UNITED STATES OF AMERICA

U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY INFORMATION CONFERENCE (RIC)

TECHNICAL SESSION (W20): SPENT FUEL SAFETY

MARCH 13, 2013

3:30 P.M.

TRANSCRIPT OF PROCEEDINGS

Public Meeting

APPEARANCES

Session Chair:

Greg Casto
Branch Chief, Division of Safety Systems
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission

Session Facilitator:

Rick Daniel
Safety Culture Specialist
Office of Enforcement

Panelists:

Steven Jones
Senior Reactor Systems Engineer
Division of Safety Systems
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission

Earl Easton
Senior Technical Advisor for Transportation
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission

Mary Lampert
Executive Director
Pilgrim Watch

Gordon Thompson
Executive Director
Institute for Resource and Security Studies

P R O C E E D I N G S

RICK DANIEL: All right. Thank you all for being here this afternoon to this RIC session. This session is about spent fuel safety. So if you're in the wrong session, don't worry. You can get up and leave. We're not going to keep you here.

Just a few administrative items before we get started. I'm sure you've been talked to death about cellphones and electronic things. If you just want to make sure that those are off. I'd appreciate it so you don't disrupt your neighbor. The exits to exit the room are right there behind you.

You should have been handed out an evaluation paper -- just a one-page white paper -- in the beginning as you came through the door. Please fill that out at your leisure as the session proceeds.

The presentations that you're going to see, you'll be able to access after the meeting. So when you go home tonight, if you're real excited and passionate about this subject, you can sit down at the computer and review things. So they are available.

So I just want to welcome you folks that are here today, and those on the webinar, I think we have about 30-some people on webinar. So they'll be able to see the slides. They won't be able to see the panelists up here. But welcome to all of you. We appreciate you being here today.

You know, two years ago, the world watched as the nation of Japan dealt with a horrific disaster. Two years to the day, we were watching it unfold. The NRC was watching. This country, the whole world was watching. And as horrific as that event was, for the nation of Japan, and still is, it actually was a silver lining to the United States of America -- to this country -- and to the nuclear industry in this country. And what I mean by that is it's a silver lining because it put us on notice: that we're not infallible, that things do go wrong, that it could happen here. And to a large degree, it brought a lot of people together. It brought us closer to our stakeholders. And if you heard the chairman yesterday talking about stakeholder involvement and public involvement, I believe he cited a number of studies that have been done in the regulatory industry. Those industries that maintain a collaborative environment with their stakeholders and their public and their licensees enjoy a stronger safety culture. And I can tell you from working at the NRC that that is where this organization is and where they're trying to improve, improve, improve -- continuous improvement. I see that myself in my very limited perspective.

So as a result of that horrific event two years ago, the NRC has been involved -- intimately involved in analyzing, reanalyzing many different things about safety from top to bottom. One of those areas that the NRC has looked at is spent fuel safety to the point of the Fukushima near-term task force developed two orders. One had to do with spent fuel pool instrumentation, and the second one was having to do with mitigating strategies for beyond design basis external events. So those two orders were issued since post-Fukushima.

Not to rest on our laurels, the NRC is still looking at other things having to do with wet and dry storage and spent fuel pools. In fact, they're looking at speeding up, expediting spent fuel pool -- movement of spent fuel from the pool to dry cask storage. And I'm not the expert. I'm only a facilitator. These folks are the experts. And in maintaining what the chairman pointed out about that collaborative environment with our stakeholders, we set out to put together a panel of people that we felt were passionate. Two of them are NRC people and two of them are what we call NGOs -- non-governmental organizations. And I'm going to introduce them to you in just a minute.

Even though these folks are here joining us -- the NGO folks -- they may represent a position or perspective that's contrary to our own. And that's not a bad thing. They're passionate about those things, and we can learn from them. As I said yesterday in another session I facilitated, the NRC doesn't have a monopoly on intelligence. So we want to listen to stakeholders. We want to listen to licensees. We want to listen to the public. We value your questions -- all of them.

So this session is about spent fuel storage, spent fuel safety. That's a main objective -- to talk about how to increase safety. The other objective of this meeting is to involve you folks. So don't be shy. Ask questions. There are going to be cards that you can write your questions on or you can stand up and raise your hand. I will come to you and we'll ask the question. We'll hear your comment. We're very much interested.

Let me introduce our panelists. Closest to me is Steve Jones. Steve is from the NRC. He's a senior reactor systems engineers in the Division of Safety Systems under the Nuclear Reactor Regulation Office. He's going to be talking with us about spent fuel pool defense-in-depth measures, strategies.

To the left of Steve is Dr. Gordon Thompson. Dr. Thompson is the executive director for the Institute for Resource and Security Studies. Gordon is going to be addressing the case for expedited transfer for spent fuel to dry storage.

And to the left of Gordon is Mary Lampert. Mary's from up in the Cape Cod area. Mary is the executive director for Pilgrim Watch. I go striped bass fishing up there. It's a beautiful area.

And finally on the end, furthest away from me is Earl Easton. Earl is the senior technical advisor of transportation in the Division of Spent Fuel Storage and Transportation, which is part of the Nuclear Material Safety Safeguards Office. That was a mouthful.

So let me explain to you how this is going to work. Each of these folks are going to give a presentation. We're going to start with Steve. After Steve does his presentation, we're going to take comments from the rest of the three panelists -- brief comments, okay? And then we're going to move to the next presentation -- go right on down the line and take comments.

After we get through the four presentations, we're going to go out to you folks -- the audience. So again I appreciate you being here. I'm excited about this session. This has a high value to a lot of people. I'm thrilled that we have folks here that are passionate about their opinions.

So, Steve, why don't you start us off? And by the way, folks, I'm the facilitator. My name is Rick Daniel. I work for the NRC. Go ahead, Steve.

STEVE JONES: Thank you, Rick. My name's Steve Jones, as Rick mentioned, from the -- a senior reactor systems engineer in the Balance of Plant Branch in the Office of Nuclear Reactor Regulation. I'm just going to advance the slides. Okay.

First I'd just like to address how we ended up where we are. Spent fuel pools were originally set up for low-density storage with the intent that fuel would be reprocessed. In the '70s, the government made a determination that, you know, reprocessing was a proliferation risk and changed -- that resulted in the need to find alternate ways of storing fuel. That resulted in a transition to high-density storage within the spent fuel pools and also the development of dry cask storage capabilities on site.

Currently, there's widespread adoption of dry cask storage and also as pool limits have been approached as far as storage capability, and most of the pools have now high-density storage.

The plants are generally maintaining a full core offload capability by transferring fuel as necessary to dry cask storage from the spent fuel pools. The staff has done several studies evaluating the risk of high-density storage beginning in the -- really in the early '80s. NUREG 1353 addressed Generic Issue 82, Beyond Design Basis Accidents in Spent Fuel Pools. And NUREG 1738 was looking at decommissioning regulations for spent fuel pools, and that was in 2001. Both of these studies identified the largest contributor to spent fuel pool damage and possible offsite release was very rare seismic events that were -- had ground acceleration several times the design of the facility.

Other contributors were cast drops generally associated with loading of the spent fuel and loss of forced cooling, where there would be an extended boil off of the cooling inventory in the pool.

In -- both of these phases [spelled phonetically] were considered relatively conservative with respect to their evaluations of the seismic risk and also these other initiators because they didn't specifically evaluate the progression of those events.

