# NUCLEAR WASTE TECHNICAL REVIEW BOARD

## ENGINEERED BARRIER SYSTEM, TRANSPORTATION AND SYSTEMS JOINT PANEL MEETING

## TECHNICAL CHALLENGES OF INTERIM STORAGE OF SPENT FUEL

Dallas, Texas
November 2, 1993

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Dr. Ellis Verink, Session Chair
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Dr. John J. McKetta, Member
Dr. D. Warner North, Member
Dr. Dennis L. Price, Member

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# I N D E X

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P R O C E E D I N G S

8:30 a.m.

DR. VERINK: Good morning. My name is Ellis Verink, and I am a Professor Emeritus in the Department of Material Science and Engineering at University of Florida. Naturally, despite the emeritus title, I'm still very active in the university. I have several graduate students, and so on, and teaching assignments, and I chair the Board's panel on the engineered barrier system.

Yesterday, we heard overviews of interim storage programs and issues from EPRI, NRC, and DOE representatives, in Dr. Price's morning session; and also yesterday, as you all know, we heard many views regarding institutional issues on interim storage in Dr. North's afternoon session, then participated in what I considered a very lively and productive round-table dialogue, which Dr. North so skillfully moderated.

Today, we're going to be talking about the technical issues and challenges of interim storage. The first three talks relate to dry storage technology and, in particular, the multi-purpose canister. How do we get spent fuel out of the pool and into the MPC? What are the current MPC design concepts? And even though there are no plans to keep spent fuel in dry storage at the reactor for ultra-long periods, how does prolonged dry storage, say, 50 years or more, affect our ability to transport or to continue to store the spent fuel?

Clearly, this is a contingency that must be recognized and planned for, particularly in view of the record over the past 15 or more years in which the repository opening date seems to recede nearly two years for every year that passes.

After the morning break, I am pleased that we'll be hearing again from Dr. Rao about the Canadian storage system. Then we will hear about the MPC, or maybe it's now a DPC, it's hard to tell, and how it integrates with repository plans, including thermal loading, and we will hear how existing commercial interim storage devices will be handled in the waste management system.

At the close of this technical session, there will be a summary by either Ron Milner, or perhaps Jeff Williams, depending on airline schedules, and I'd like to cover what the ground rules will be today. They're going to be slightly different from yesterday.

I've asked each of the speakers to allow ample time for questions, and I will be soliciting questions from the Board and the staff and, if time permits at that time, we will take some from the floor for each speaker. I'm going to do my best to keep on schedule. This will be a schedule-driven operation, so if I don't get your question or comment, please try to hold it until the public comment session that we're going have as a closing feature.

Our first speaker is Alan Wells, who's going to discuss spent fuel transfer technology.

Alan?

MR. WELLS: I'm a cask designer. I've actually worked on these things and licensed them with the NRC over the years, and been involved in the actual operations, and what I'm going to talk about this morning is the methodologies with which we move fuel from the pool into a cask, and, in some cases, move from one cask to another.

The topic is, "Current and Emerging Fuel Technologies," and as far as current fuel technologies go, we have been moving fuel at reactor sites in the United States for quite a few years, from a variety of pools. In some cases, these pools are not very, how shall I say it, well-designed for moving fuel. They were designed originally with the idea that we'd use truck casks. In some cases, we use casks that are a bit larger, and it's inconvenient, and there isn't much space, so we've gotten fairly good at finding ways to take use of the available space and use it efficiently.

There are five dry storage cask sites currently operational. I shouldn't call them casks. One of them is Fort St. Vrain, which is a storage vault, but it is a dry storage situation.

One of the ways that we move fuel is directly to the cask. We take it from the pool, bring it up into a fuel-handling machine, and then drop it into the transportation cask. This is the most straightforward way to do things, because you end up with the fuel exactly where you want it to be, and no intermediate transfer is necessary. In some cases, you can't do that. This is done with transport casks, such as legal weight truck, overweight truck casks, and, in some cases, rail casks. It's also used with casks like the ones at Virginia Power, Surry Plant, where you put the actual storage cask into the pool, put the fuel directly into it, and then put the cask out in dry storage.

