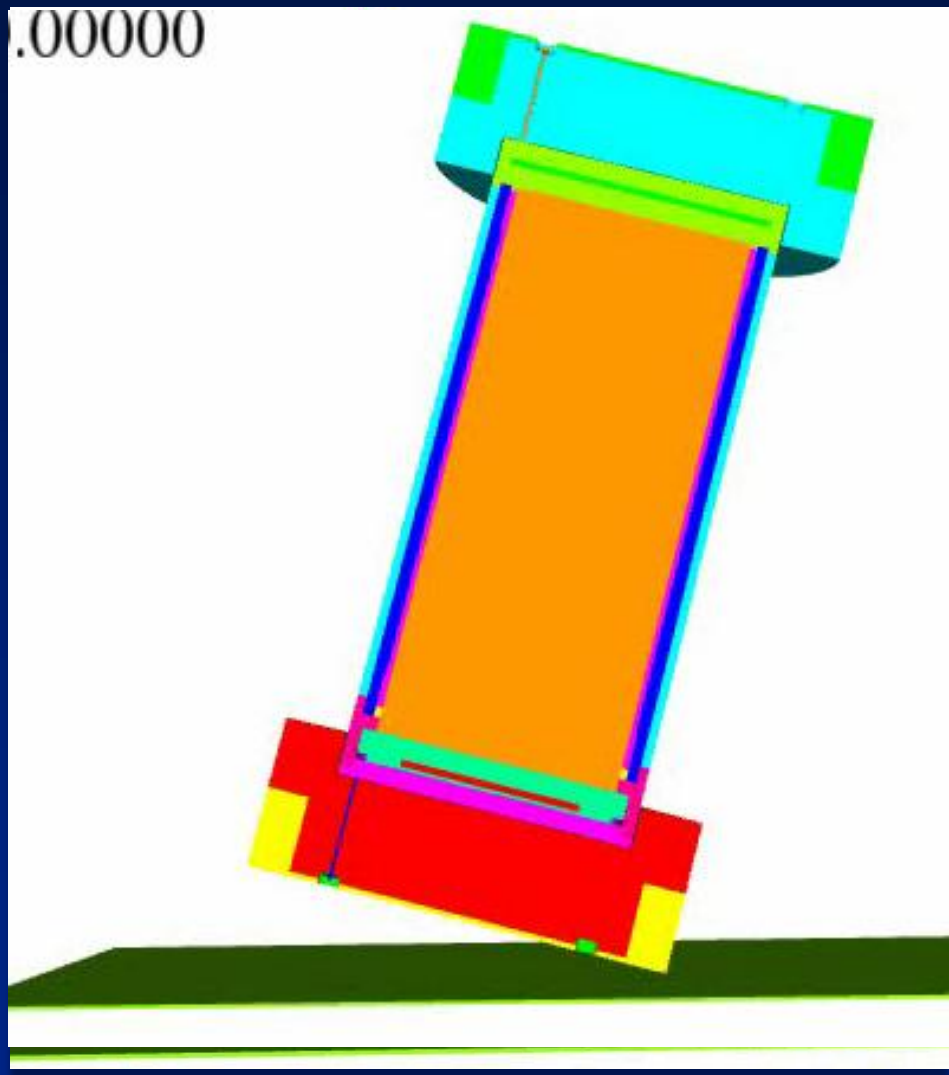
Results from Routine Transportation:

Example for Maine Yankee to ORNL truck shipment



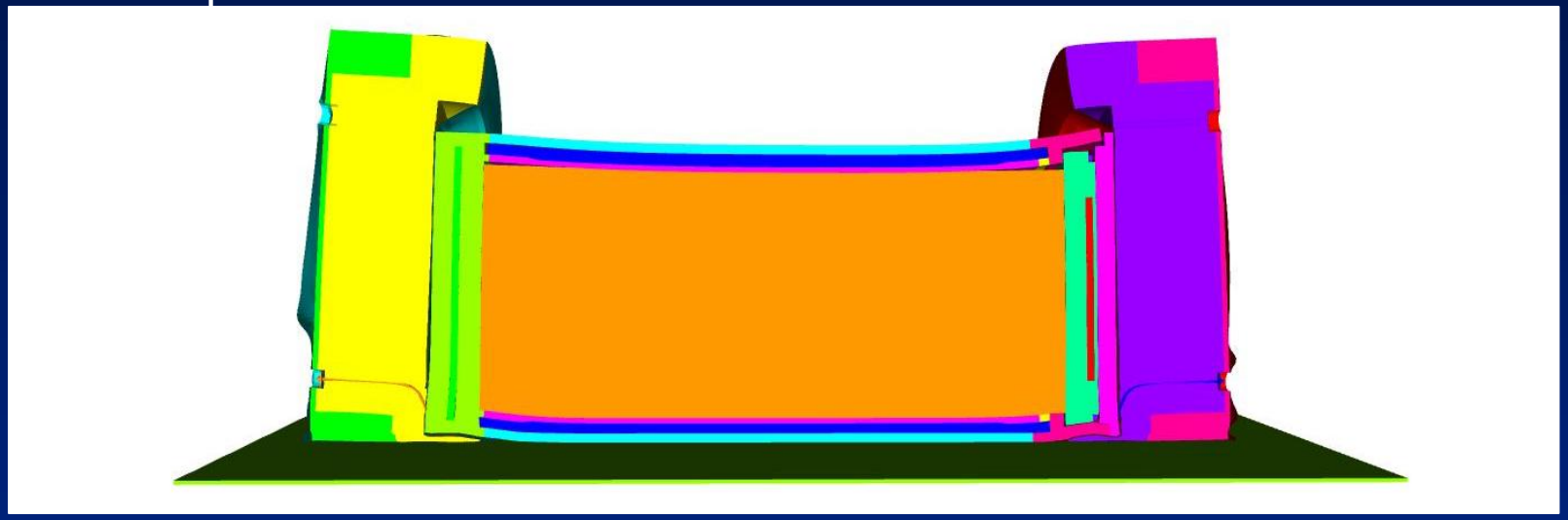
Rail-lead cask impact analysis

- Deformed shape of the rail-lead cask following the 120 mph impact onto a rigid target in the corner orientation
- No leak-path is formed so there is no release of contents
- Lead slump is treated as a loss of gamma shielding in the risk assessment



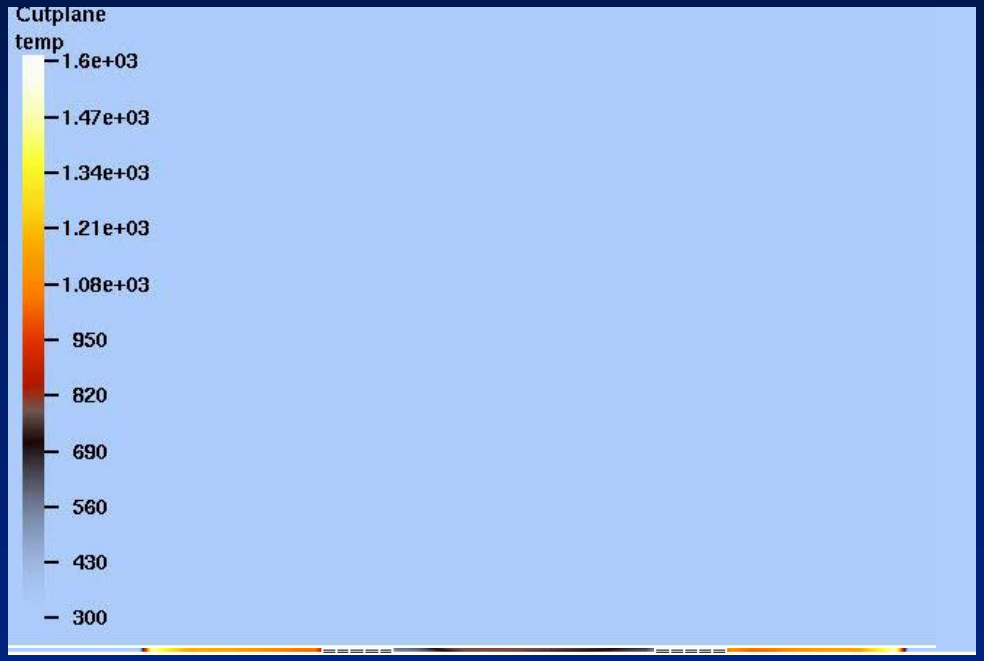
Rail-lead cask impact analysis

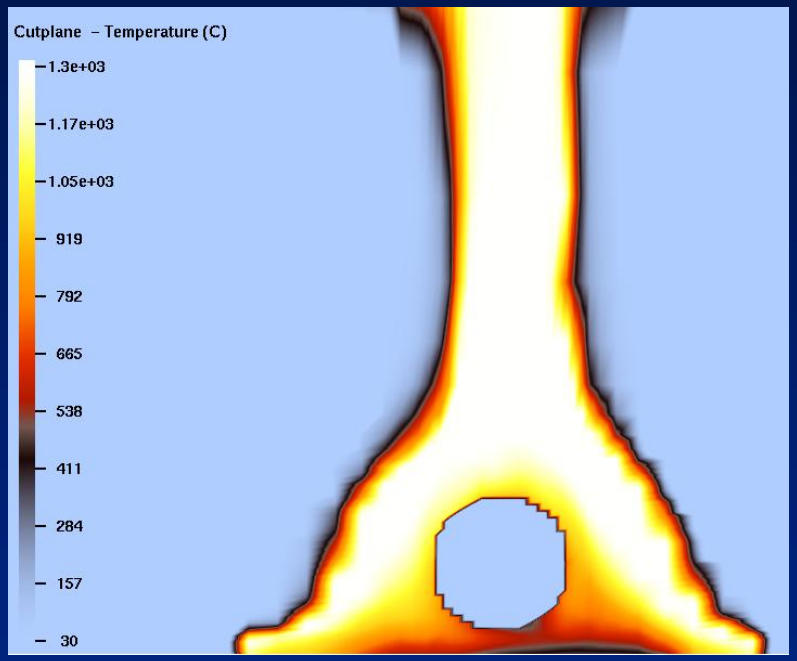
- **Side orientation 90 mph impact onto a rigid target**
- **Only cask and orientation resulting in a leak-path**
  - no leak-path if fuel is loaded in an inner welded canister



- **Side orientation 60 mph impact onto a rigid target**
  - No leak path, but
  - The risk assessment assumes impacts into hard rock (5% of route wayside surface) above 50 mph result in a leak-path
- **Side orientation impacts at any recorded accident velocity onto targets softer than hard rock do not result in a leak-path**

Flame temperatures

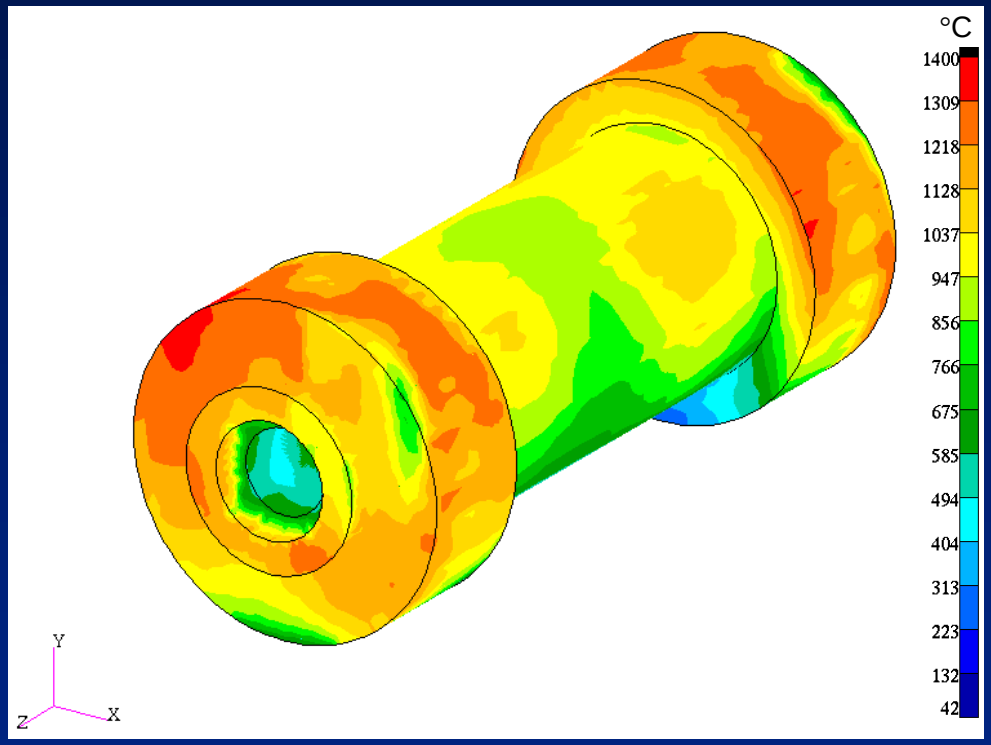




Fully engulfing pool fires have temperature variations both spatially and temporally.