A spent fuel pool structure -- I think most people are familiar with here -- is very robust and very resistant to damage. If any damage were to occur due to, say, a seismic event, it's more likely to occur near the floor of the pool or at the juncture of -- with the wall, for instance, cracking there. And the pools are configured with penetrations that are all higher than the stored fuels such that if there were any damage to connecting systems outside the pool, the fuel would remain covered with water. The large cooling inventory in the pool ensures that any damage would progress very -- relatively slowly to any release of radioactive material.

In addition to that, since the 2000, one attacks the agency has furthered the defense-in-depth available to spent fuel storage. That first of all includes passive strategies to enhance the ability to air cool the fuel and slow the heat-up of any fuel. That's established by maximizing the airflow passageways available in the spent fuel pool with the existing high-density racks, and also distributing fuel to avoid any hot spots.

The staffs at the various facilities have also developed strategies to maintain or restores spent fuel pool cooling following damage to large areas of the plant. That includes the provision of high-capacity makeup systems on site, including permanently installed systems as well as temporary systems and spray capability in the event of very large leaks in the spent fuel pool.

In response to the 2001 events in Japan, the staff is taking additional measures, including validation of the spent fuel pool design for -- to verify or validate the margin to damage from seismic events.

Secondly, the staff has, as Rick discussed earlier, issued orders to enhance the mitigation capability at nuclear power plants. This includes deployment of spent fuel pool, level instrumentation, and also further enhancements to the availability of makeup and spray systems at nuclear power plants.

Finally, the staff, as part of the Lessons Learned activities, is evaluating or reassessing the safety of high-density fuel storage. This includes validating our determination that any release from a spent fuel pool would be a very low-frequency event. We're also assessing the change in various consequence measures that may result from expedited transfer of fuel to dry storage.

And finally the near-term task force, as part of the post-Fukushima review, identified potential to consider alternative regulatory frameworks that consider defense-in-depth more to a greater degree than the current regulatory framework.

I did want to point out that the events in Japan do to some extent demonstrate the robustness of the storage facility in that all the spent fuel pools maintain their integrity and there was no damage to fuel in Japan, despite both a relatively large ground motions and hydrogen explosions affecting a couple of the facilities.

That's all I had. I'll now turn it over to Mr. Gordon Thompson.

GORDON THOMPSON: I think it's probably best, Rick, if I just give my presentation.

RICK DANIEL: Okay. Let me ask Mary if she has any comments at this time.

MARY LAMPERT: I'd rather go with the agreed plan that we have our presentations first.

RICK DANIEL: Okay, all right. Go right ahead, Gordon.

GORDON THOMPSON: Good afternoon. I'd like to thank the NRC for giving me the opportunity to be here. Get this slide up. This is who I am. Some qualifying statements. This -- I represent a variety of organizations in interventions for the NRC. But in this instance, I'm expressing [unintelligible] my own opinion.

I'm focusing on reduction of density in spent fuel pools. The crucial matter is replacement of high-density racks with low-density racks. This point is not always appreciated. And I'm focusing here on a limited set of issues. I could expand to greatly given a lot more time but I'm sure we don't want to hear that.

I'm making a number of statements here that may appear controversial. I can back all of them up with documentation.

Initially, nuclear power plants were designed to use low-density racks in their spent fuel pools. The example shared is from a PWR. In this configuration, criticality is suppressed by the geometric configuration, by the distance between fuel assemblies. If order is lost from such a pool, there will be vigorous three-dimensional, natural circulation of air and steam, providing ample cooling in almost all conceivable circumstances. Thus the spent fuel is passively protected against the self-ignition of the zirconium cladding across a broad range of scenarios for water loss from the pool. And I repeat this was the configuration for which the fleet of plants was designed. It was first equipped.

With a high-density rack configuration now in use, criticality is suppressed by the presence of neutron-absorbing material in the cell walls. As a result, if water is lost, heat transfer from the exposed fuel will be comparatively feeble, especially in the presence of residual water in the base of the pool. As a result, across the broad range of water loss scenarios, the spent fuel will heat up and experience self-ignition of the zircon-like cladding with air or steam. That reaction is highly exothermic and is -- would be ample to liberate radioactive material to the atmosphere, especially seasonal.

So what's the history of understanding of this threat? In the winter of '78-'79, I was involved in a activity where we were conducting independent review of a proposed nuclear fuel center in Golabe [spelled phonetically] in Germany. This was to be a reprocessing plant, ventrification, MOX fuel fabrication and disposal, all into one place. One of the issues that was addressed was high-density storage of spent fuel. The regulator, the state government accepted our group's finding that high-density storage of spent fuel posed an unusual risk and they regard that risk as unacceptable and ruled that would not be permitted at that site. And that ruling applied elsewhere in Germany. When a later proposal was made for a process in [unintelligible] Bacasdorf [spelled phonetically] in Germany, dry storage was used instead of wet storage.

At almost exactly the same time, Sandia Labs produced a report under NRC sponsorship, which addressed the same issue. And this report stands up quite well, looked at from present vantage. Unfortunately, its introduction contained an erroneous statement, namely that instantaneous drainage of water was the worst case. This contradicted the report itself, for anyone who'd care to actually read it. But unfortunately that erroneous statement was carried through in all subsequent NRC studies until late in the year 2000, which were all predicated on the assumption that instantaneous loss of water would be the worst case. As I mentioned earlier, presence of residual water in the fuel would actually be create the worst case because it would inhibit heat transfer much more than would be the case in the event of total drainage.

Unfortunately, after 2000, the NRC ceased publishing any analysis on spent fuel pool files, has apparently done some work in this area but it's all been secret. So to this day, this erroneous assumption undermines the body of analytic work that NRC's done on this issue. There has been some recent empirical work apparently ongoing, which has not been published.

Unfortunately, over the intervening decades, in a large lost opportunity to do some thorough research on this problem, but we do know enough to act. And what we know and what NRC agrees is that loss of water from a spent fuel pool reactor high density could lead to a fire and a large atmospheric release of radioactive material.

There are special implications of having this hazard co-located with an operating reactor. This arrangement compounds the reactor risk by introducing a new risk that's highly coupled to reactor risk. The pool in that configuration or with that proximity to a reactor often contain short pooled fuel, which means that in the event of water loss, it will heat up very quickly to the ignition point. For example, fuel discharged for 100 days will heat up to self-ignition in about four hours. That's an adiabatic case for this [unintelligible] terminology.

If a reactor core melts occurs with some breach of containment or some failure or leakage in containment, the presence of radiation fields and other effects on the site could preclude personal access in order to restore cooling or water makeup to the pool. That's a powerful mechanism by which the reactor risk is coupled to the pool risk. There's a reverse arrangement and I credit my colleague David Lochbaum for this insight, but leakage or overflow of water from a spent fuel pool could disable support systems for the reactor. And that's a caution to plans to have emergency high-volume provision of water to a pool. That provision might prevent the pool from catching fire but could disable the reactor support systems. So you have a two-way coupling of risk.

Now this issue's been around a long time. But Fukushima brought it to much high levels of attention than had been the case hitherto. I imagine most of you've seen photographs like this one. The concrete pumping truck, the red boom is adding water to spent fuel pool -- that Unit Number 4.

What we all know if we recall this incident is that days were taken to establish this method of cooling of the spent fuel pool. So Fukushima illustrated for us the situation where the site was in a degraded condition where access by personnel was difficult or in many cases precluded entirely.

This is an indication of scale. I have here the Chernobyl release and estimates from Fukushima by paper by Stahl [spelled phonetically] et al. The units of petabecquerels -- that's 10 to the 15 disintegrations per second. That's about 300 grams of elemental cesium per petabecquerel. Fukushima release, estimated by these authors, about 36 units, of which 6 were deposed on Japan. The release there was a small fraction of the available inventory. More than 900 petabecquerels in the reactor cores and over 2,000 in the spent fuel pools, about half of that in the unit 4 core. And most of us have seen this picture also. This is what happened with the 6 petabecquerels of cesium on 37 on Japanese territory plus cesium 134 is also included in this chart.