Schematically, one puts the fuel into the cask, puts the closure lid in place, and I just wanted to mention in passing that, in some cases, the lid of the cask is a single unit piece, solid piece of steel, or a piece of steel with lead in it. In some cases, we choose to use a shield plug, and when you're dealing with a massive piece of steel that weighs perhaps two and a half, three tons, it's convenient, sometimes, to break it down into a shield plug, which is just there for shielding, and the separate piece that is put on is the closure lid, which is then sealed in place.

In the case of the multi-purpose cask, it's nice to have the shield plug there, because it's a separate unit that is inserted, just physically, it sits there, and then, afterward, the lid goes on top of that, and all the welding operations take place over the shield lid, not directly over the fuel. So, when you see a closure lid and, in some cases, shield plug, it doesn't make a lot of difference to the licensing of the package, but for handling purposes, with bigger packages, it's convenient.

Okay. You put the lid on the cask, take the cask out. Usually, the handlers will bolt at least some of the bolts in place in the lid when you take it out of the pool so that the lid doesn't come off. Often, they do the final torque down of the bolts in the decon area, or an area near the pool. It depends on the site. Everything's very much site-specific in how you do that sort of handling.

There is nothing particularly to it, however. I wouldn't say it's routine, but it's done under a procedure that you develop for the particular site that you're working at, and there are very rarely any surprises.

Then you put the cask on the transport vehicle--in this case, a truck is shown--and ship it off site. As far as handling at powerplants for the dry storage goes, the ones that are in operation are Virginia Power, Surry Plant, which has metal dry storage casks. It has quite a few of them out there. It's one of the largest facilities around so far.

The Palisades plant is very new to the independent spent fuel storage business. They only have two cask cylinders loaded at this point, and they're a dry, vertical concrete cask technology, and they use a transfer cask. At Surry, of course, as I said earlier, we load the fuel directly into the cask and, in that sense, it's quite simple. At Palisades, you load the fuel into a cylinder that goes in the transfer cask.

At Oconee, which is operated by Duke Power, the cask is loaded in the pool, transfer cask with a cylinder inside, and then that's taken out to the dry storage, and it's all loaded horizontally. As you might surmise, you can do this horizontally and vertically, or at any angle you want. Horizontal and vertical have advantages each over the other. It depends on what you're trying to optimize.

And then Fort St. Vrain is a bulk storage system, which is quite different. The way this transfer is handled with a transfer cask, is that you put the--I would call it a multi-purpose canister, since that's what we're working on here--into the transfer cask, and put the transfer cask into the pool. Once you've put the transfer cask in the pool, you have an opening that you can put the fuel directly into, and that's shown here, and it's just like loading a transportation cask. There's nothing particularly special.

You do put the shield plug and the lid, the inner lid of the canister in place before you pick the cask out of the water, and at some point there, once you've picked the cask out of the water, you set it near the spent fuel pool itself--either right on the edge of the pool, or in an area that's a little bit away--and then you weld the lid in place. This is an artist's conception of the welding rig. Usually, it's just a gizmo that goes around in a circle. It's an arm that's pinned at the middle of the lid. That's a pretty straightforward way of making a circular weld.

But in any case, you put the fuel in the pool, and make the weld once you've taken the cask out of the pool. Now, at that point, the cask is vacuum dried. You blow the water out with compressed air, and then connect it to a vacuum pump, pump on it for awhile, and after it's been dried and the seal weld is in place, you backfill it with helium. The helium is used, of course, to keep the fuel cool and in an inert environment for storage.

The transfer cask, then, is a cask that can be handled at the facility and moved around, and it can be taken down into the loading bay area of the powerplant reactor auxiliary building, and loaded directly into a concrete cask there. Alternatively, it could be trucked on a heavy haul vehicle out to the actual storage pad, and be transferred into the concrete cask on the pad. This is an operational choice of the powerplant. It's not particularly the limitation of the system one way or another. You can do it out at the pad, because the cylinder is already seal-welded.