Cask Temperatures

- Peak impact limiter skin temperature is overestimated by the analysis
- No pool fire test performed at Sandia has seen melting or rapid oxidation of stainless steel
- Peak cask body temperature is below 1100℃



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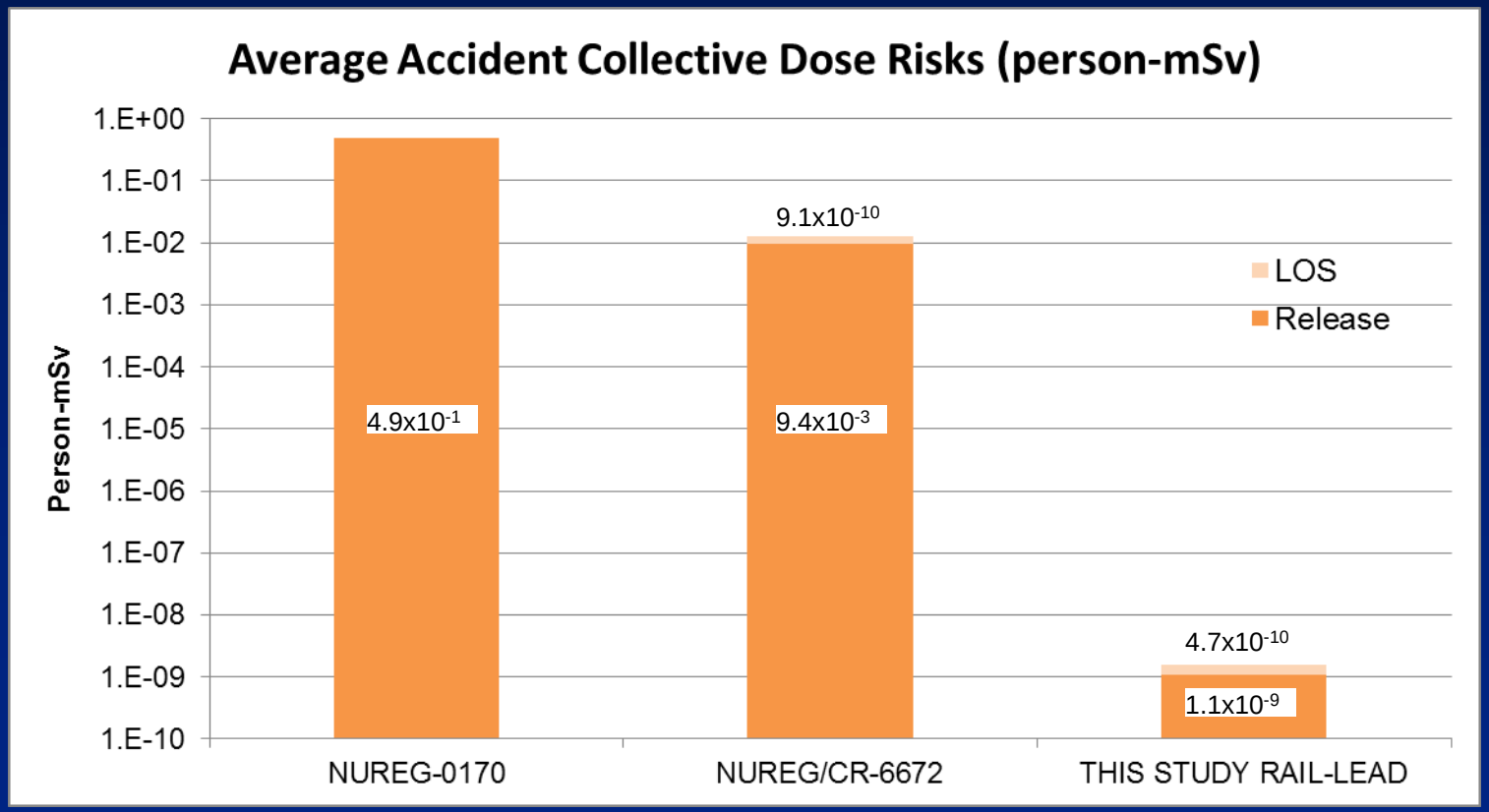
Accident risk summary

- The overall collective dose risks are very small.
- The collective dose risks for the two types of extra-regulatory accidents (accidents involving a release of radioactive material and loss-of-lead-shielding accidents) are negligible compared to the risk from a no-release, no-loss-of-shielding accident.
- There is no expectation of release from spent fuel shipped in inner welded canisters from any impact or fire accident analyzed.
- The collective dose risk from loss of lead shielding is comparable to the collective dose risk from a release, both are very small.
- These accidents occur with extremely low probability (less than one in a billion accidents).

Accident Results Comparison:

Accident collective dose risks from release and loss of gamma shielding (LOS) accidents. The LOS bars are not to scale.



SFTRA Findings

- The collective dose risks from routine transportation are very small. These doses are about four to five orders of magnitude less than collective background radiation dose over the same time period and exposed population as the shipment.
- There was little variation in the risks per kilometer over the routes analyzed.
- Radioactive material would not be released in an accident if the fuel is contained in an inner welded canister inside the cask.
- Only rail casks without inner welded canisters could release radioactive material, and only then in exceptionally severe accidents.
  - **If there were an accident during a spent fuel shipment, there is a very high likelihood (more than 99.99%) that there would be no radiological impact. There is less than a one in a billion chance the accident would result in a release of radioactive material.**
  - **If there were a release of radioactive material in a spent fuel shipment accident, the dose to the maximum exposed individual would not result in an acute fatality.**

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SFTRA Conclusions

- This study reconfirms that estimated radiological risks from spent fuel transportation conducted in compliance with NRC regulations are low, in fact generally less than previous estimates, which were already low.
- Accordingly, for spent fuel transportation, the regulations for transportation of radioactive material are adequate to protect public health and safety.
- No changes are needed to the regulations for spent fuel transportation.

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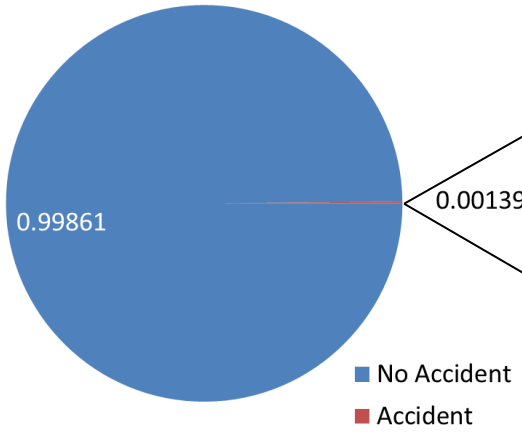
Revisions to Draft NUREG-2125 based on ACRS Subcommittee comments

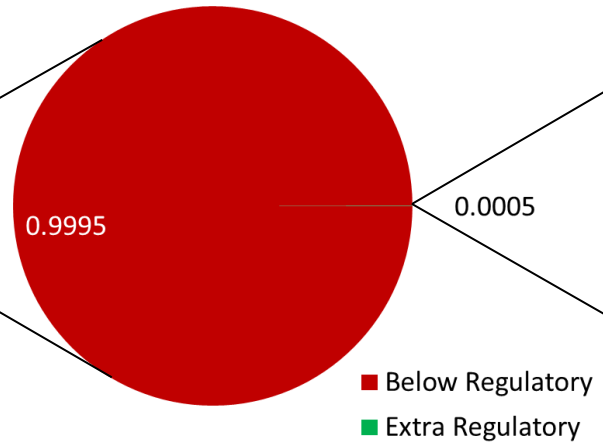
- Fire accident probability (and risks) for NRC's other SNF transport fire accident studies. e.g., for Baltimore Tunnel Fire (BTF)
  - Probability of cask present in BTF accident = 4×10^{-10}
  - Release = 0.3 A_2 [Rail-lead cask only; 1 A_2 per week is post Hypothetical Accident Condition test conditions release acceptance criterion (10 CFR Part 71)]
  - Result is a 4% increase to the SFTRA rail accident collective dose of 10^{-11} person-mSv.
- Routine transport results state that passenger vehicles occupy positions in the adjacent lane and immediately following the cask truck for the entire route
- New potential criticality section
  - Probability of seal failure due to severe impact = 4×10^{-10}
  - Probability that water is present post severe impact = 9×10^{-3}
  - Probability (estimate) that water is sufficiently deep and cask is fully immersed = 1×10^{-3}
  - Probability of water inleakage following severe impact = 4×10^{-15} (Rail-lead cask only; note criticality is still not assured. No inleakage if there is an inner welded canister)
  - Criticality is not credible
- MEI consequence text "…would be non-fatal" changed to "…would not cause an acute fatality"
- Reference to Public Summary (plain language) in Executive Summary

Possible Outcomes of a Rail Shipment from Maine Yankee to ORNL

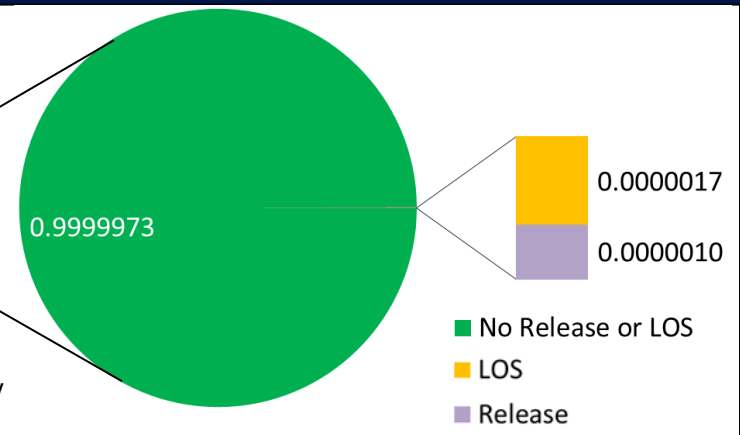
Routine Transportation



All Accidents



Extra-Regulatory Accidents



Most shipments are routine

- 99.86% of shipments occur without accidents
- Collective Dose from Routine Transportation: 2.3 Person-mSv

Most accidents are less severe than the hypothetical accident casks are designed to withstand

- 99.95% of accidents would not exceed regulatory requirements
- Collective Dose Risk from 10-Hour Stop: 0.085 Person-mSv

Casks provide safety well beyond the regulatory requirements

- 99.99973% of accidents that are more severe than the regulatory hypothetical accident do not lead to release or loss of lead gamma shielding.
- Collective Dose Risk from Loss of Lead Gamma Shielding: 0.00000000025 Person-mSv
- Collective Dose Risk from Release: 0.000000000035 Person-mSv
- Dose to a maximally exposed individual would not result in an acute fatality

The overall probability of a release or loss of shielding is less than one in one trillion per shipment for the rail lead cask. There is no expectation of release if an inner welded canister is used.

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SFTRA Path Forward

- ADAMS Accession Number for Draft NUREG-2125 is **ML12125A218**
- Staff has prepared a revised Draft (not publicly available) that includes revisions made to accommodate public comments and ACRS Subcommittee comments
- Staff intends to
  - Improve presentation of results to the public
  - Either revise census data or demonstrate that using 2012 census data does not significantly affect the results
    - Expect less than ~5% increase (in very low dose estimates) for some states
  - Analyze 70 mph impact for rail-lead cask
    - Currently assuming side impacts > 50 mph (event tree breakpoint) result in release
- Pending ACRS recommendation, staff intends to publish the completed revised Draft as Final NUREG-2125 by mid-2013

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Back-up Slides

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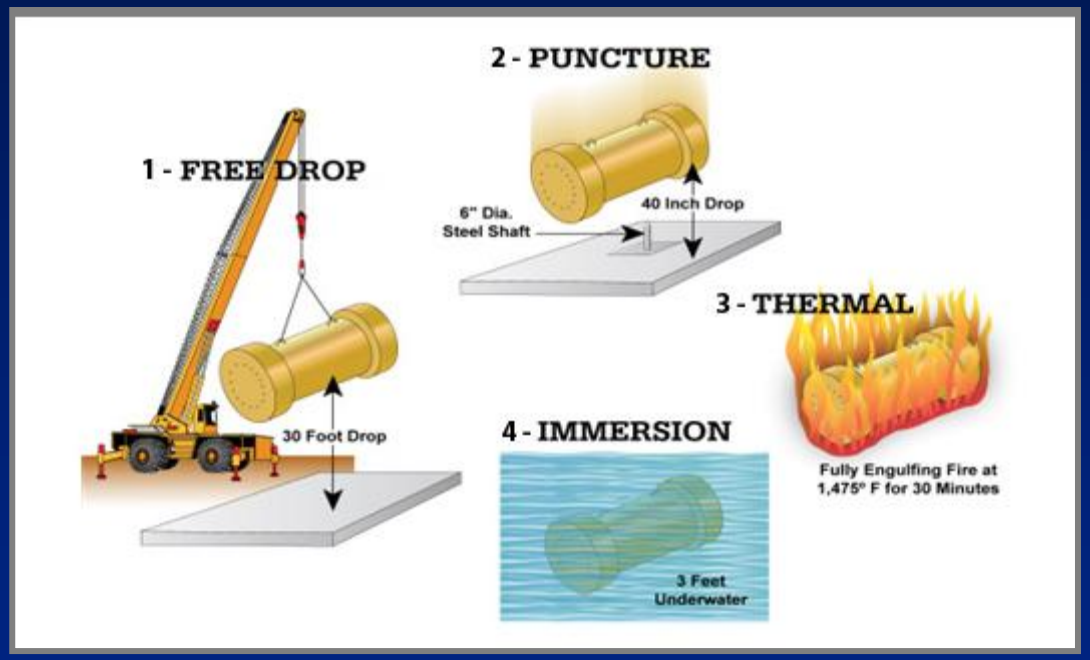
Outline

- Background and introduction
- Risk analysis of routine transportation
- Cask response to impact accidents
- Cask response to fire accidents
- Risk analysis of transportation accidents
- Findings and conclusions

Use of certified casks

- Prior generic risk assessments have used generic casks.
- This assessment uses casks that have been certified to meet the requirements of 10 CFR Part 71.