During the incident, the head of the Japanese Atomic Energy Commission wrote a memo to the government of Japan indicating the possibility that there would be a fire in one or more spent fuel pools, which, in the event of adverse wind conditions, could require the evacuation of Tokyo. So that official was aware of the large radioactive inventory of the pools and the potential for release by a pool fire.

So what's the probability of this event? PRA is our main tool, or the NRC's and industry's main tool for estimating probability. The numbers coming out of PRA simply don't match observed experience. Typical values for the core damage frequency are 10 to the minus 5 or less per reactor year. But as we all know, we've had five of these in the about 15,000 reactor years in commercial experience, producing a much higher number -- probability number based on experience. If you consider accident precursors and known core melts that non-commercial reactors, such as prototype reactors, the number goes even higher.

Now why is PRA limited? That's a complicated story that I can only touch upon. One factor is that it can't account for underlying issues. And I quote here three examples based on studies performed after core damage accidents. In the case of Three Mile Island in 1979, there were two official studies, the president’s commission, the Kennedy Commission, and an NRC investigation, the Regoven [spelled phonetically] Report and they concluded that a major underlying factor was what I’ve summarized as complacency and weak regulation. And of course it was a little more complicated than that.

For Chernobyl in 1986, a study by two Harvard physicists identified the major underlying factor as secrecy. These physicists are Richard Wilson and Alexander Shyakhter. Wilson, as some might recall, is a -- was a very strong proponent of nuclear power. Just as an illustration of how secrecy played out, that reactor had the design property that it had a positive void coefficient reactivity, which meant that it in simple terms blew up when pushed beyond its operating envelope. That fact was not known to the management of the station or the operators in question. And in fact a member of the academy of sciences at the Soviet Union wrote numerous letters to officials in the Soviet Union pointing this factor out and was told to be quiet or he'd be sent to the gulag.

The third instance, Fukushima 2011. A report commissioned by the Parliament of Japan says flatly that the primary cause of the accident was government-industry collusion. I know that's an uncomfortable statement for any Japanese colleagues present, but that's the findings of the parliamentary commission. When we turn to a question of attack, malevolent events, PRA does not account for these events, although it has a limited ability to do so and was used to some extent for that purpose in establishing NRC's vehicle bomb rule of 1994.

Although PRA does not generally touch this matter, there are four things that are very important to bear in mind. Firstly, there are attackers that have means, motives, and opportunities to attack our nuclear power plants. And just as one illustration of means, an entity funded by the United States Government has published in great detail the design and construction specifications for a shaped charge that has been experimentally shown to penetrate five to six meters of rock or reinforced concrete.

Second, present defenses address only a limited range of threats. There is no air defense, either passive or active; water defense for our coastal plants is very limited. The primary defense is against vehicle bombs and a limited land attack. Thirdly, plants were not designed to resist attack and this is not accidental, this is a product of a rule passed by the Atomic Energy Commission in 1967, specifically exempting licensees from any requirement to design and operate facilities in a manner that they would defend them from attack by an enemy of the United States. So any ability the plants have to resist attack is a byproduct of design for other purposes.

And finally, by coupling the pool risk with the reactor risk, by co-locating these risk centers, the configuration creates a beacon of opportunity for attackers, learning the consequences.

The atmospheric release of Cesium 137 from a pool fire could substantially exceed 1,000 petabecquerels. And we saw a little earlier the map showing contamination of Japan with 6 petabecquerels. A little bit of imagination will show us that the effects of releasing 1,000 units would be dramatically greater. Some colleagues of mine B.A. Adel [spelled phonetically] estimated the economic impact of releasing 1,300 petabecquerels at about $400 billion just in direct economic effects alone. The indirect economic impact could be substantially larger. Indirect impacts would be those that would spill out across an entire region or across the country affecting trade, tourism, property values, economic activity in general. So those indirect impacts could be at least as large as the direct economic impacts.

The sociopolitical impact of a large release could be severe, very hard to predict. There are political scientists who believe that the Chernobyl accident was the biggest, single factor causing the collapse of the Soviet Union as a political entity. And a release of this magnitude in the United States could and probably almost certainly would lead to a phase out of the nuclear power industry. So it’s a threat to that industry as well as everybody else.

So conclusions: there are three grounds for thinning out the pools and reverting to the low-density configuration that was originally used and for which the pools were designed. First set grounds are based on NRC’s traditional cost-benefit analysis provided that realistic numbers are used for probability and consequence. And by realistic I mean not PRA numbers, but numbers closer to actual experience and that take into account the possibility of attack. And on the consequence side, they're considered direct and indirect economic impacts as well as sociopolitical impacts. Second, the defense-in-depth philosophy also calls for expedited reduction of the density of spent fuel pools. The arguments here are analogous to those that the NRC staff has made in proposing filtered venting for BWR Mark I and II plants.

And thirdly, our high-density pool storage is simply bad engineering practice. There's a movement towards passively safer technology and this is growing in the chemical industry. And high-density pool storage is just completely contradictory to any principles of passively safer technologies. So, I submit that there are three grounds for the expedited reduction of density in spent fuel pools, reverting to low-density open frame racks, thank you.

RICHARD DANIEL: Thank you, Gordon. There, third time's a charm. Thank you for that very informative presentation. NRC folks, analysts, do you have any immediate thoughts, comments?

MARY LAMPERT: The understanding was we'd have the presentations first. So, can I go and then we can move forward to the questions and answers?

RICHARD DANIEL: Sure.

MARY LAMPERT: I think that will work better.

RICHARD DANIEL: Okay, sure.

MARY LAMPERT: A little more logical, I think.

RICHARD DANIEL: Okay, you're going to talk to --

MARY LAMPERT: Thank you.

RICHARD DANIEL: -- us about costs; right, Mary?

MARY LAMPERT: Ah, yes.

RICHARD DANIEL: Okay.

MARY LAMPERT: Good afternoon. Dr. Thompson, I think, clearly has made the case for the vulnerability of spent fuel pools and the consequences of densely packed pools; the necessity to go to low-density, open-frame storage. The question is this has been known for a very long time, over three decades, why hasn't expedited storage been required? And I think there's a very simple answer and that simple answer is money. The reason being that the industries do not wish to pay to thin out the pools out of their operating budget, we'd rather simply go along, when the pools become full to capacity, to take out the requisite number to fit in the next required batch, and save the majority to the time when operations cease and they can dip into the other bucket of money, the decommissioning trust fund and monies that are set aside. So, the question -- can you get it back?

So the question then becomes is expedited transfer really that more expensive? And I'd suggest that it not necessarily has to be. When you consider that all spent fuel generated in the past and the foreseeable future, will be eventually transferred to dry casks located either at the reactor sites or a centralized facility. And the only real question is when this will happen. The cost of transfer to dry casks will be paid sometime, the question again is when. The total number of casks and the size of the related facilities will be the same. And there is no reason to think that the cost of the casks and the associated costs are not going to increase 10 to 30 years from now. And so I would suggest some potential sources of funding and discuss what the probability of those options are and what their strengths and weaknesses are.

Option one is that the licensees would voluntarily pay for expedited transfer to thin out the pools. Probability of that happening is zero. The reason for that is, again, that they do not want to take that cost out of the operating budget, particularly, at this point in history, when there are cheaper sources of energy, gas. And there is no assurance that things are going to turn around. Budgets are tight.