To get it into the concrete cask, one simply places the transfer cask on top of the concrete cask, and I have a picture of one of these transfer casks. The cylinder sits inside the cask, and it sits on the bottom floor of the cask, which is a valve. The valve that's shown here is a gate valve, which is a very simple way of doing things. There are other transfer casks out there which use rotary valves. It has a lot to do with the size of the cask, which valve arrangement you pick. If you have no length constraints, rotary valves are very convenient. If the length is a problem, as it is in light water reactor fuel handling, then the gate valve arrangement is favored.

But, since the cylinder sits on the gates, one has to lift the cylinder up an inch just to give yourself some clearance there so that you can slide the doors out from underneath the cylinder, which is sitting over the concrete cask, and then you lower away and lower this thing into the concrete cask.

The transfer cask itself is a fairly straightforward object. It's just got, in this case, an inner and outer seal wall, with a layer of lead for gamma shielding, and a layer of a concrete-like material for auxiliary gamma shielding, and also neutron shielding.

The horizontal system is the same thing, except that when you load the transfer cask in the pool, it's loaded vertically. Believe it or not, there are some places where fuel has been loaded horizontally. It's not the easiest thing in the world to do, but some reactor sites, research reactors, especially, have required this.

You load the fuel. It's actually the way you did with the vertical concrete cask arrangement, but then the transfer cask is handled afterwards in the horizontal position. It's taken out on a truck, very much like a transportation cask would be, horizontally, out to the storage site, and then the cylinder of the fuel is either pulled into a horizontal concrete module, or pushed. At the Robertson plant, it's pulled by a ram that extends through the back end of the vault. At the Oconee site, it's pushed. It's your choice.

The handling of getting these things out of the site at Oconee would be to pull it into a transfer cask, and then use an arrangement very much like the loading on a vertical concrete cask. Once you get it into a transfer cask, you set that on top of the transportation cask, and use the gate valve arrangement to lower it into a transport cask. So, regardless of whether you handle the fuel vertically or horizontally, it can end up in dry storage, and it can end up in a transportation cask.

This is just a picture of the transfer cask used at the Oconee powerplant, and it has a removable plug at the bottom of the cask so that you can put the hydraulic ram through, so that you can push the cylinder into the concrete modules at Oconee.

Another technology that's used and really isn't quite the same as what we're proposing with the MPC, is the dry vault storage arrangement. In this particular schematic, we're looking into the vault area, where you have cylinders to store the fuel in, all in the floor of a large vault. The fuel is loaded by bringing an actual transportation task--the Fort St. Vrain cask is used to ship fuel to Fort St. Vrain. You bring it into a bay area, push it up against the mating arrangement, and lift it into a transfer device, which is just a transfer cask, and that's moved over to the hole in the floor that you want to put the fuel in. They take a plug out and slide the thing in.

There are several arrangements in place right now for handling fuel that are trying to take the existing technology and evolve it into something that would be more useful for us today. EPRI is working on a project with the Department of Energy and Transnuclear, and we have also received some descriptions of systems that Newport News uses to move fuel for the Navy. This is to unload the reactor vessels from their ships and submarines.

The methodology of transfer is the same, so I'll get right to the transfer cell, but the EPRI/Transnuclear design uses a shielded cell to effect the transfer from a transfer cask into the storage cask, and, in this case, the transfer cask is relatively small, and the arrangement on top of the transfer cell moves so that you can align that transfer cask containing fuel over the hole that you want the fuel to get into in the basket of the storage cask.

So, the arrangement here allows you to move fuel directly from the transfer cask into a storage cask, using a cell that has a vacuum and air filtration system so that it never leaks radionuclides outward, it's always leaking inward, where anything that was loose would end up trapped in filters.