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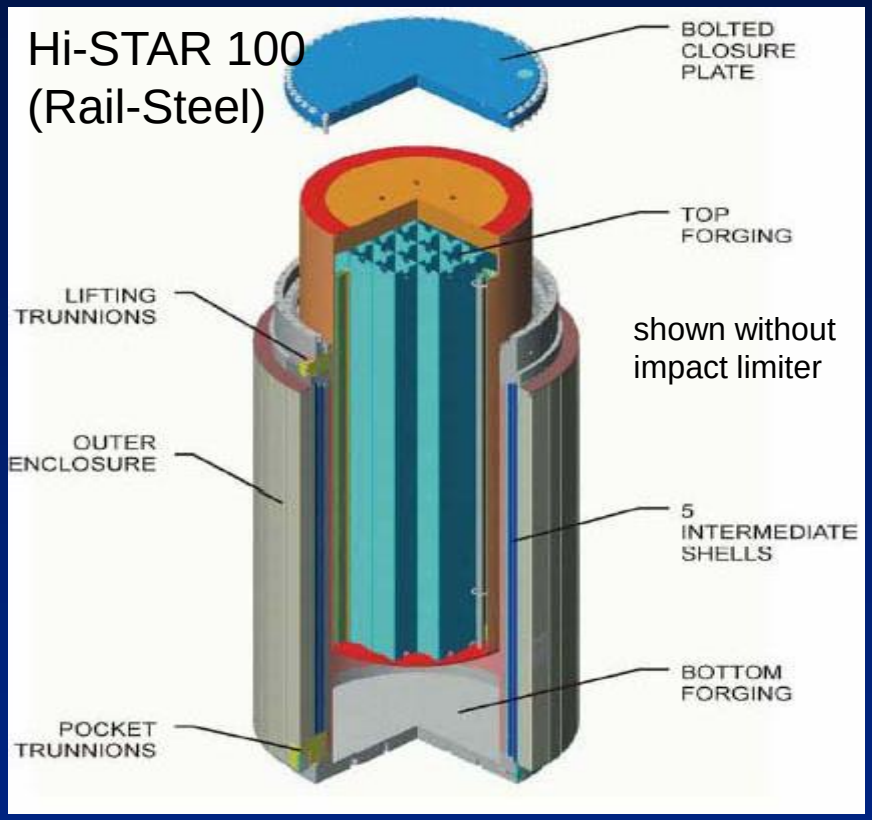
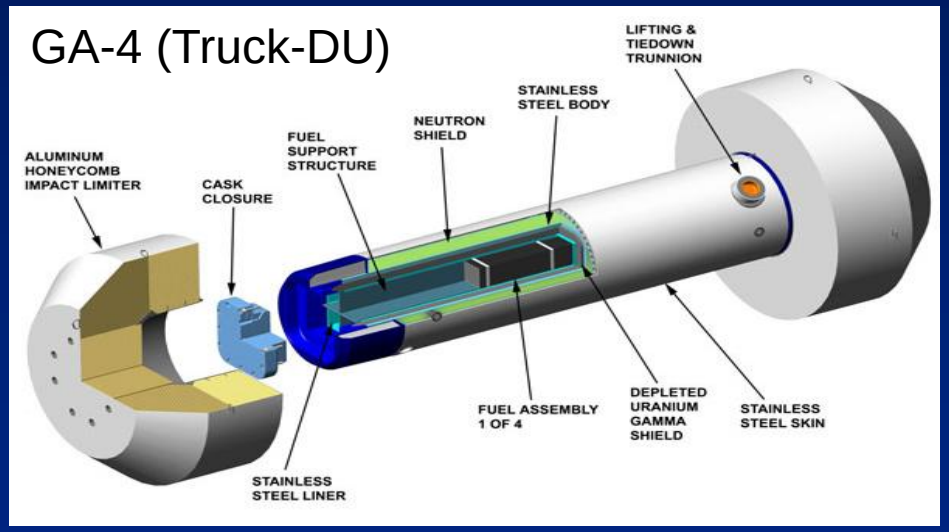
NAC-STC
(Rail-Lead)

Cask illustrations





- Each cask represents a type (Rail-Lead, Rail-Steel, Truck-DU)
- Casks of the same type would perform similarly

Investigated example routes

- Example routes do not represent current or planned transportation campaigns

Origin	Destination
Maine Yankee	ORNL
Kewaunee	Deaf Smith
Indian Point	Hanford
INL	Skull Valley

- WebTRAGIS routing code determines rail and highway routes and exposed populations
- Rail casks only by rail (no heavy haul or barge), truck casks by legal weight truck (no overweight truck or rail)

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Report Structure and Format

- Audience
  - Public, state and tribal governments, elected officials, federal agencies, industry, and media
- Graded structure and content
  - Executive Summary and Public Summary **- all audiences**
  - Main body text **- informed public, science media**
  - Appendices **- industry, other federal agencies**
- Electronic and printed versions
  - NRC ADAMS Accession Number: **ML12125A218**
  - Printed Draft NUREG in black and white only (CD inside back cover contains color version)
  - Final NUREG in full color

External radiation from casks

- The maximum permitted dose rate is 10^{-4} Sv/hour at 2 meters from the cask, or about 1.4×10^{-4} Sv/hour at 1 meter (input to RADTRAN).
- The external dose rate at one meter from each of the casks was the maximum value from its Safety Analysis Report, 1.03×10^{-4} Sv/hour for the HI-STAR 100 and 1.4×10^{-4} Sv/hour for the other casks.
- The total dose to each receptor is calculated by RADTRAN.

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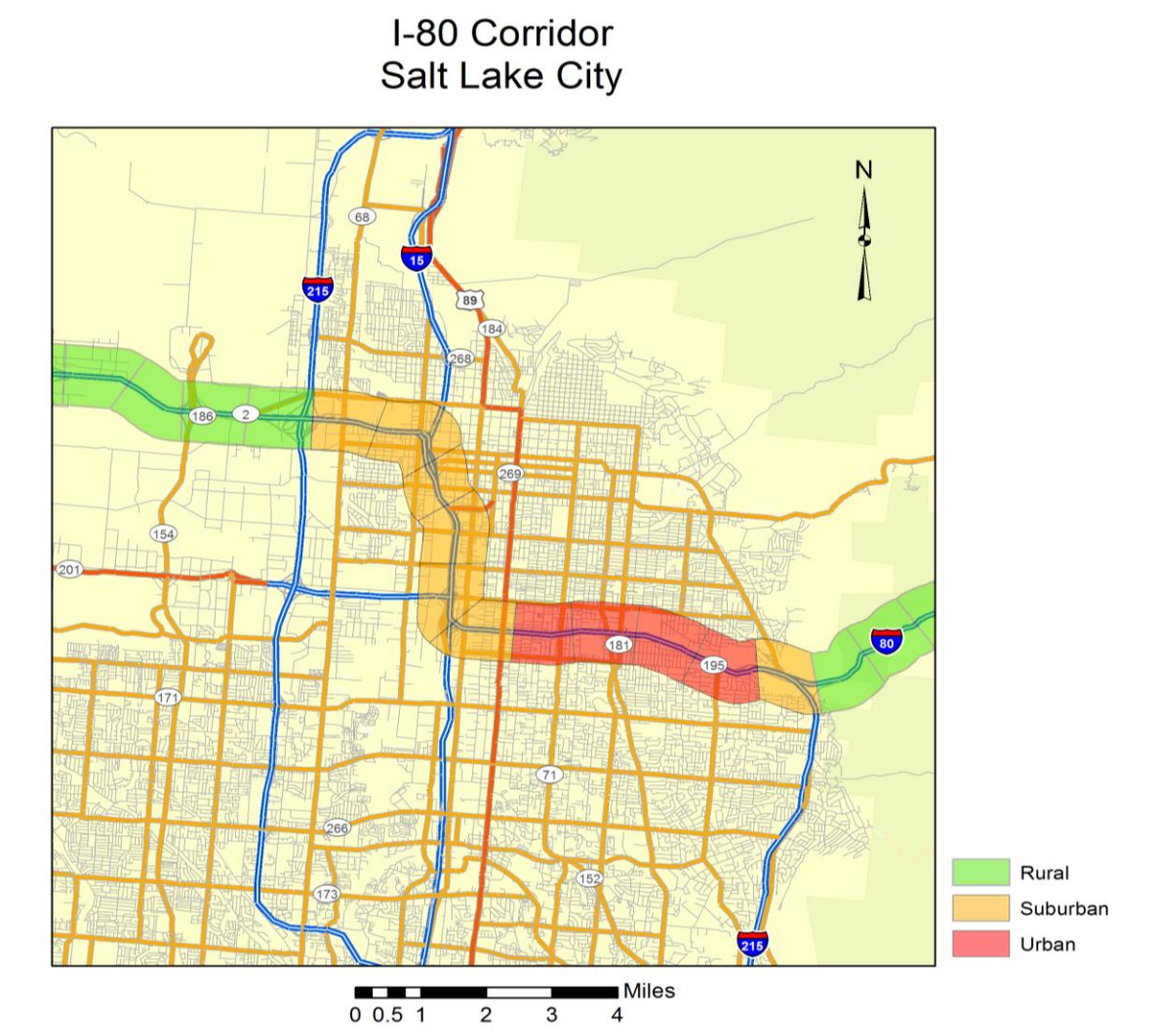
The routes studied

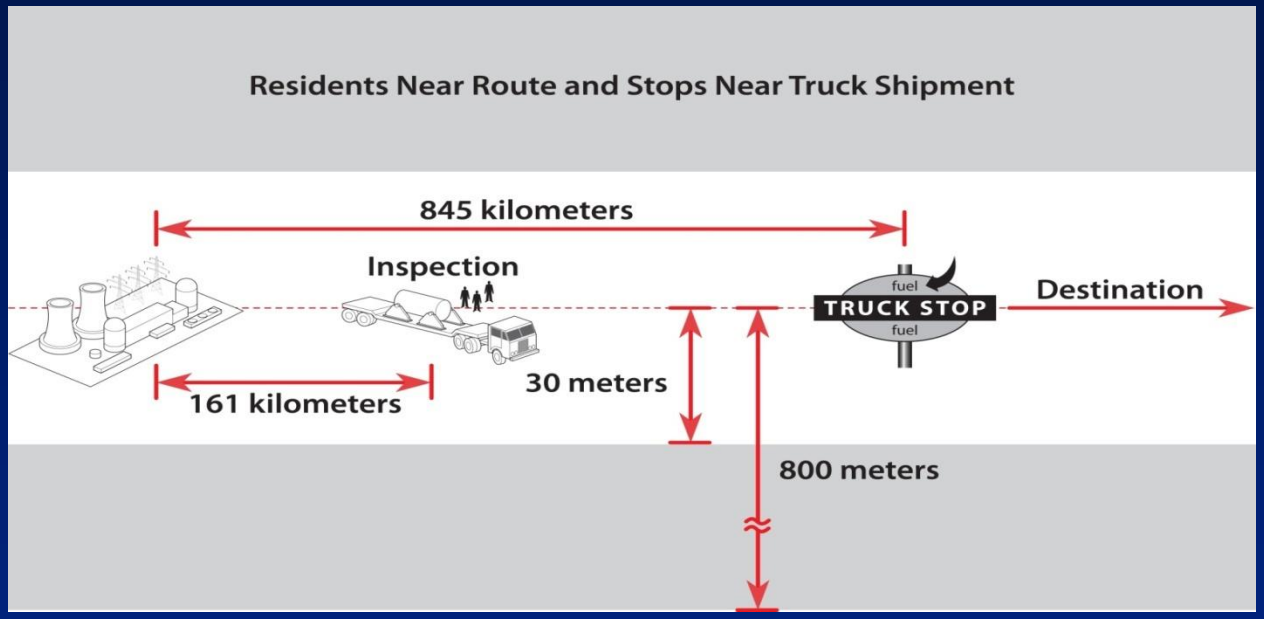
- The destinations include
  - two proposed repository sites (Deaf Smith, TX, and Hanford, WA)
  - the proposed private fuel storage facility (Skull Valley, UT)
  - ORNL
- SFTRA's road and rail routes span many states and thousands of miles through rural, suburban, and urban areas across the country, and are adequate to represent other routes.
- No SNF shipments are planned from any of SFTRA's points of origin to any SFTRA destination.