Option two is Congress. That congress would choose and vote, actually vote to amend the Nuclear Waste Policy Act that is now restricted to use those funds for offsite solutions. Or, alternatively, they could decide to amend the Nuclear Waste Policy Act and increase the fee to maybe a tenth of a cent per kilowatt hour, which in a period of five to 10 years would cover the cost. What is the probability of that vote happening? I would give that a zero or maybe a zero point one.

The third option, and the one that I feel has the greatest success of happening, actually getting us moving down the road we should be on, is the NRC would order the licensees to expedite the transfer and allow them to use the decommissioning trust fund monies during operations that is actually permitted on to regulation that is on this slide. I feel this is a greater probability. And the NRC, not only has the authority to do this, but has been doing this. I know that Pilgrim, Vermont Yankee have requested use of the decommissioning trust funds and they have been permitted to do so. How large a practice this is? I don’t know; and have submitted a FOIA as of February to the NRC to get the record across the industry.

The beauty of this option is that there's something in it for everybody. And if we're going to move forward, everybody has to gain something. NRC gains because they're actually fulfilling their AEC requirements to protect public health, safety, and national security. Also, they gain by gaining -- regaining some confidence in their operation by the public.

The problem with spent fuel storage is a big issue in the public surrounding nuclear reactors. Industry also gains economically because now as their pools are filling; they have to put some in dry casks, that's costing money. They have to build a pad. And this would then come out, not of the operating budget, but other budget -- not the other budget out of the decommissioning trust fund. They would have other gains also because the NRC is making some regulations here and there. It's costing money; for example, the issue on Boraflex in some reactors to put in criticality alarms. I think Oyster Creek just spent $65,000 and more frequent testing of the water and so on. And a huge amount of money with lobbyists and lawyers fighting against more regulations, so that'll be saved.

And also saved would be money now spent in lawsuits in court, DOE, trying to get money back. That in turn has cost a lot of money and would be moot? Not necessary if the pools were thinned. The public gets a huge benefit, a huge reduction in risk. The nation gets a benefit too because there has been a huge, a huge amount of tax-payer money that has gone into defending suits against DOE and the payouts. The industry so far has filed lawsuits, I understand $6.4 billion in total claims and the government spent -- paid out $956 million and it's going to go on and on.

So, as far as I can see, everybody's getting something out of it and that makes it a no brainer to go forward. And once again, the real issue is the cost of transferring to dry casks is going to be paid sometime. The only question is when. Here's a path of least pain that can occur to do what should be done.

What will be the blow back? The blow back from the public will be, "Look, the decommissioning trust fund is already inadequate," they say, "and they'll be nothing for cleanup. We're going to be stuck holding the bag." My response to that is, "Look, you have a clear and present danger, risk today. So don't stop dealing with that, providing an opportunity to reduce that risk today with a hypothetical issue that there might be a problem 10 to 30 years from now." In other words don't ask me, who lives six miles from a reactor, to risk losing my home, my property, my family, my friends, my community because there might not be enough money 30 years from now. And if that's your problem, you have an opportunity every two years when the licensees give their reports on the status of the decommissioning trust fund to go to the NRC, go to your state, and see whether it's inadequate or not to make your case then, but don't throw up a ridiculous roadblock.

And industry might complain, "Oh, wait a minute. If that decommissioning trust fund comes down, then there won't be as much money in it, then it might not grow so much, and then NRC might make us add more." Well, think about it. Number one, the costs of casks, the cost of spent fuel management is going to go up over the next 10 to 30 years. I think that's a given. However, how much the investments are going to grow is a real good question. I would say it would be reasonable to hypothesize, it'll be a wash.

Number two, and as important, if the industries have been correct in their reports to NRC every two years where it's been looking like everything's okay with often a surplus based on a 2 percent or 1.34 percent increase in investments, then what are you complaining about? NRC, as far as I know, has been approving these. And so, I believe what I read.

So, therefore, I will leave you with this to think about. The last slide talks about the timing of expedited transfer. EPRI technical report of 2010 said we take -- in five years they could go to low-density, open-frame design, thin out those pools; however, in EPRI's technical 2012 report, they say after listening to industries, they decided, "Don't think so. It would take 10 to 15 years." Read the two reports; compare them and I don't think you'll be very convinced of the reasoning. There are actually no hard facts of why it's supposed to take so long.

Let's take a simplistic view. We fought World War II in under four years. So you mean to tell me they can't unload and thin out those pools in five years? That's ridiculous. We hear that the industry can build these super, wonderful new reactors [snaps fingers] like that, but they can't do something like this? No. Clearly, it can be done. Clearly, it should be done. Fukushima showed that the dry casks withstood the earthquake, the tsunami, et cetera fine. And we saw the picture of Unit four. There's no point to discuss this any further. I hope I've shown a way where everybody could come to the table and we can get it done. Thank you.

RICHARD DANIEL: Thank you very much, Mary. Immediate questions, comments from Steve? Anything just now or you want to wait? Okay, good. Thank you very much, Mary, you're very passionate. Thank you, I like that. Earl? Your husband says that too. Okay, that's good. Is he here?

[laughter]

MARY LAMPERT: He's waiting for me to come home tonight.

RICHARD DANIEL: He's waiting for you to come home tonight. We'll see that you get home tonight. We won't go past five. Earl, why don't you go ahead and then we're going to start in with questions.

EARL EASTON: Okay, thank you. My name is Earl and I'm here to talk a little bit about potential impacts on the back end of the fuel cycle if we expedite the movement from wet to dry in the near term. I wanted to start by just saying that, you know, I've been here a number of years at the Commission. And to put it in perspective, the NRC has often made the case, the determination that both storage in wet and dry is safe that is both are low risk. However, in light of Fukushima, I think it's always prudent to step back and look and does that remain the same? I, being in the back end of the fuel cycle, am concerned that in the debate on whether to move from wet to dry, that people actually pay attention to what the impacts could be on the back end of the fuel cycle. So I'm just going to focus on the back end of the fuel cycle and point out some of the areas that I think may be impacted. And I generally speak to much smaller audiences; I tend to be more visual, you use viewgraphs. So I have a designated laser man, okay? Okay. [laughs] We'll see if this works.

Okay. Hopefully, you can see the chart on this, but this slide is intended to show where the movement from wet to dry storage generally occurs. This is a heat curve, a cooling time curve for a BWR fuel element, although it's very similar to PWR. And you see there's the knee of the curve. The assemblies drop very rapidly in the heat and then sort of level out. But that is not an L shape, that's a curve. So, as you go out more and more years, you can put more and more fuel in a cask because casks are limited by heat low. So keep that in mind as we go through the rest of this presentation. What does spent expedited fuel look like? If you move the fuel after five years, it's been estimated that the pool inventory really is only reduced by 30 percent -- reduced to 30 percent. 70 percent of the assemblies are moved. The decay heat is reduced by 30 percent. You still have most of the decay heat in the pool and the radioactivity is reduced by 45 percent. So it's not totally removing the risk, moving from wet to dry, okay? And this is, if you just arbitrarily say five years is the point at which you want to move it.

Okay, potentially a whole range of stakeholders could be impacted. Nuclear power plants, they could be impacted through schedules and competing demand on equipment such as cranes. Generally, these loadings are done during -- spent fuel movements are done during outages. Power plant workers, well, there will be increased dose and there may be the need to load more casks because the casks will not hold as much of hotter fuel than they will of cold fuel. And, of course, you increase the risk of cask handling, if you try to do a lot of handling in a short period of time.