The Newport News system is something that we're looking at to do handling on-site for loading the MPCs, and in this case, we have a transfer cask that's set up so that it can handle more than one fuel assembly at a time. One of the ways to do this is to put fuel into a stand in the pool, and you load the fuel with the fuel handling machine into a stand, then put the transfer cask on top of that, and pull several assemblies up into the transfer cask. Then this multi-assembly, multi-fuel assembly transfer cask can have the welding of the steel cylinder, like an MPC, that can be done at the fuel pool area, and the operations after that are pretty much the same to what we've described before.

You take the transfer cask out, and mate it with the cask that you're trying to put the fuel in--either a transportation cask or a concrete storage cask--and it either goes off to the concrete pad for storage, or it goes off for transportation.

This sort of multi-assembly transfer is used pretty commonly with the Navy for their transportation of fuel assemblies. They operate some pretty big transportation casks.

The fuel assembly machine for handling that they use at Newport News right now, they do have a multi-fuel assembly transfer cask that they use, and it's very similar to the other ones.

I see I'm running out of time, so I'll go right to the summary, which is that we've been doing fuel assembly direct transfer into transportation casks for many years, and in recent years, we've been using this multi-assembly transfer through transfer casks that hold cylinders of fuel. The cask-to-cask transfer of fuel that was envisioned for the conceptual design allows you to take their fuel and move it from one cask into another cask, so we're just evolving on the existing technology. There's nothing particularly new or exotic, but it's tuned to the particular system we're looking at. That takes a lot of work.

Are there any questions, briefly?

DR. VERINK: I'll take questions first from the Board.

DR. PRICE: This is Dennis Price; Board.

You indicated that everything is site-specific, and there are a number of different technologies which have been shown here, or different ways of doing it. How does this affect standardization for the designs of things like that multi-purpose canister?

MR. WELLS: Actually, when I say it's site-specific, I was referring to the procedure for handling the package. The casks that have been used in the past have been used in very restrictive conditions, a lot of difficulty with the handling, and the package works fine. The procedures for a particular site sometimes have to get fairly elaborate into how you move this before you move that, because there's only enough area for one thing to be there at a time.

But the handling works, it just requires some pre-planning, but I would expect this thing to be useful at any site this crane is big enough to lift in.

DR. PRICE: So you don't see the differing technologies having any particular impact on standardization, other than whether or not the crane can handle it?

MR. WELLS: That's correct. It's something that a designer worries about, because he wants to make it easy for the handler, but the handler is going to be able to do it no matter which design he has, as long as he can handle it.

DR. PRICE: Another question: Do you have, for each of these designs, systems safety analysis things performed?

MR. WELLS: All of the ones that are used at powerplants have been approved by the NRC in some way. Sometimes it's transportation, and sometimes it's--

DR. PRICE: Yeah, that's not my question. Has it had systems safety analysis? Do you have systems safety--

MR. WELLS: You're talking about a systems analysis of the safety?

DR. PRICE: No, I'm talking about systems safety analysis.

MR. WELLS: I'm not sure what the differentiation means. I just write SARs for the NRC, and they either approve or disapprove.

Does anybody want to comment on systems safety analysis?

(No audible response.)

DR. PRICE: There are systems safety professionals out there who do systems safety analysis, and it's the application of inductive and deductive techniques.

MR. WELLS: Um-hum. Yeah, our analysis approach and safety analysis for the NRC, I can say, is deterministic. You say: What can happen? Assume it happens. Mitigate the consequences, and we don't get into a lot of the interactions of various components of the system. One of the reasons for that is these systems are relatively straightforward. They're not that complex, and the NRC hasn't required detailed systems analysis.

What they require, instead, is that when you do something, it will be safe, and you look at the operation involved, like putting fuel in the cask. You know, if there's something that will hang up the fuel assembly, you're just not allowed to do it.

Alden might contribute.

MR. SEGREST: We did have, in part of the MPC design work, you know, we, of course, with all engineering work we're concerned about the system safety and the overall safety, and as part of the M&O organization, we do have some system safety-type analysis capability.