Routine Conditions: Truck Route Segments

WebTRAGIS was used to determine the urban, suburban, and rural segment population densities and lengths on a state-by-state basis.

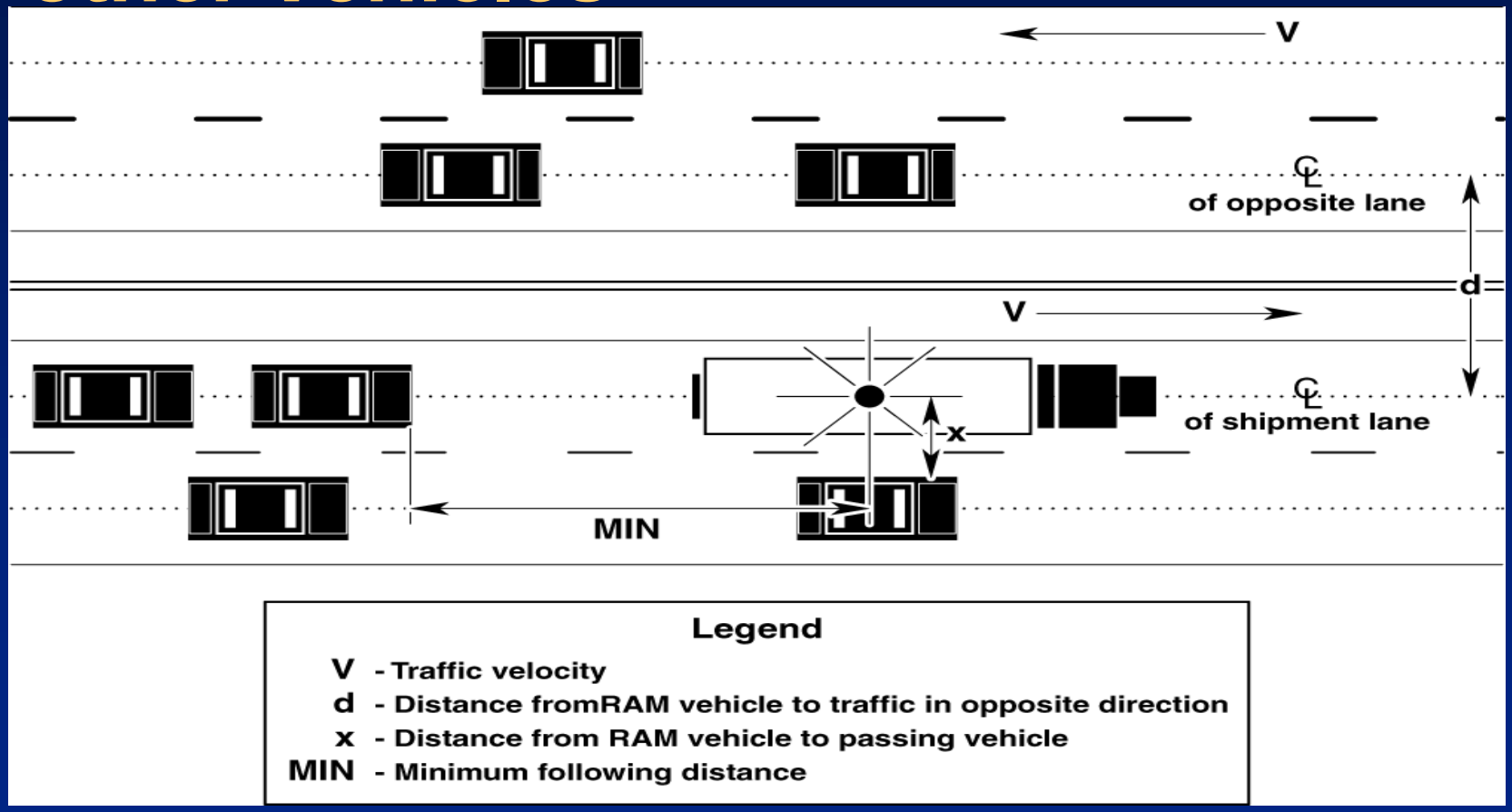


RADTRAN model for truck shipment



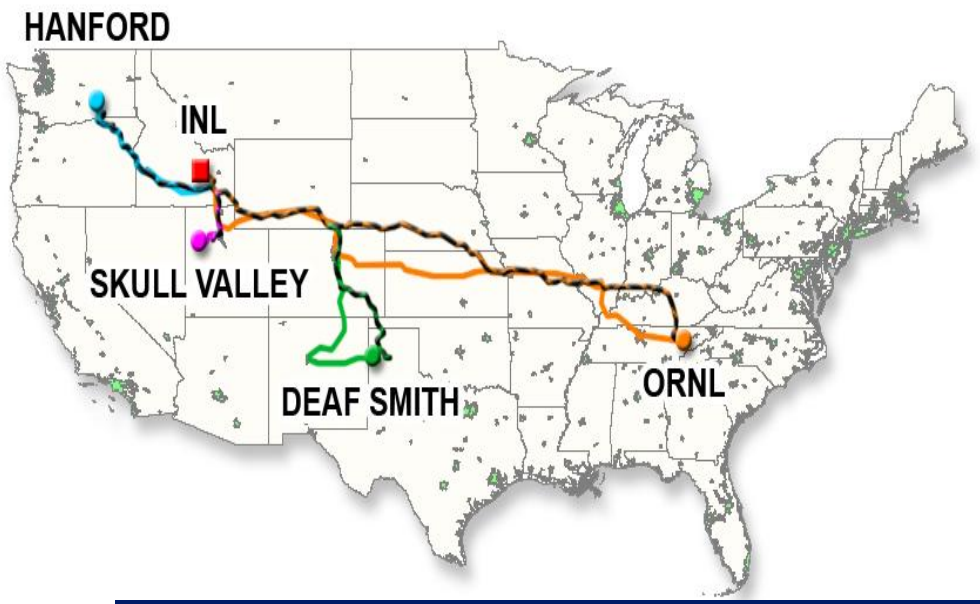
- Residents are uniformly distributed from 30 to 800m on either side of the route
- Vehicle inspections occur every 161 km, cask inspections occur at state boundaries, refueling stops occur every 845 km

RADTRAN model for occupants of other vehicles



Example Routes (continued)

Idaho National Laboratory Routes



Indian Point NP Routes

- INL included as an origin because spent fuel is stored there.

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Types of exposed populations

- Residents along the route
- Occupants of vehicles sharing the route
- Residents near stops
- People sharing the stop
- Crew of the transport vehicle (truck or train)
- Inspectors

Maximally Exposed Individual (MEI)

- A member of the public who is at a distance of 30 meters from the route.
- Vehicle is moving at 24 kph for both truck and rail.

Cask (mode)	Dose, Sv (rem)
Rail-Lead (rail)	5.7×10^{-9} (5.7×10^{-7})
Rail-Steel (rail)	4.3×10^{-9} (4.3×10^{-7})
Truck-DU (truck)	6.7×10^{-9} (6.7×10^{-7})

- These doses are about the same as 1 minute of average background: 6.9×10^{-9} Sv.

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Sample Collective Doses for Routine Truck Transportation

Origin	Destination	Residents Along Route	Occupants of Vehicles Sharing Route	Residents Near Stop	Persons Sharing Stop	Crew/ Truck Stop Worker	Total
MAINE YANKEE	ORNL	9.6×10^{-5}	4.6×10^{-4}	1.2×10^{-5}	8.6×10^{-4}	6.8×10^{-4}	2.1×10^{-3}
	Deaf Smith	1.4×10^{-4}	7.3×10^{-4}	1.8×10^{-5}	9.2×10^{-4}	1.4×10^{-3}	3.2×10^{-3}
	Hanford	1.2×10^{-4}	8.3×10^{-4}	1.4×10^{-5}	1.3×10^{-3}	1.9×10^{-3}	4.2×10^{-3}
	Skull Valley	1.1×10^{-4}	7.0×10^{-4}	1.4×10^{-5}	1.1×10^{-3}	1.6×10^{-3}	3.5×10^{-3}

Total Collective Dose (Person-Sv)

Routine transportation summary

- Individual and collective doses are calculated for a single shipment and are very small.
- Maximum individual doses are comparable to background doses.
- Collective doses from routine transportation are orders of magnitude less than the collective background dose.

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Response to regulatory impacts

- Casks are required to withstand a free fall from 9 meters (impact velocity of 48 kph) onto a flat, essentially unyielding, target in the most damaging orientation.
- The NRC requires conservative approaches in demonstrating the casks withstand this impact.
  - Materials
  - Material properties
  - Allowable stresses
- This assures the cask will survive more severe impacts.

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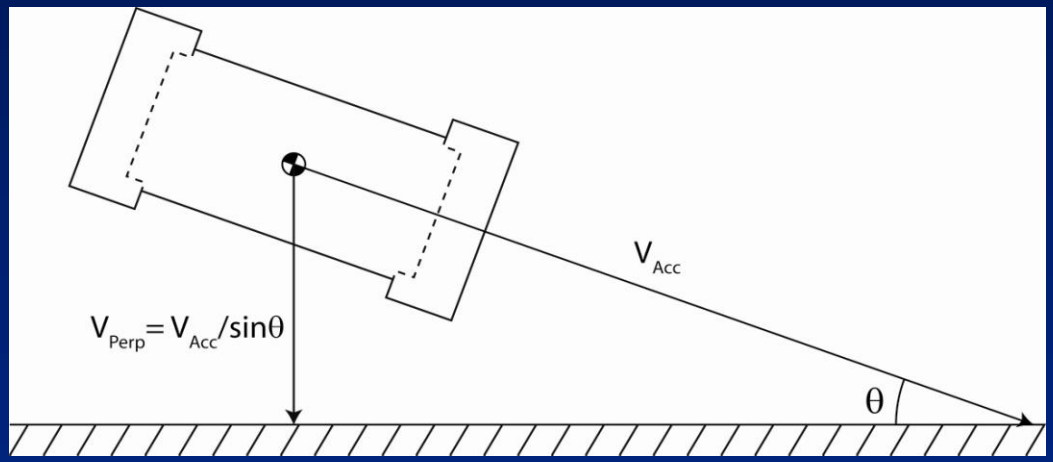
Finite element analyses of casks

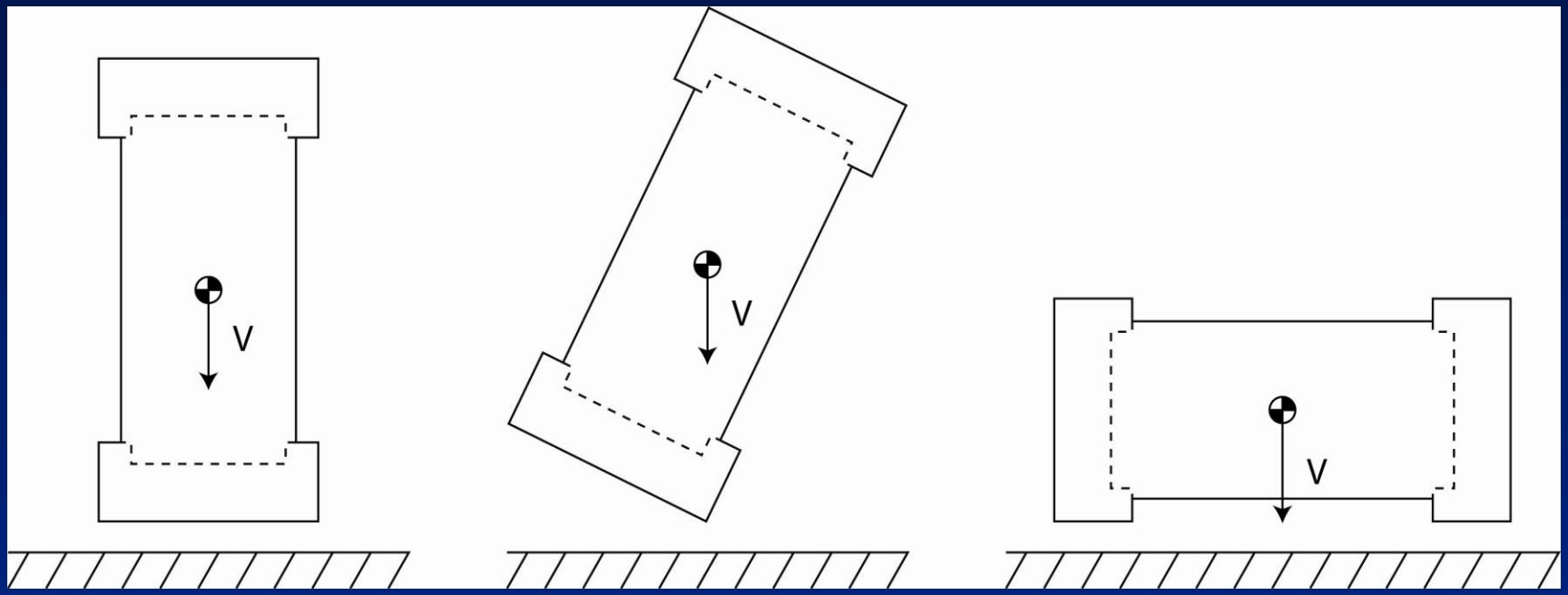
- The response of the two rail casks studied to impacts of 48, 97, 145, and 193 kph (30, 60, 90, 120 mph) onto rigid targets.
- The responses were determined using the nonlinear transient dynamics explicit finite element code PRESTO.
- In the cask models, the fuel region was treated as a homogenized mass.
- The response of the truck cask was inferred based on finite element calculations carried out for other projects.