The impact on the NRC may include the need to do license amendment for a certification of storage casks, oversight. We do have some issues that we're looking at for long-term storage, which is high burn up fuel and stress-corrosion cracking of casks canisters in marine environments and we're in the process of solving some of those issues. So, if you move things into the casks that are designed now, will we lose the advantage in making improvements in either one of those areas?

Also, you know, there is a question whether transportation package vendors can make the number of casks in the short period of time that you might want to actually move this. Also, DOE, Fed Corp, as you know there was a blue-ribbon commission that made recommendations on how to handle the back end of the fuel cycle and it may very well impact the schedule, cost, design of the back end of the fuel cycle facilities that they're now looking at. And I'm going to go over some of these in more detail, but I just -- this is my summary upfront. And the public, you know a lot of times the type of casks you use in the end determines the number of shipments and the length of time that fuel may have to reside at a particular site. So, you're dealing with a lot of different stakeholders on a lot of different issues. Okay, you ready designated -- okay. [laughs]

This, again, is stuff I stole from an EPRI report. It's not an NRC report. It's not been audited by the NRC, but it's an illustrative of the type of things I think we need to look at. What it shows is an expedited loading campaign. The bars in blue would be the normal loading campaign and that is the normal industry practice. As your pool fills up, you move into dry storage, okay? And the higher blue bars at the, let's see, right-hand side indicate that some of these reactors are coming offline and the fuel is moving out.

Okay, the expedited fuel movement is depicted here by five, large, red bars. That's if you define expedited movement, I'm going to move everything that five years older out of the pool in a five-year time period, for example. This is what this illustrates. What it shows is that that during that time period, utilities have to load four or five times the number of casks they typically load, okay? And the real question is, you know, is the industry prepared to build those? Is the NRC prepared to inspect those? How do you do this without impacting operations schedules, and do you increase the risk by compacting all that loading into a very short period of time?

Another way of looking at this is over the lifetime -- EPRI again --

this is EPRI projection. They predicted that the number of total casks that you'd really have to load would probably increase by about 700. That's on a base of about 10,000. So maybe a 7 percent greater number of casks have to be loaded. And all these, you know, you have to figure out what you're going to do at the tail end of the fuel cycle. And, again, this is based on five-year cooling time. Many casks now are certified that you can't actually put fuel in them until they've cooled seven or 10 years, so it may be de-rated even more. You may need -- you may even need more casts. Okay. And I'm trying to talk fast to keep on schedule. Okay.

Nuclear -- okay -- nuclear power plants, what's the impact again? They may need a larger number of casks because they have to be de-rated for heat, okay. However, if DOE chooses to go to standardized casks as part of their disposal process, you may need a larger number of casks anyhow. There's going to be increased dose for loading operations if you do have a larger number of casks, and industry has presented the estimates of the increases in doses for various loading scenarios. And also there's going to be a greater cost, and that cost is estimated around $3- to $4 billion depending on the length of the campaign and how quickly you're trying to do it. Also there's going to be impact on schedules. Typically, the movement from wet to dry occurs during outages and usually takes about a week. So there's a limited window to actually move spent fuel without impacting a reactor operating schedule.

Again, the NRC and industry, we may need to certify a large number of casks or cask amendments to deal with all the different types of fuel. We're dealing with stress grows [spelled phonetically] and cracking and high burn-up issues now and it's not sure if you can take full advantage of all that work if you move out in a shorter timeframe. We may not have the ability and manpower to do all the cask inspection we would want to do or observe cask loadings. And, you know, if industry has to be build four times or five times as many casks in the timeframe, do they really have the capacity to build high-quality products in that time? And I'm not trying to guess what the answers are. These are just the impacts we think need to be looked at.

Okay, and now one that's near and dear to all of our hearts. How is the back end of the fuel cycle going to look like considering that we had a Blue Ribbon Commission and DOE is now trying to respond to the Blue Ribbon Commission, right? We know that DOE Fed Corp. will be the major player in actually storing and disposing of spent fuel, and we believe that they have put out a very ambitious schedule. They are projecting that they will have a pilot storage facility perhaps by 2021. They may have interim storage in place by 2025, and they may cite a repository by 2042 now. We don't know if these are hard and fast dates, but it only gives us a window of about 12 years before the DOE is planning to open their interim storage facility, right?

So how does this all play out? This is just a picture of a storage canister. When I say canister I'm talking about the blue container in the middle. It's a steel canister with spent fuel. Generally, the canister size is determined by the burn-up and age of the fuel because that's related to the heat load. So I just wanted to, when I say canister, give a sense of what I'm talking about.

Okay, I put this one up so that really couldn't, you couldn't really read it. But DOE is now part of response to the Blue Ribbon Commission. Is it designing, redesigning the backend of the fuel cell? This is how complicated it's getting, okay? There's many, many paths from the fuel cycle and they all have different casks and different loadings and different [inaudible].

So, I took the liberty -- and I put this here because it has a source. It actually is the presentation given by DOE, so I took the liberty of simplifying it. Okay, generally, three big fat paths through -- the way I read it -- three big paths through the backend of the fuel cycle. The first path, the top one, using NRC-certified storage casks. That's the one we approve now. They're in dry storage at reactors. DOE intends to ship those to interim storage and open every one of them and repackage them into a disposal canister suited for a repository, so there's a potential of opening every cask. Now, we already have 1,700 of these loaded, so 1,700 are going down that path anyhow, okay, but if we expedite the movement, does that mean they all go down that path? Does that mean that 11,000 casks have to be repackaged? I don't know the answer.

Okay, the second line, DOE—and I think this is in the Blue Ribbon Commission Report—recommended that we consider standardized casts. Right? DOE is doing that. That is, you load it in a cask that will fit into the repository, so you don't have to unpackage it. Right? So there's none of that unpackaging, and it eliminates the risk of dealing with that, but DOE doesn't have a design out there for standardized casks, right? And so, we don't know what to tell licensees and it's really not our role. We don't know what to tell licensees to store it to meet the standardized whatever, but we're waiting to hear from DOE.

Okay, the last option I've found particularly interesting. DOE has said, "ah-ha," once we get ahead of this curve, we want to ship uncanistered, directly out of a pool. We want to put it in reusable transportation casks, and ship to maybe a pool at interim storage where we can pack different spent fuels and optimize the number of casks that we have to use. Maybe reduce that.

So that's what that whole DOE chart was for, and they ran nine different scenarios and you know how this all plays out. And, when I saw this presented at the Nuclear Waste Technical Review Board, I asked them a question. I raised my hand and you know I know all those guys, and I said, "Did you run the case where the NRC would require the expedited movement in five years all into current NRC casts?" And they say well why would we do that? But I said, "Well, because it may happen." And they had not run that, and we do have a request in for them to run that scenario to see how it affects the size of the repackaging facility; the throughput to the repackaging facility. Because, if you have to reopen all the canisters, the throughput may be very low, and that means they have to stay at the originating site for a longer period of time. That makes some people unhappy because they get storage longer at their site. So I think these are all things we sort of need to deal with. Sort of need, right? Okay.

This is really just a written form of what I just went through. Let me just say where we think that the impact may be on the public. We think storage options may actually effect length of time that spent fuel remains stored on sites, because that may be related to the throughput through DOE facilities. And, we also think that the numbers and types of casks that have to be transported through the public may be affected by these options that we choose, and that affects the risk of transportation, and for many folks, that's the only risk they see. So, I mean, there's a lot of outreach and, you know, work that has to be done. Okay, I'll windup here.