With respect to the MPC conceptual design, I believe that our expert did do some of the review, but I'm not certain how much, but that is something that does enter into part of the process, and will enter in, is a full safety review of the type that you're referring to.

DR. PRICE: But for these things that we've just seen, that, evidently, does not exist?

MR. SEGREST: Those are all done by private industry.

DR. PRICE: And I would assume, also, then, human factors, engineering analysis has also, likewise, not been performed in a formal sense?

MR. WELLS: In the formal sense, perhaps not, but in the informal sense it has, because, remember, a lot of handling of casks has gone into this design, and such things as using bolted closures that are easily operated by one person with a socket wrench, all that has been considered.

We looked at things like the welding, where you want to be able to make a reliable weld, but you might have to have a human intervene and back gouge out a bad weld pass or something like that. We've considered things like that. I don't think we've done it in a detailed, formal sense, but we certainly considered it.

DR. PRICE: Yes. There are people who give their lives over to the human factors profession and human factors engineering, and have a set of tasks that they perform, a task analysis, and so forth, that they would do, that should be documented, and so forth, but that kind of program has not been performed here?

MR. WELLS: No, but the specification that's under draft right now for going out for commercial bids on the final development of these MPCs has included in it a section on human factors.

DR. VERINK: I suggest that we now terminate the questions for this section, and defer further ones until the general questioning, in the interest of keeping our schedule.

MR. WELLS: Okay. The next speaker up is Alden Segrest, who will talk about the MPC conceptual design itself.

MR. SEGREST: There were so many comments made on how simple and easy the engineering for the MRS and the MPC is yesterday, that, as the engineering manager for the MRS conceptual design and the MPC, I just have to comment on that.

Since my boss is here today, and his boss, and since my customers are here today, I would appreciate it if no one else would tell them how simple this engineering really is.

(Laughter.)

MR. SEGREST: I have to worry about my career here.

For the MPC conceptual design, I'm not going to describe a lot of details. The best information on the details of the design, if you look in Ron Milner's presentation from yesterday, there are sketches of the canisters and design. I want to talk a little bit about the process, what this design should be capable of, and a few of the results of it.

I'll talk about the concepts themselves, a lot about the fuel, what fuel can be accepted into these canisters, the characteristics we considered, and how this thing will actually be implemented.

There are six design concepts, six different cans that we've done conceptual designs for. The first two, the 125 ton, if you look, is a 21 PWR can that requires burnup credit. Burnup credit will be required for that one to function properly. There is also a 40 BWR design that does not require burnup credit; the 75 ton designs without burnup credit. That one, once burnup credit was licensed and approved, the 75 ton PWR could be redesigned without flux traps, slightly smaller and lighter package.

There are also two alternative concepts we considered, did not do as much design analysis, but did some review. Within the 125-ton package, we could have a 17 PWR, and notice the difference between that and the 21. You've got four assemblies difference, and essentially the same size can. As Bob Bernero indicated yesterday, we need the larger cans. We need to be able to haul more fuel in them, and you can see the, or you can quickly calculate, I'm sure, the cost difference if we have to go forward with designs that do not allow burnup credit.

We also looked at a 24-assembly burnup credit design for PWRs. We did not pursue that too far, but we did a certain amount of analysis on it. If thermal conditions with the repository allow that, that would also improve the economics of the overall system. So, again, there's two alternative design concepts that may need to go forward as we develop this further into the detailed design.

For fuel acceptance in the design approach, like good engineers, we've gone through the very complex task of establishing all the minimum requirements. Then, engineering has to be cost effective, so we went through and applied where we could, cost-effective design features so that wherever possible we could exceed the minimum requirements. In the nuclear business, what we often find is we have to go back and re-analyze and reconsider. It's good to have some margin in there; also, for the flexibility of the canisters, we need the margin.

Where necessary, where the margin's not there for certain types of fuel, we can go to a lower capacity design, either using the 75 ton or not putting as much fuel in the can.