Affect of impact angle

Angle	V_{Acc} so V_{perp} = 97 kph (60 mph)	Probability
0 - 10	556 (345)	0.2000
10 - 20	282 (175)	0.1778
20 - 30	193 (120)	0.1556
30 - 40	150 (93)	0.1333
40 - 50	126 (78)	0.1111
50 - 60	111 (69)	0.0889
60 - 70	103 (64)	0.0667
70 - 80	98 (61)	0.0444
80 - 90	97 (60)	0.0222

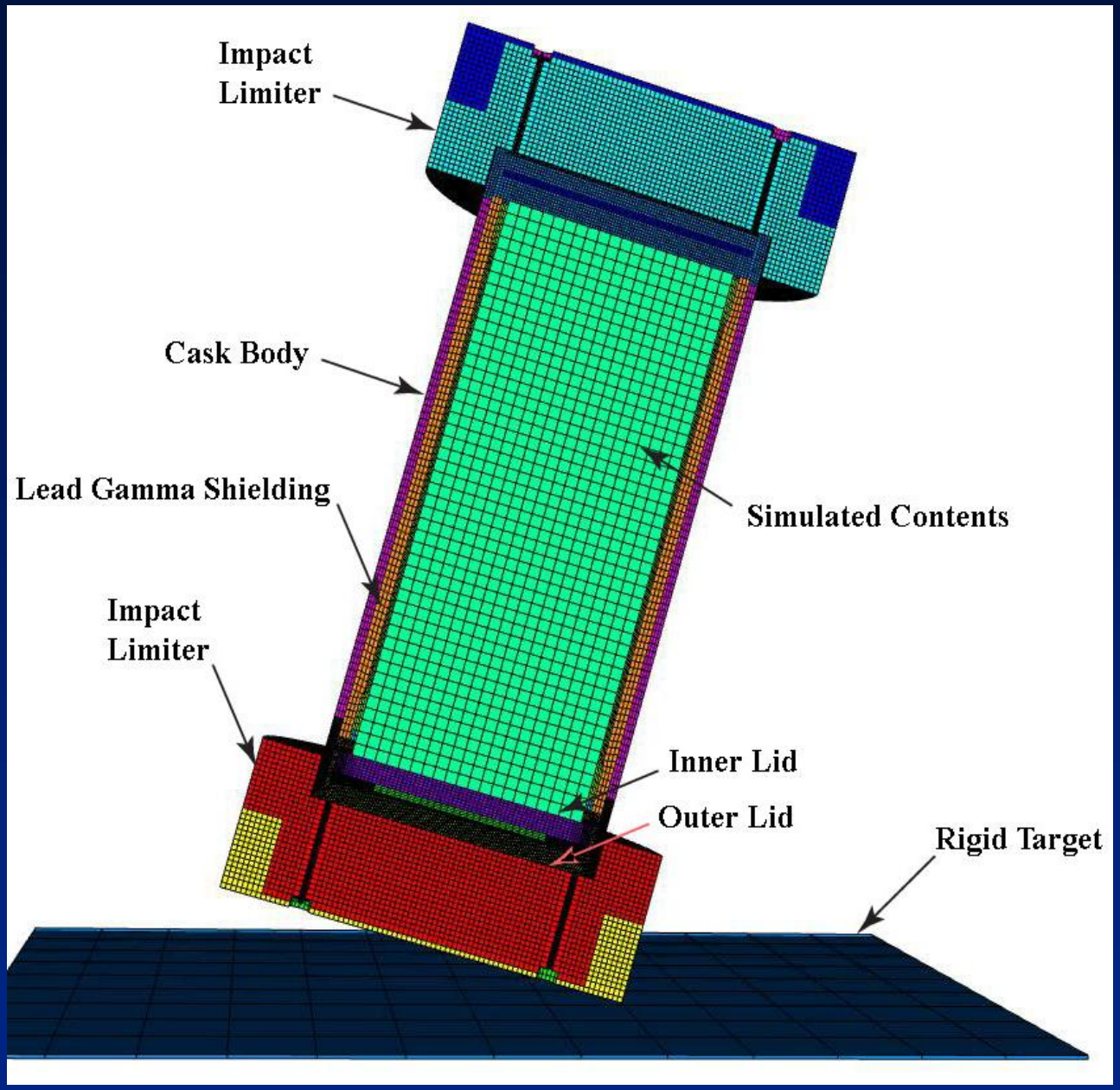


Impact orientations



End Corner Side

Finite element model of the rail-lead cask



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Impacts onto yielding targets

- When a cask impacts a “real” target the impact energy is absorbed by both the cask and the target.
- The amount of energy absorbed by the target depends on the relative strength and stiffness of the target and the cask.
- Because of the energy absorbed by the target, the impact velocity required to produce the same damage as an impact onto a rigid target is greater.

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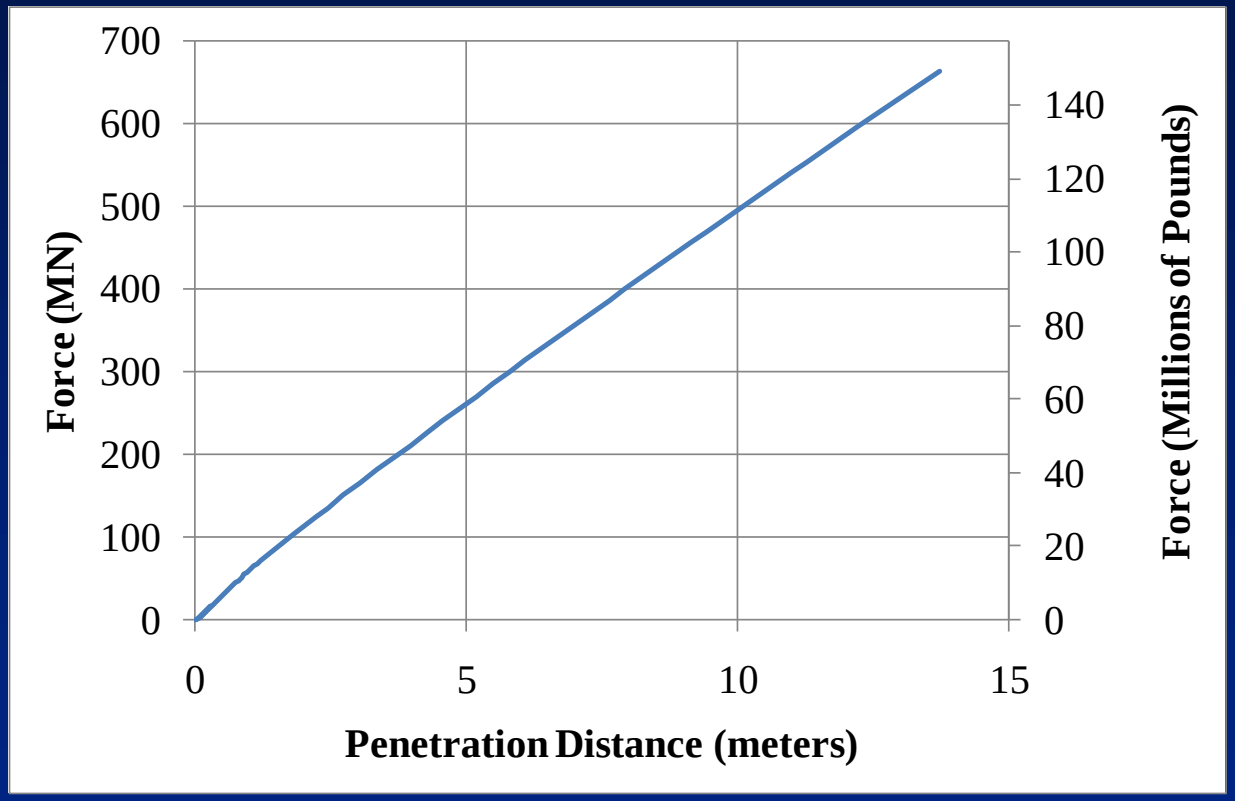
Contact forces for impacts onto a rigid target for the rail-lead cask

Orientation	Speed, kph (mph)	Acceleration (g)	Contact Force (Millions of Pounds)	Contact Force (MN)
End	48 (30)	58.5	14.6	65.0
	97 (60)	111.6	27.9	123.9
	145 (90)	357.6	89.3	397.1
	193 (120)	555.5	138.7	616.8
Corner	48 (30)	36.8	9.2	40.9
	97 (60)	132.2	33.0	146.8
	145 (90)	256.7	64.1	285.1
	193 (120)	375.7	93.8	417.2
Side	48 (30)	76.1	19.0	84.5
	97 (60)	178.1	44.5	197.8
	145 (90)	411.3	102.7	456.7
	193 (120)	601.1	150.0	667.4

Impacts onto soil



- Force generated by the Rail-Lead cask penetrating hard desert soil

Velocities onto various targets for equivalent damage for the rail-lead cask

Orientation	Rigid (or hard rock), kph (mph)	Soil, kph (mph)	Concrete, kph (mph)
End	48 (30)	102 (63)	71 (44)
	97 (60)	205 (127)	136 (85)
	145 (90)	>250 (>155)	>250 (>155)
	193 (120)	>250 (>155)	>250 (>155)
Corner	48 (30)	73 (45)	70 (43)
	97 (60)	236 (147)	161 (100)
	145 (90)	>250 (>155)	>250 (>155)
	193 (120)	>250 (>155)	>250 (>155)
Side	48 (30)	103 (64)	79 (49)
	97 (60)	246 (153)	185 (115)
	145 (90)	>250 (>155)	>250 (>155)
	193 (120)	>250 (>155)	>250 (>155)

Shaded cells represent the equivalent velocity from the regulatory impact

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Impact accident summary

- Only 1 in 2000 accidents is more severe than the regulatory hypothetical accident.
- Due to conservatisms in cask design, only 1 in a billion accidents is severe enough to cause release or loss of gamma shielding.
- A rail cask with an inner welded canister results in no release.
- An impact speed onto a rigid target greater than 60 mph is required to cause seal failure in a rail cask.

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Impact accident summary (continued)

- A 60 mph side impact onto a rigid target
  - produces a force of 45 million pounds
  - is equivalent to a 115 mph impact onto a concrete roadway or abutment
  - is equivalent to a 153 mph impact onto hard soil

- For impacts onto rock that is hard enough to be able to resist these large forces, impacts at angles less than 30 degrees require a speed of more than 120 mph to be equivalent.

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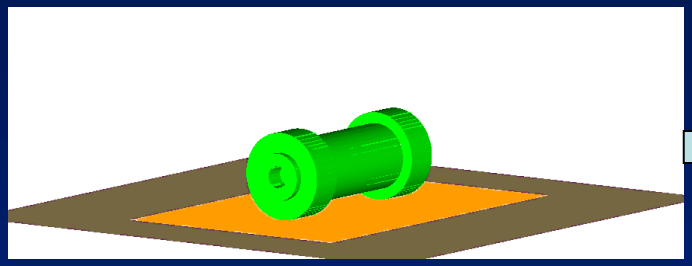
Response to regulatory fires

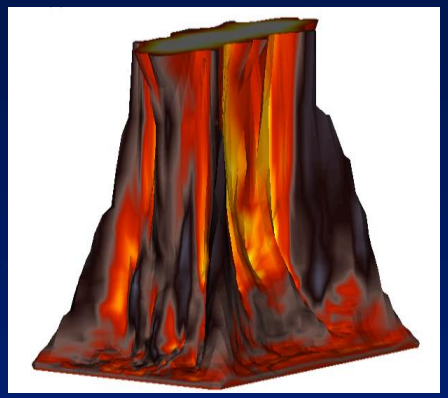
- Casks are required to withstand a fully-engulfing hydrocarbon fuel fire for 30 minutes.
- Generally demonstrated by analysis using a prescribed boundary condition of 800°C.
- Real fires have temperatures that vary with both time and location – but the average heating is similar to that from the uniform thermal boundary condition.
- Regulatory review requires seal temperatures and fuel temperatures stay below their failure thresholds.