I've worked at the NRC a long time. Many of the NRC folks know me and I think that's probably coming to near an end sometime soon -- I was going to retire -- but I've worked for a long time, and I have no doubt that this agency will put safety first. I have no doubt in my mind that this decision will be based on safety, okay? I have no doubt. But, I do believe that when we consider the relative merits of what's safe that we have to consider the impacts -- either intended and unintended -- on the backend of the fuel cycle. Okay? And I would just -- my last word is I've enjoyed being on the panel with these three. They're focused mostly on wet storage. My world has revolved around dry storage and that sort of connection so and that's why I'm making the plea that we really need to consider these things before we take action.

RICHARD DANIEL: Thank you very much Earl. Mary? Comments?

MARY LAMPERT: Ah, yeah. I have quite a few comments because I also did read --

RICHARD DANIEL: Well I have a question before we—

MARY LAMPERT: —EPRI 2012—

RICHARD DANIEL: Okay, I have a question for—

MARY LAMPERT: -- let me just say this one before you. It did say that NRC has already approved higher-capacity storage systems, so that problem, we can put aside. Looking at the DOE hodge-podge of creative thinking, we could certainly see that the optimistic timeframe that interim storage facility is going to be available, et cetera, et cetera, is a pipedream. That they, at this point, don't know what they're doing; they're coming up with ideas. I'm not going to monopolize this. I'll ask Gordon and others if they have something to say about it. I have a lot more to say later.

RICHARD DANIEL: Thank you. Let me ask you one question of all the panels. Can you folks stay until 5:15 p.m.?

MARY LAMPERT: Oh, I could stay with you for a long time.

[laughter]

RICHARD DANIEL: Hey. You know, I'm married too, Mary. I don't know that my wife now -- we can talk later, but --

MARY LAMPERT: We're becoming friends.

RICHARD DANIEL: Thank you. Gordon?

GORDON THOMPSON: I have two predominant comments about Earl's presentation. Firstly, he talked about the reduction in inventory, decay heat and so forth would occur with expedited removal of spent fuel from the pool. He didn't address at all my primary point, which is to revert to the low-density open-frame racks that were originally used. That was the point. That creates a quantum change in risk, a dramatic change in risk, and that's far more important than inventory or the decay heat. So we're talking past each other; talking about completely different issues.

As to this business to the backend of the fuel cycle, we have a present reality which is that these pools are almost full across the country and fuel is going to dry storage onsite. And then we have some kind of hypothetical future that DOE is speculating about that might involve some centralized wet pool. Now given the history of DOE's program to dispose of highly radioactive waste which has now gone for about 55 years with no accomplishment, the idea that we should defer our present action so that it will fit with some hypothetical future DOE policy, I think, verges on irresponsible.

RICHARD DANIEL: Thank you, Gordon. Let's not lose track of the DOE issues, the speculation there. Is there an NRC person here that can talk a little bit to Dr. Thompson's low-density rack suggestion? Either you folks at the table or here in the audience? Anybody who'd like to talk about that? Steve? Go ahead.

STEVEN JONES: I can address some of that. I guess from the NRC's perspective, we look at risk as a combination of frequency of an event times its consequences. In general, we believe our previous assessments have shown there's a very low frequency of anything happening to a spent fuel pool, and we have developed mitigating measures if something very unlikely but possible should occur, we have some means of mitigating that. In addition, there's passive features we've introduced to the plants to enhance the cooling capability. Open-frame racks, you know, do provide some added heat transfer capability, but it's a very complicated scenario going through the progression from draining a pool or even partially draining a pool, heating up the assemblies, reaching a critical temperature where there -- an initiation of a runaway reaction with either, well, with oxygen occurs -- and then actually having a release and the release is dependent on both how long the fuel assembly stays hot; what temperature it ultimately reaches. So I think there's all those factors need to be considered at one time. We have a lot of worst case examples raised here with regard to heat up times. I think what we've done is dramatically increase the time it takes for an exposed fuel assembly to heat up. If there is reduced cooling for whatever reason, then there's also, I think, reduced availability of oxygen to produce damage to the fuel assemblies and heat them up. So there's some off-setting things going on there that you tend to not have a worst case scenario in any of these events. It's -- there are various mitigating factors that are present in just about any scenario we've looked at.

RICHARD DANIEL: Dr. Thompson.

GORDON THOMPSON: Let's take the question of heat up to the ignition point. It's not worst case, it's just simple physics. If you have 100-day cooled fuel in an adiabatic situation, it'll heat up to ignition point in about four hours. It's a very simple calculation, anybody can do it; nothing worst case about it. Then with partial drainage where the residual water is present in the base of the pool, the upper half or so of the fuel assembly is in approximately adiabatic situation. The fact that it's approximate might extend that period from four hours to maybe five, maybe six, which is irrelevant if there is a coexisting or preexisting reactor accident. This business about introducing passive measures of cooling. There's a practice called checkerboarding where you place hot fuel in some cells and colder fuel in surrounding cells. This practice will give you some benefit in the event of total and instantaneous complete drainage, which Earl said earlier was the erroneous assumption that guided NRC analysis on this subject from between 1979 and the year 2004 when all their studies were dark and secret. So I'm not talking worst case at all. The -- you have to ask what's the probability of a drainage event. That's not an everyday matter. Fortunately, the world has not experienced such an event but, particularly in view of the attractiveness of this target for potential attackers, I think that's it's a probability that we should not allow to exist and we do not have to have it exist. This is an easily solvable problem. This risk can essentially disappear. Thank you.

MARY LAMPERT: Gordon could you also mention adding water and the exothermic reaction that you can be bringing about?

GORDON THOMPSON: The zirconium cladding will experience an exothermic reaction with either air or with steam. And the hydrogen explosions at Fukushima are evidence of the exothermic reaction with steam, which produces hydrogen, which is what exploded and produced the results we all saw. A concern raised by spraying water onto a spent fuel pool is that if the fuel dries out and reaches its ignition temperature prior to the introduction of spray water, you could wind up feeding the fire and making it much worse. Presumably the operators would be aware of this, but they're in a very difficult situation; could still fall into this trap. And I repeat, this problem can, in simple terms, just be made to go away by a very simple step of reverting to the design that was in use when these reactors were first designed.

RICHARD DANIEL: Thank you, Gordon. So clearly there's a basis for you folks to be talking about some of this in the future. So, why don't we move on? We're going to take some questions. I would expect Steve and company, the NRC, will be talking with Dr. Thompson with some of these things in the future. We're going to take some questions. Are there any questions in the -- Dale?

MALE SPEAKER: I want to point out that currently spent fuel pools have multiple rack modules so it would seem logical that if you -- I'm not on top of the thermal characteristics, but if you actually believe you need open racks, you could have a module of open racks which I guess would be half as -- take twice the volume per that we currently have, but that does not mean that you then have to remove all the fuel, and so Earl's large number of fuel movements would not be necessary if all you need is a open rack for the recently discharged fuel. So, I'm afraid the industry arguments against what's been proposed are a little weak from my point of view.

RICHARD DANIEL: Thank you, and you're from the NRC, right Dale?

MALE SPEAKER: No.

RICHARD DANIEL: Where are you from? Why don't you tell us?

MALE SPEAKER: I'm a consultant with the nuclear industry in criticality analysis.

RICHARD DANIEL: Thank you. Thank you very much. Stand up, introduce yourself, and tell us where you're from.

KEITH WALDROP: Keith Waldrop from EPRI. I just want to provide some clarifying comments on some of the points that you were making, Mary. In looking at -- first, looking at the costs. You're right, if it's the same number of casks that we're loading and you're having to spend the money anyway, you saw the slide that Earl put up showing that it's really that you're accelerating loading, loading earlier, the cost really does come down just the time value of money of the order of close to four billion for the industry just in primarily the time value of money. There are additional costs added. You are having to load actually more casks, at least that was the assumption in the report because you're having to load hotter fuel which is likely to require smaller-capacity casks, so that adds to the costs as well.