Fire cases analyzed for rail casks

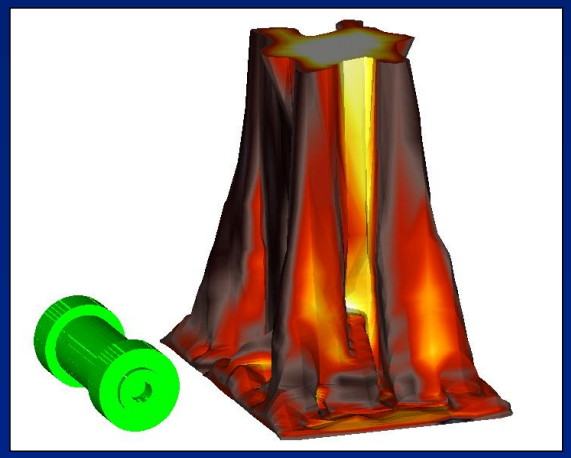
All pools are 46 ft x 29.5 ft and burn for 3 hours



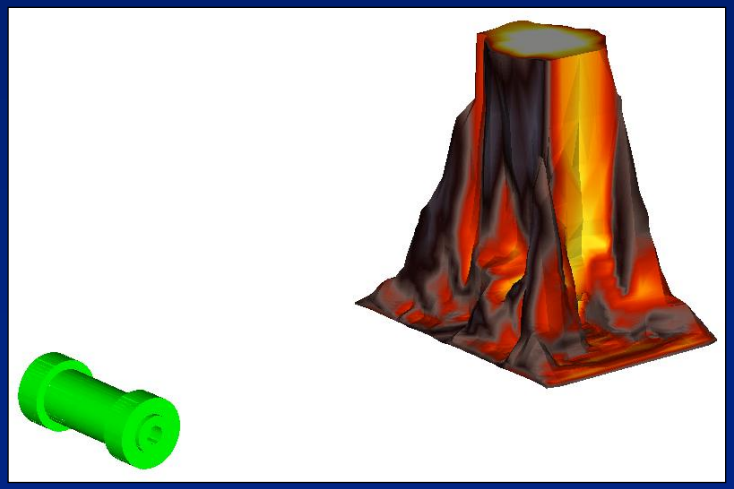
Cask in the middle of flammable liquid fuel pool region (shown in orange) before the fire starts



Fire engulfing the cask



Cask offset from the flammable liquid fuel pool by 3 meters (10 feet)



Cask offset from the flammable liquid fuel pool by 18 meters (60 feet)

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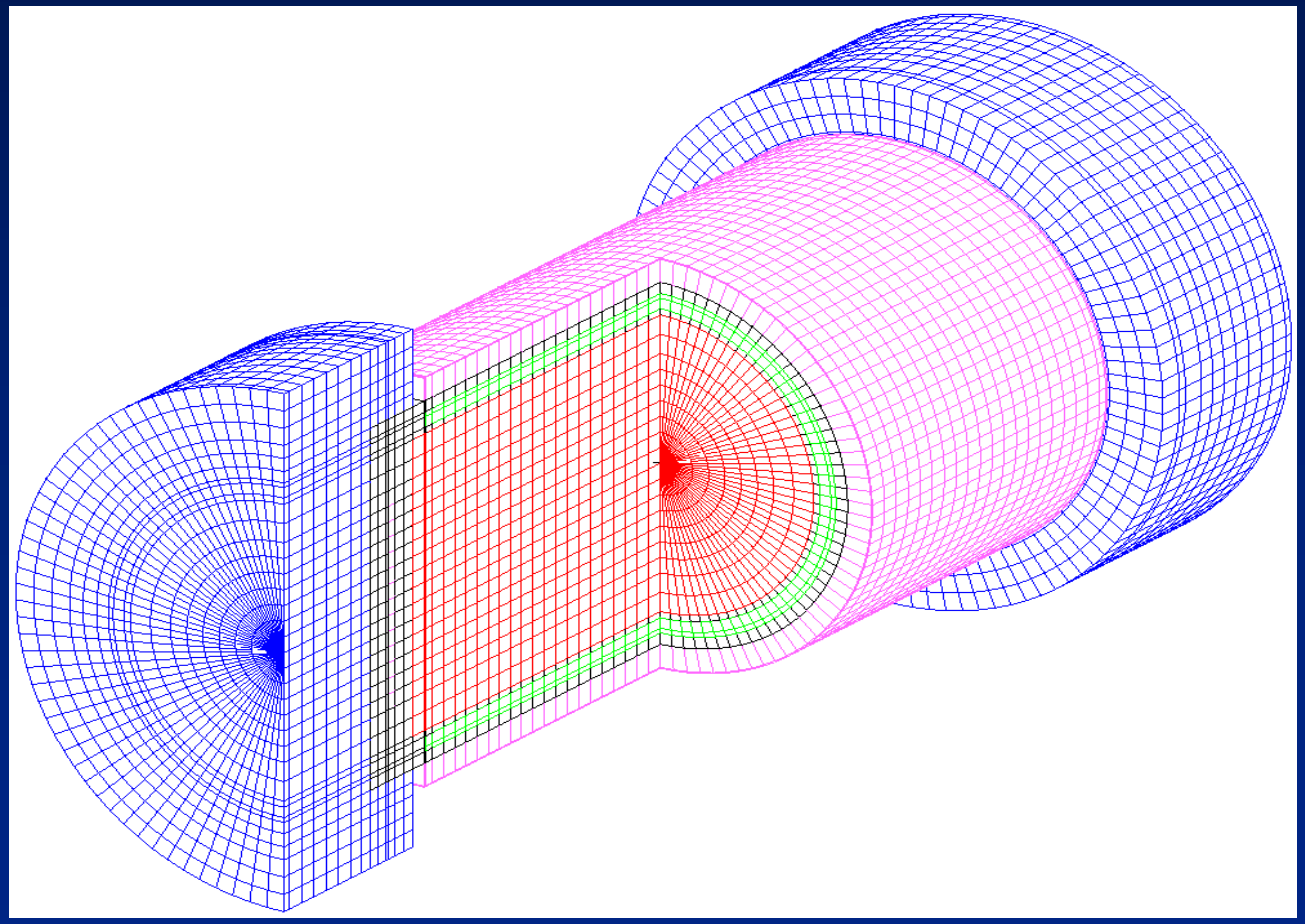
Fire simulations

- A 30-minute regulatory fire was analyzed with
  - the regulatory thermal boundary conditions using P-thermal (a finite element analysis code)
  - the Cask Analysis Fire Environment (CAFE), a 3D coupled heat transfer / computational fluid dynamics code

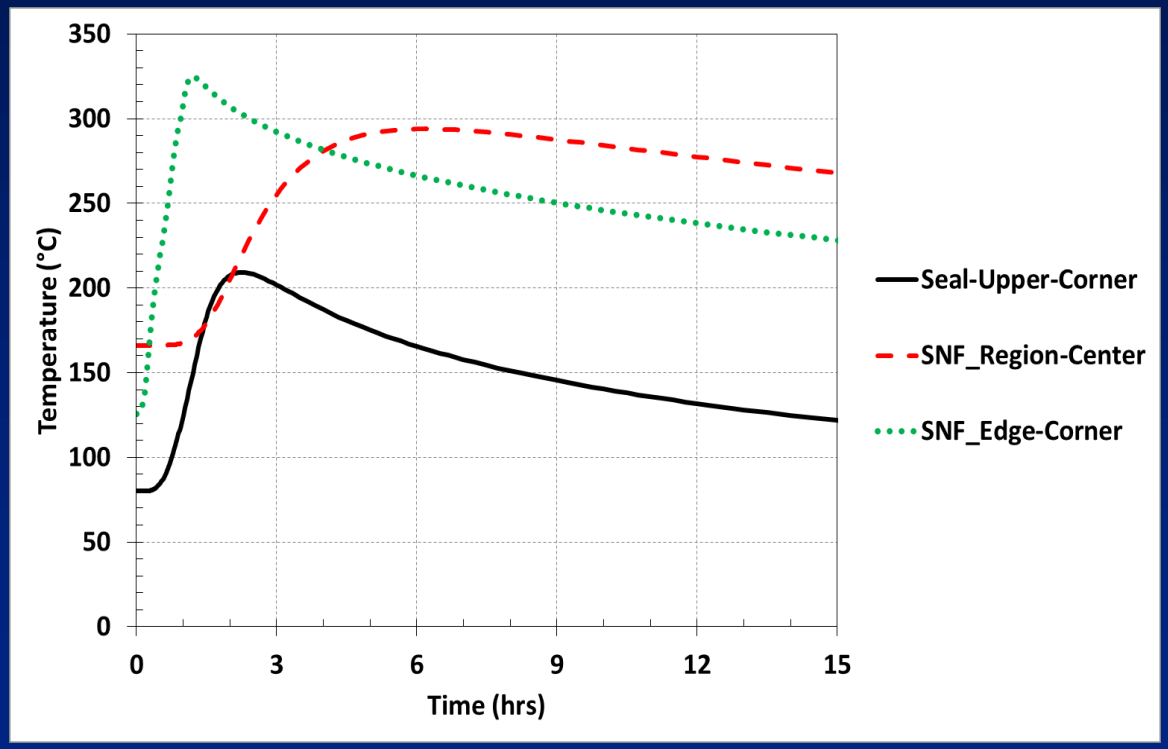
- All accident fires were analyzed using CAFE.

Finite element mesh of the rail-lead cask



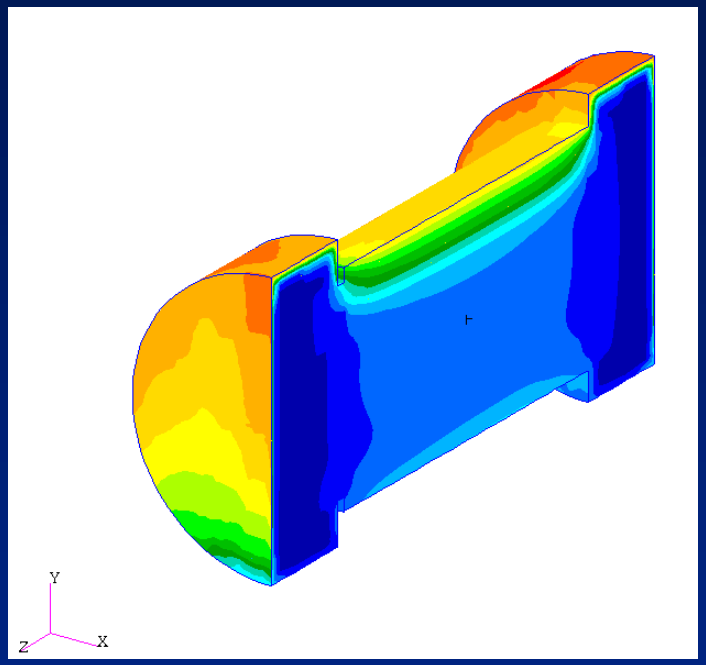
Thermal analysis of the truck cask

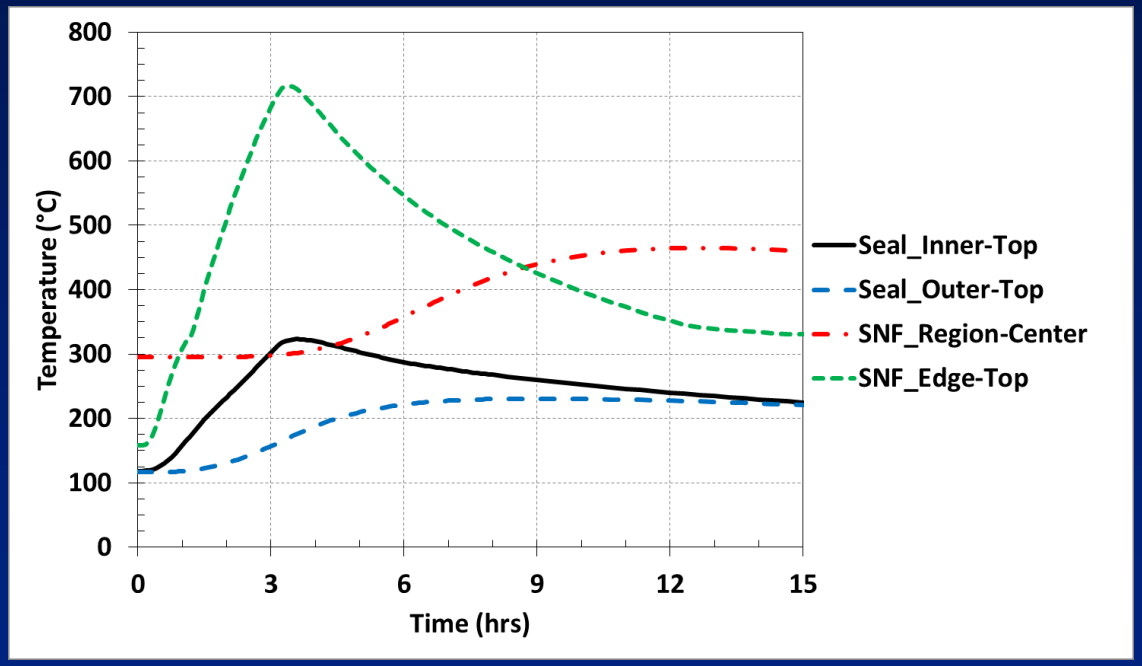
- Similar to the engulfing fires for the rail casks, except for a 1-hour duration



- There is no seal failure and no rod burst, therefore no release

Rail-lead cask fire accident
After 3-hour concentric fire:

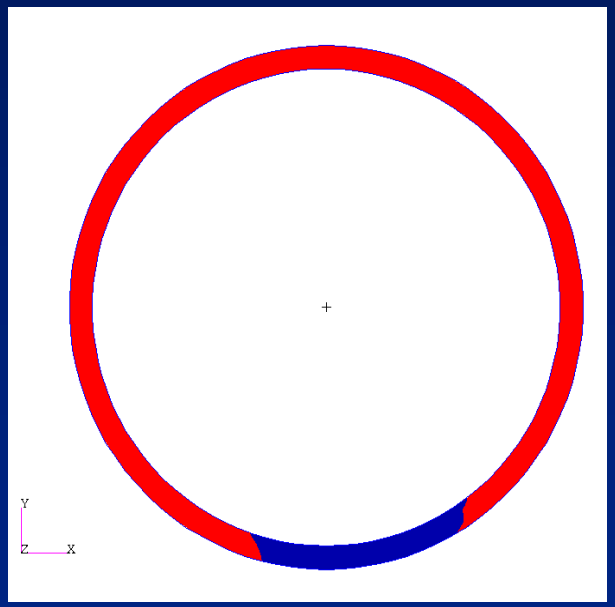




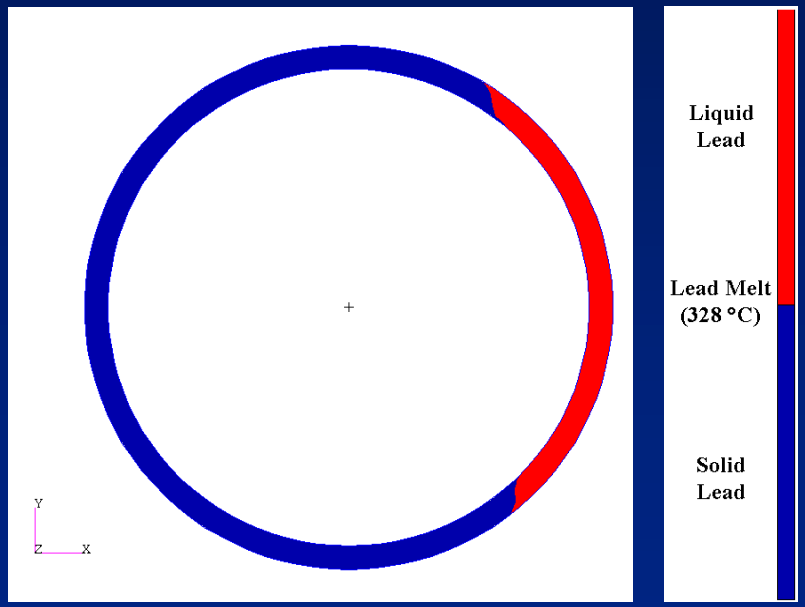
- Seal temperature is below its failure temperature of 350°C.
- Spent fuel temperature is below the rod-burst temperature of 750°C.

Lead melt

When lead melts it expands and deforms the lead cavity. When it solidifies, it shrinks, leaving a gap.



Concentric fire



3m offset fire

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Fire accident summary

- No cask loses containment in the fires analyzed.
- The fuel rods do not fail in the fires analyzed.
- Reduction in neutron shielding is likely for many fires (this is assumed in the certification of the casks).
- Reduction in gamma shielding is possible for very severe fires with lead shielded casks.
  - exposure to a concentric fire that burns longer than 65 minutes
  - exposure to a fire offset by 10 feet that burns longer than 2.25 hours
- Confined fires, such as tunnel fires or fires under overpasses, were not analyzed because other NRC studies have evaluated these environments.

Types of accidents and incidents

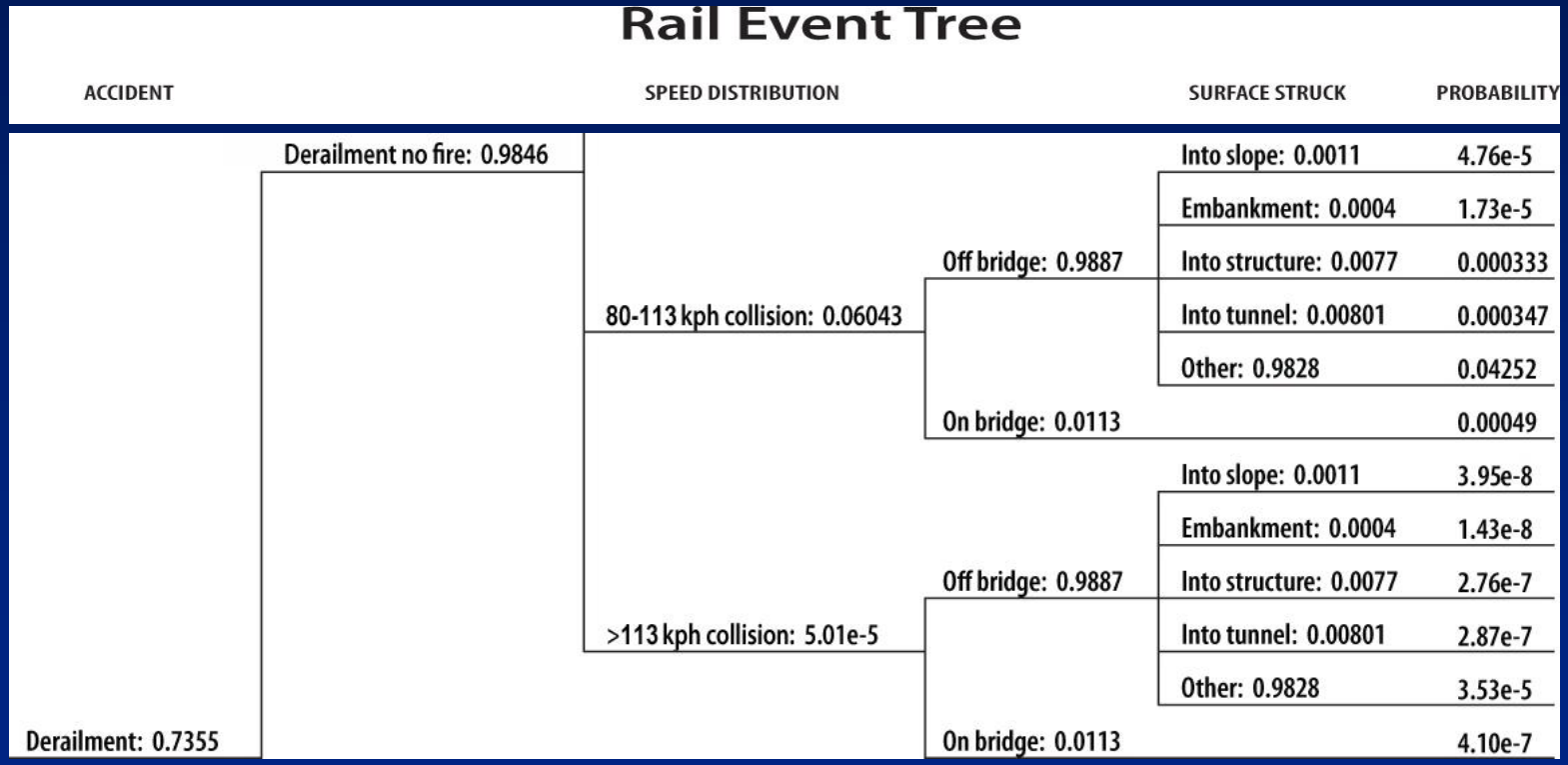
- Accidents in which the spent fuel cask is not damaged or affected, but the shipment is delayed

- Accidents in which the spent fuel cask is affected
  - Accidents resulting in loss of neutron or gamma shielding, but no release of radioactive material
  - Accidents resulting in release of radioactive material

Probabilities of all accident types

- Highway and railroad accident statistics are maintained by DOT's Bureau of Transportation Statistics.
- The average probability of an accident is
  - 1.9×10^{-6} per km for heavy trucks (3.1×10^{-6} per mi)
  - 1.1×10^{-7} per km for railcars (1.8×10^{-7} per mi)
- Accident severities are categorized using an event tree with conditional probabilities.
  - For trucks, the event tree was developed at Sandia National Laboratories.
  - For rail, the event tree was developed at the Volpe National Transportation Systems Center.

Accident Conditions: U.S. DOT Rail Accident Event Tree Segment



Additional probabilities included in analyses

- The rail event tree does not include target hardness, so the distribution from the truck event tree was used.
- Neither event tree includes impact angle or orientation, so conservative engineering judgments of angle and orientation distributions were assumed.
- The truck event tree does not include impact velocity, but since impacts at even the highest velocity analyzed did not result in release, this was not needed.
- The rail event tree does not divide accident speeds greater than 113 kph (70 mph), so it is assumed that 95% of them are between 113 and **1**45 kph (90 mph), and 5% are above 145 kph (needed for lead slump dose risk calculations).

Accidents without loss of shielding or release

- Almost all accidents will fall into this category.
- Dose depends on the external dose rate of the cask.
- A 10-hour stop time is assumed for all accidents of this type.
- Collective doses are calculated using the average rural, suburban, and urban population densities for each route.
- 10 hour dose to an emergency responder at a 2 meter distance from the cask is **~0.001 Sv** (100 mrem).
- Collective population dose risk to nearby residents is **~7 x 10^{-5} person-Sv** (7 x 10^{-3} person-rem).

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Accidents with loss of gamma shielding but no release

- Less than one in a billion impact accidents is severe enough to cause a loss of lead gamma shielding resulting in a dose rate greater than the regulatory post-accident dose rate.
- Because these accidents are so rare, the collective dose risk is much smaller than that from the no loss of shielding case, about **10^{-13} person-Sv** (10^{-11} person-rem).

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Accidents with release

- Only rail casks without an inner welded canister have release.
- Dose depends on
  - the inventory (quantity and physical form), assumed in this study to be the maximum the casks are certified to transport
    (9-year cooled 45 GWD/MTU burn-up).
  - the exposure pathway, which includes rod-to-cask release fraction, cask-to-environment release fraction, and dispersion

Release fractions

	Cask Orientation	Side	Side
	Rigid Target Impact Speed, kph (mph)	193 (120)	145 (90)
	Seal	elastomer	elastomer
Cask to Environment Release Fraction	Gas	0.80	0.80
	Particles	0.70	0.70
	Volatiles	0.50	0.50
	CRUD	0.001	0.001
Rod to Cask Release Fraction	Gas	0.12	0.12
	Particles	4.8×10^{-6}	4.8×10^{-6}
	Volatiles	3.0×10^{-5}	3.0×10^{-5}
	CRUD	1.0	1.0
	Conditional Probability	1.79×10^{-11}	3.40×10^{-10}

Doses from release

- Dominated by inhalation
- Includes resuspension, cloudshine, groundshine, and ingestion
- Because of thermal loft due to the elevated temperature of the cask interior, the maximum dose occurs 21 meters downwind from the accident.
- Maximum individual dose to a hypothetical person at this location is **1.6 Sv** (160 rem).
- Collective dose risk is **10^{-12} person-Sv** (10^{-10} person-rem).