And then also, the fact of what the 2010 report looked at doing this transfer over the course of five years. That was an initial assumption that then went back to industry to gain some additional knowledge to find out you know that it's really going to take longer to do that in a normal operating condition, given everything else that's going on in the spent fuel pools in the fuel buildings. The 2012 report also includes a graph in there looking at a typical PWR that shows that there's with loading casks just to maintain full core reserve, you only have about nine weeks additional to load in any extra casks during a normal operating period, so I just wanted to provide those clarifying comments.

MARY LAMPERT: Yes, I did say that the -- for the 2012 report, it says right in the introduction I think at V, or five, that you talked with industry and they came up with a lot of reasons why it was going to take a lot longer and cost a lot more. They were assumptions that are debatable. For example, having to load many more casks. Your own report says that NRC has approved casks that can hold hotter fuel then hold more assemblies, number one.

Number two, the assumption of workers, worker exposure. Granted that that can be a problem, it can be dealt with by bringing in another team. Granted you would be paying for another team but there are ways -- these are not roadblocks. So each of the assumptions that were in the 2012 can be analyzed and looked at and argued on both sides. That's all I'm saying. Again, let's go back. If these guys are running nuclear reactors and they can't figure this out, we're all in trouble.

RICHARD DANIEL: Thank you, Mary.

EILEEN SUPKO: Eileen Supko, Energy Resources International. I'm the principal investigator of the 2010 and 2012 reports that were published by EPRI on the accelerated transfer of spent fuel. I actually have a question though. I'm not going to make comments. I don't think this is the appropriate forum for a back-and-forth. I do disagree with some of the comments that were made by the panel, but I have a question.

My question, and this is either for Earl or for Steve. How does the NRC's analysis of spent fuel pool risk balance, one, very low-frequency events that would cause the loss of spent fuel pool cooling which do potentially have high consequence versus two, the very real consequences associated with accelerated transfer of spent fuel to dry storage. And those are increased worker dose, and it’s the increased worker dose comes from loading somewhat more casks. In the 2012 report, it wasn’t a large increase of casks, but its loading hotter fuel into casks. The hotter the fuel, the higher the dose rate, the more worker dose you get. There’s also increased worker dose associated with surveillance and maintenance of the packages while they’re sitting in dry storage. There’s increased worker dose associated with construction at a facility that already has fuel in storage. And, it is significant cost, and billions of that we could potentially spend on real safety improvements and things that have real risk. How does NRC balance this potential risk versus something that has a 100 percent probability, if in fact this accelerated transfer occurs?

RICHARD DANIEL: Thank you.

STEVEN JONES: I guess I can handle that. Again, we’re really dealing with risk as being a product of frequency times consequences. You have -- you’re talking about expedited transfer resulting in occupational dose to the workers involved with repackaging or packaging the fuel in the storage casks and preparing them for storage on the site, and that’s almost a given frequency of one if you’re actually going ahead with expedited transfer. And there’s other risks that might come about due to that expedited transfer like just in the increased frequency of lifts while there is hotter fuel present in the spent fuel pool might be another issue. And we’re looking at ways of balancing that against risk decreases that might result from having less fuel in the pool. There’s less heat available overall, but still the hottest assemblies are going to be in the pool. However, you can produce a total inventory of -- excuse me -- cesium, principally, is the constituent we’re concerned about, but I think stepping back and addressing the other gentleman's question about there's other ways of mitigating that, and we're trying to explore all those ways. We could segregate the hottest fuel to a location where it can have enhanced cooling. It may not require fully a low-density open frame rack. It may be just by checkerboarding it within an otherwise empty high-density rack, the fins, you know the storage cell walls can act as cooling fins, and to some extent, delay the heat up of the fuel.

RICHARD DANIEL: All right.

GORDON THOMPSON: I'll have to comment on that.

RICHARD DANIEL: Go ahead, Gordon.

STEVEN JONES: Yeah, I understand it's better if we can get full flow up through the bottom, but—

RICHARD DANIEL: Go ahead, Gordon.

GORDON THOMPSON: That's just impossible. You, if you have a pool rack wall-to-wall, there's no way you can improve the heat transfer. You have to empty out a substantial amount of the fuel before you can do anything constructive to improve heat transfer. The checkerboarding issue, I've dealt with previously. That's a carryover from this two-decade misconception by NRC of what the worst case is, and in order to put the hottest fuel in an open frame rack, you'd have to clear out space all around it in order for the convective cooling to operate in three dimensions and so you're really much better to just bite the bullet and do it properly. Much lower risk in the end, much simpler from a management point of view. This is issue has had decades of obfuscation and bad analysis and misconception and misunderstanding; lack of appreciation of what would happen to a society if a thousand petabecquerels or more of cesium were to descend upon it. This would be a national catastrophe, an unimaginable catastrophe if this quantity of radioactivity were to descend upon a modern society. Let's just fix that problem and most of the stuff about worker dose and so forth, it's real but it's a second or third order issue.

RICK DANIEL: All right. Thank you, Gordon --

MARY LAMPERT: -- and if there's an accident, the workers aren't' going to do well either.

RICK DANIEL: All right. Thank you. Earl, quickly?

EARL EASTON: Real quick. I think this is one of the real hard things that regulators have to do often. You got to weigh -- event that has very, very bad consequences, but you don't ever think is going to happen because it has a very low probability, against events that you know may happen, or are more frequent, and they have consequences. And you if you just used straight risk analysis, risk probability times consequence, you actually have a higher risk going with the, you know, smaller consequences more frequently. So, you get down to you have to make a policy decision. Are there some events that have catastrophic consequences that are so dire that you just throw away the risk informing tool and just say, "We're going to do everything we can to avoid a consequence." And I think really, that's going to come down to a policy decision. Okay --

RICK DANIEL: Okay.

EARL EASTON: -- which way you go.

RICK DANIEL: All right. Thanks, Earl. Dave?

DAVE LOCHBAUM: Dave Lochbaum with Union of Concerned Scientists. I'd be more impressed on the worker radiation dose thing -- I'd be more impressed if the industry and the NRC treated that issue consistently instead of cherry picking it, to stop protection of the American public and allow financial safety things to do forward. That worker dose issue is much highest when the fuel first comes out of the reactor core. We went from reducing refueling outages from 75 days down to less than 20 days. We're moving that fuel much higher. And neither NRC nor the industry gave a fig about that, when that policy went forward.

Last year the NRC approved a scheme up at Indian Point, where you transfer fuel from one of the units to another unit, because you don't want to update to cranes. Involves higher work dose, the way that's planned, neither the industry nor the NRC gave a fig about how that was done. Now what's being done is when it's step and inspecting 50 million American lives and cost a few extra bucks. If you treat it consistently, I'll buy into the program. When you cherry pick it and only use it to step safety advances, I ain't impressed.

RICK DANIEL: Thanks, Dave.

EDWIN LYMAN: Hi, Ed Lyman, also from the Union of Concerned Scientists. So I just want to nail this down because we had a dialogue going and I didn't hear a clear answer from the NRC. So one issue is, have the compensatory measure the NRC has imposed including -- and everything I'm going to say is unclassified -- going to a one by four configuration where feasible. Now the analysis that the NRC did supported the idea that if you go to that kind of configuration, you extend the time when ignition can occur so that, by going that configuration, the potential for an ignition of zirconium fire is considerably decreased. Now that analysis was based on a complete pool drain down or partial drain down also. And also, if it was only based on the complete drain down, would the scenario of a partial drain down, call into question the efficacy of going to a one by four configuration.

RICK DANIEL: Thanks, Ed. Steve?

STEVEN JONES: I guess I'm not the best person to speak to this, but I'll attempt to address your question. As far as the enhanced cooling, is really in effect regardless of whether there's a full or partial drain down because there is radiational cooling going on. And there more mass that surround the fuel, the slower the heat-up is. As Dr. Thompson has mentioned, you know, if there's full air flow through the racks, it's much, much more effective heat transfer. Nevertheless, there is some delay and there's more time to implement mitigative strategies, such as possibly reflooding the pool or applying spray.

There is some doubt, though, between the time you have to worry about air oxidation and water oxidation -- or steam-zirconium interaction of the fuel. There's a much higher initiation temperature for the steam-zirconium interaction. So, if you are applying the water in a spray form, early enough, you can effectively mitigate that situation.

RICK DANIEL: All right. Steve, thank you. I'd like to just -- quickly here.

HUSSAIN SMILEY [spelled PHONETICALLY]: Hussain Smiley, I work for the Office of Research. In the previous session, Dr. Brian Sheron was discussing the spent fuel pool scoping study. We are currently doing the study. We are doing our best tools available. These are supported by the experiments. If you go outside, you can see the type of experiments that we have been doing. So hopefully when the study becomes available later this year, I think, some of the questions that you're asking will be answered be we look at the entire spectrum of accidents and a detailed accident progression. We are looking at steam oxidation, we are looking at air oxidation, and we are looking at low-density. You know, if -- some of things that we can never think about is that, you know, you are removing assemblies. So you have more water, so it's going to take longer. So probably the fuel is going to heat up faster. So, you know, some of the things that I think Steve said or Earl said that, you know, when you remove the fuel, you still have about 80 percent or 85 percent of the decay in the pool.

So the low density still has a lot of energy and it requires a lot of large-scale circulation. So, we really need to look at this with our best available tools. We are doing the study and once that study becomes available, we can share that information.

GORDON THOMPSON: I have a question. For the last 12 or 13 years, we've been told repeatedly that work of the kind you described has been done. Not a single piece of it has been published. Is that going to change?

HUSSAIN SMILEY: Yes. The study is going to be public by the end of this year. We will provide the report to NRR, sometime, I think in October, right? In this year and then it will be published.

RICK DANIEL: Thank you. That was fine. Okay, we're going to take a couple of questions on these cards. Folks, I just want to point something out. We're going to go another 10 minutes. Hopefully I won't lose my job for doing this. But we're going to go another 10 minutes. And I want to give you an email address and I want to give you folks on phone an email address to send questions to, should we not get to all of them.

And the email address is this, it's Greg, G-R-E-G dot Casto, C-A-S-T-O. He's sitting right here next to me. Greg Casto. Greg.Casto@NRC.gov. G-O-V. But Greg is going to read us one of these questions right now.

GREG CASTO: Okay. I'm going to address a couple really quickly. There was question about installing spent fuel pool instrumentation into spent fuel pools, and concern about the contaminated water in the spent fuel pool. That's not really an issue as far installation. Water in a spent fuel, although it is contaminated, it's very lightly contaminated. The spent fuel pool cooling systems are also filtering systems. And so they keep the contamination down in spent fuel pool. Typically things are removed from the spent fuel pool; contaminations contained or managed, and it's a pretty normal or routine process. So those instruments can easily be installed, particularly the type that are being designed for installation in all spent fuel pools.

Also, there was a question about the timing of when to move fuel from spent fuel pools to dry storage, with what appears to be the understanding that that only occurs during outages, and that's not the case. Spent fuel is routinely moved to dry storage during operating cycles and not during outages because spent fuel is being moved from the reactor to and from the spent fuel pool during these outage times.

Okay, a question for the NRC speakers. What can you tell us about the analytical and experimental results? And some of this has been discussed already. But some of the results regarding spent fuel pool transfer and the potential for an ignition from new offloaded fuel versus old fuel that's predominately in the spent fuel pool, as far as the differences between the two.

Steven Jones: Earl, early in his brief, showed a decay heat curve. From that you can really see how dramatically the decay heat from an individual assembly decreases with time. It's really extremely fast during the first several days after an outage, after the reactors become sub-critical and the fuel's beginning to move. And I think that the fuel during those first many days can reach a temperature that would support runaway oxidation of the zirc alloy in an air environment, like we've talked about. But after a year or more, the fuel generally could not reach that temperature, unless -- under any normal storage configuration, because there are enough cooling mechanisms to prevent the temperature from reach that critical initiation temperature.

GORDON THOMPSON: I have to object to that --

RICK DANIEL: Gordon?

GORDON THOMPSON: As I've said repeatedly, with residual water present in the base of a fuel, the exposed portion of the fuel is in a situation that is approximately adiabatic, meaning it's in effect an insulating blanket. In that situation, fuel of quite advanced age can reach the ignition point. The age of the fuel determines the time it will take for the fuel to heat up. And, I mentioned an example, 100-day fuel will heat up in about four hours. All it takes is for the shortest cooled fuel in the exposed portion of the fuel to ignite. Once ignition occurs anywhere, then with a pool packed wall to wall, the fire will propagate to all the other assemblies in the pool.

HUSSAIN SMILEY: Okay, this Hussain Smiley again. I'm again referring to the same report that we are working on. Adiabatic heating up of the pool, I think it's a very, very conservative assumption because you still have some of the cooler assemblies around. They have some terminal inertia. As you heat up the fuel, you have to heat up those assemblies, too. In addition, the heat is being complicated radially. It can reach all the way to walls and it can heat up the walls. So these are the types of analysis that really requires a very detailed code calculations. This is the type of analysis we are doing. I'm not suggesting that you are not going to get a zirc fire. Of course you are going to lose the water. There are conditions under which you can get zirc fire. But you want to see what are the best estimates -- under what conditions do we get a zirconium fire. And so, a very detailed thermohydraulic and analysis is really what we need.

GORDON THOMPSON: And I agree, absolutely. And we needed that about 30 years ago. And this agency should have done it 30 years ago. It's been dragging its feet all this time, producing shoddy analysis; and, in the last decades, secret analysis. I really hope we're going to see something much closer to the principles of science in this area. And I think you have a heavy obligation on you to correct 30 years of really bad practice.

RICK DANIEL: Thank you, Gordon. Thank you, Hussain.

MARGARET LAMPERT: And I would also mention that I hope in the assumptions in this new study, you're also considering the bar flex degradation and those factors, which certainly would affect the heat-up.

RICK DANIEL: And I know when that study is done near the end of the year, you folks will be taking a look at it and we'll be in touch with you.

MARGARET LAMPERT: Will there be, after the publication, opportunity for public input?

RICK DANIEL: Absolutely, absolutely. Correct, Hussain? There will be public meetings after the release of the study.

[laughter]

Mr. Casto says, "Yes."

GREG CASTO: Yeah, I can comment briefly. The study that Hussain is talking about will be part of recommendations to the Commission to address Fukushima and near-term task force items on expedited transfer and spent fuel to dry storage. And that study will inform our recommendations and, prior to the recommendations, we will have public meetings and we will discuss it.

RICK DANIEL: You know, folks, unfortunately all good things must come to an end. And I appreciate you being a very attentive audience. I'll just ask you to give a round of applause to this panel.

[applause]

And again, Greg Casto.NRC.gov. Thank you. Have a good evening.

[whereupon, the proceedings were concluded]