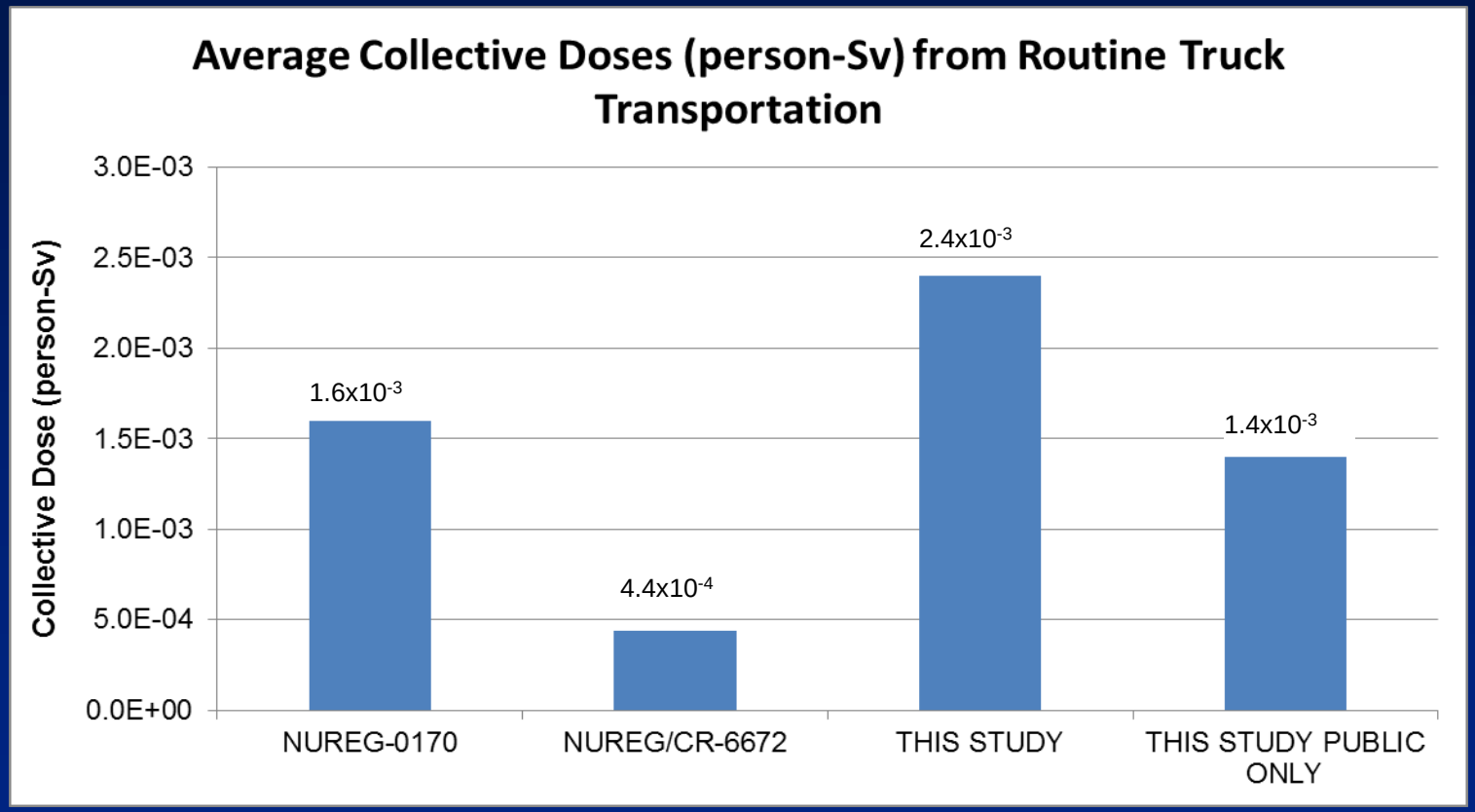
Conditional Probability Examples

- Impact in side orientation at 145 kph into hard target
  - Derailment: P=0.74
  - Speed >113 kph: $P=5x10^{-5}$
  - Accident not on bridge: P=0.989
  - Impact into slope or embankment: P=0.0011+0.0004
  - Impact into hard rock: P=0.055
  - Impact angle < 45°: P=0.333
  - Side orientation: P=0.3

  $P=0.74*5x10^{-5}*0.989*(0.0011+0.0004)*0.055*0.333*0.3=3x10^{-10}$
- Fire example
  - Derailment > 48 kph: $P=1.6x10^{-5}$
  - Pileup: $P=2.4x10^{-5}$
  - Offset<10m: $P=2.4x10^{-5}$
  - Flammable Hazmat in consist: P=0.6
  - Release of flammable material: P=0.04
  - Pool Fire: P=0.001

  $P=1.6x10^{-5}*2.4x10^{-5}*2.4x10^{-5}*0.6*0.04*0.001=2.1x10^{-19}$

Routine Transportation Results Comparison:



SFTRA Findings

- The collective dose risks from routine transportation are very small. These doses are about four to five orders of magnitude less than collective background radiation dose over the same time period and exposed population as the shipment.
- There was little variation in the risks per kilometer over the routes analyzed.
- Radioactive material would not be released in an accident if the fuel is contained in an inner welded canister inside the cask.
- Only rail casks without inner welded canisters would release radioactive material, and only then in exceptionally severe accidents.
  - If there were an accident during a spent fuel shipment, there is less than one in a billion chance the accident would result in a release of radioactive material.
  - If there were a release of radioactive material in a spent fuel shipment accident, the dose to the maximum exposed individual would be non-fatal.

Draft NUREG-2125 published for comment

- Federal Register Notice**: 77 FR 28406**, May 14, 2012
- ADAMS Accession Number for Draft NUREG-2125 : **ML12125A218**
- Public comment period closed on July 15, 2012
- Comments received from
  - The State of Nevada
  - The State of Oregon
  - Western Interstate Energy Board
  - Nuclear Energy Institute

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Comment: 60 day comment period is inadequate/extension request

- Draft response
  - Given the nature of the subject, the staff considered granting the extension request. However, in considering various factors, including contract expiration date, the staff felt that the comment period could not be extended. Furthermore, the Federal Register notice states that comments received after 60 days will be considered if it is practical to do so.
- No changes to Draft NUREG-2125

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Comment: Accident scenarios underestimate potential fire durations and temperatures

- Draft Response
  - The probability, given an accident, of the most severe fire considered in DRAFT NUREG-2125 is 10^{-14} as explained in Section E.3.1.2. While it is possible to envision a more severe fire accident; such events would have an even lower probability and would not affect the overall risk of spent fuel transportation unless they had a release of more than 10,000 A_2, which is not feasible.
- Changes to Draft NUREG-2125
  - Add discussion on Caldecott and Baltimore Tunnel Fires and MacArthur Maze Fire, including their probabilities, and show it does not change the risk results.

Comment: Calibration of finite element models

- Draft Response
  - The report provides an example of a comparison between finite element analysis and test results for a large fire test in Appendix D. Similar comparisons have been made for regulatory and extra-regulatory impact analyses. There have been many physical tests on casks and cask components that have been compared to finite element predictions of the tests. Many spent fuel casks are certified by a combination of testing and analysis, where the testing is used to validate the finite element analysis.
- Changes to Draft NUREG-2125
  - References on comparison between test and analyses for impact analyses will be added to the report.

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Hanford should not be an example destination

- Draft Response
  - Transportation risk assessments require designation of shipment points of origination and destinations. Currently, there are no planned spent fuel shipping campaigns. DRAFT NUREG-2125's shipment points of origination and destination were selected to illustrate long-haul geographic diversity. We believe the disclaimer "The routes shown are for illustrative purposes only, and no SNF shipments are planned from any of these points of origination to any of these destinations" makes this clear. While other origination/destination pairs are possible, the DRAFT NUREG-2125 pairs are adequate for the stated purposes of the study. Also, the report makes clear that DRAFT NUREG-2125 is a generic spent fuel transportation risk assessment, and is not intended as a facility- or site-specific environmental assessment.
- Changes to Draft NUREG-2125
  - Repeat existing DRAFT NUREG-2125 disclaimer at least once in chapter 2, chapter 5, chapter 6, appendices B, E, and F

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Comment: Results should be used to risk inform 10 CFR Part 71

- Draft Response
  - NUREG-2125 will be available for consideration in NRC's risk management activities.
- No changes to Draft NUREG-2125

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DECOMMISSIONING PLANNING RULE AND GUIDANCE

REG GUIDE 4.22 (DG-4014)

J. C. Shepherd
FSME/DWMEP/RDB

6 Dec 12

LICENSE TERMINATION RULE

- Commission directed staff to review 1997 LTR
- Staff response in SECY 03-0069
  - **Proposed rulemaking** for prevention of legacy sites
    - Limit Environmental Contamination
    - Monitor Site, Including Subsurface
    - Keep Results In Decommissioning Records
    - Update Financial Assurance
- Commission approved rulemaking in SRM

DPR & Guide Development

- Workshop April 2005
- ACNW briefing June 2005
  - Committee supports the issuance of generic guidance
  - Groundwater monitoring should be a prime consideration
- Draft guidance for comment Sep 2005
- Draft Rule *en route* Sep 05
  - Braidwood ^{3}H issue
  - NRC Task Force (LLTF)

DEVELOPMENT CON'D

- ACNW Briefings
  - March 2006
    - Expert panel unanimously agreed that staff had factored panel's input into proposed guidance.
  - July 2006
    - Committee encourages staff to draft rulemaking, guidance on contaminant release prevention, early detection, remediation
  - October 2007
    - Committee believes that unplanned releases that could <u>contaminate ground water</u> deserve special attention

DPR & Guide Schedule

Rule	Guidance
• Draft Jan 08	Jan 08 (Draft)
	Jan 09 (Draft)
• Final Jun 11	Dec 11 (DG-4014)
	Jul 12 (Draft Rev)
• Effective Dec 12	Dec 12? (RG 4.22)

SURVEYS AND RECORDS

PRE-DPR	DPR
§ 20.1501 General. (a) Each licensee shall make … surveys that— … (2) <u>Are reasonable under the circumstances</u> to evaluate— (~~b~~c) … instruments … are calibrated	§ 20.1501 General. (a) Each licensee shall make … surveys of areas, **including the subsurface** that— … (2) <u>Are reasonable under the circumstances</u> to evaluate— (b) … records from surveys … of subsurface residual radioactivity … must be kept with records important to decommissioning ….

DPR RAD PROTECTION

PRE-DPR	DPR
§ 20.1101 Radiation protection programs. (a) Each licensee shall develop, document, and implement a radiation protection program commensurate with the scope and extent of licensed activities ….	same
(b) The licensee shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that ALARA.	same
(c) The licensee shall periodically (at least annually) review the radiation protection program content and implementation.	same

RG-4.22: DO SURVEYS

- SURVEYS PER § 20.1501(a)
  - SURFACE
    - ACCESSIBLE AREAS
    - NOT READILY ACCESSIBLE
  - SUBSURFACE IS NOW **EXPLICIT** CONSIDERATION
    - NEAR TO POTENTIAL SOURCES
    - IN GW FLOW PATHS (DOWNSTREAM)
  - NEI-07-07 OBJECTIVES MEET RULE INTENT

RG-4.22: KEEP RECORDS

- RECORDKEEPING PER § 20.1501(b)
  - RETAIN SURVEY RESULTS WITH "RECORDS IMPORTANT TO DECOMMISSIONING"
    - SIGNIFICANT RESIDUAL RADIOACTIVITY REQUIRES REMEDIATION AT TIME OF LICENSE TERMINATION FOR UNRESTRICTED RELEASE
    - BASES FOR CHARACTERIZATION SURVEYS AT LICENSE TERMINATION

RG-4.22: FINANCES

- UPDATE FINANCIAL ASSURANCE
  - DETAILS IN RG-1.159 & NUREG-1757 V. 3 R. 1
  - ESTIMATE COST TO REMEDIATE
  - ARRANGE FOR SUFFICIENT FUNDS
    - REACTORS PER 10 CFR 50
      - §50.75: major factors that could affect the cost
      - §50.82: site-specific cost estimate
    - NON-REACTORS UPDATE DFP ANNUALLY

GUIDANCE COMMENTS 1/2

- SIX COMMENTERS (RTRs, CORAR, POWER INDUSTRY)
  - HIGH PERFORMING AND LIMITED INVENTORY LICENSEES SHOULD BE EXEMPT
  - FLUID PROCESSES NOT SUFFICIENT REASON FOR REVIEW – CONSIDER SITE ENGINEERING
  - GUIDE DOES NOT SAY HOW MANY SAMPLES ARE NECESSARY TO DEMONSTRATE COMPLIANCE

GUIDANCE COMMENTS 2/2

- NEED MORE INFORMATION ON RISK-BASED APPROACH
- "AVAILABLE SOURCES" FOR COMPARISON NEED MORE EXPLANATION
- REQUIRING UNRESTRICTED RELEASE IS TOO HARD
- APPEARS TO INCORPORATE INDUSTRY INITIATIVE INTO REGULATORY FRAMEWORK
- HOLD ANOTHER WORKSHOP

GUIDANCE RESPONSES

- EXEMPT "GOOD" LICENSEES
- NO. PAST IS NOT PERFECT INDICATOR OF FUTURE
- FLUID PROCESSES INSUFFICIENT BASIS
- EXPERIENCE IS ENOUGH TO REQUIRE A LOOK
- GUIDE DOES NOT SAY HOW MANY SAMPLES
- IT DOES / WILL NOT. THIS IS LICENSEE JOB

GUIDANCE RESPONSES

- RISK-BASED APPROACH
- **ADDED TABLES AND APPENDICES**
- "AVAILABLE SOURCES"
- GUIDE SAYS "COMPARE"
- RESTRICTED RELEASE
- APPLIES ONLY AFTER SHUTDOWN
- INCORPORATES INDUSTRY INITIATIVE INTO REGULATORY FRAMEWORK
- MINIMIZED REFERENCE; IT IS ONE ACCEPTABLE METHOD

NEXT STEPS

- ACRS REVIEW AND COMMENT
- REVISE PER COMMITTEE COMMENTS
- PUBLISH FINAL IN DEC

QUESTIONS

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Dripping Water Wears Through Rock

NOT

THE END