The fuel, as Bob Bernero pointed out yesterday, there's a lot of differences in the fuel. The reactors did not use standard fuel, the vendors did not design standard fuel, so there's not a lot of standard fuel out there, no matter what the contract calls it.

If you look at the first three categories on this list, there are actually enveloping requirements. The 180-inch length includes everything except the South Texas fuel. 6x6 and 9x9 are enveloping requirements. Interestingly enough, the 9x9 is larger than necessary, so when we did the conceptual design of the 21-element basket, we used a little bit smaller envelope of 8.8x8.8, and we believe that will hold at least 90 per cent of the fuel within that envelope.

Of course, the smaller can, the 75 ton, we went ahead with the 9x9 to make sure that we could accommodate even the larger fuel. We used these enveloping weights for the aged in years, even though the standard contract says 12-year-old. We did a lot of consideration about the additional cost of going with a five-year-old fuel rather than the ten, started with the ten, and then looked at ways to accommodate where necessary for the small percentage of fuel where five-year-old fuel would need to go in the can.

Then we took what we considered to be an appropriate enrichment burnup, decay heat, based on the fuel inventory that was out there. We've got some pretty good databases of the fuel inventory that exists, so we took that--those databases and analyzed them there.

So what we come up with, we need to accommodate a multitude of assembly types and a wide range of enrichments and burnups in this fuel. There's a lot of variation in it, and we minimize decay time restrictions, the goal being to maximize the number of assemblies that we can accept that are only out of the reactor for five years, but being sure that we can accept all of it that's out of it for longer periods of time.

The results of the design is we got into the process, starting doing various things with the design. We came up with a number of things we could do which would actually exceed the minimum requirements we had established for the design. By using a lot of aluminum in the basket design--aluminum's not used in the structural uses, but it is used in the design--it allows us in a storage mode to accept about any of the fuel five-years-old; the majority of the fuel with a five-year cooling.

The transportation cask, by taking some flexibilities in the design of that cask, it can be tailored to accommodate fuel with, from a radiological shielding standpoint, fuel that's in the five-to-ten-year-old range.

And then the MGDS, of course, there's still a lot of study and a lot of work going on there, but that should be able to accommodate the 10 to 20-year cooled fuel in the large capacity MPCs, even though our concept, for the most part, is based on 21-element designs. Possibly, we'll continue to look at a 24 PWR.

The utilities are very interested in the PWR because they know that the fuel pool clients can handle it, and they would like to put as many assemblies into a can as practical.

Now we have a simple engineering chart. This chart is prepared to reflect the amount of fuel that we can put into a 21-element MPC. The yellow band is the fuel that's acceptable for the 21-element MPC with five-year cooling. More than 90 per cent of the fuel is in that band. The chart, based on when we compare enrichment, we look at burnup, and we prepared this grid just putting the number of fuel assemblies--this is just PWR, by the way--the number of fuel assemblies with each band, and then developing the curves and analyzing, determining that more than 90 per cent of the fuel will work in the MPCs, based on the current conceptual design.

Now, there are some--there is some fuel in the blue area here which will not fit, based on that analysis, but we do have ways to accommodate that. I'll identify some of those for you shortly. We also have a situation, the numbers here in red indicate the stainless steel fuel. That's another outlier that presents some difficulty.

There's been a good deal of study and analysis concerning the zircaloy-cladded fuel, so that the NRC is comfortable with how long that fuel can be stored. We do not have the same analysis and study concerning the stainless steel cladded fuel to know how to deal with that.

If you look above the five-year line, into the ten-year area, you see there's a small amount of fuel between five and ten years, has to be cooled between five and ten years before it will go in the can. Of course, there is some that would have to be cooled longer before it can go in the cans, but we did have 90 per cent, which is within the band, and our initial starting point was to make sure we could deal with 80 per cent of the fuel.

So what do we do with the outliers that are outside of the yellow zone?  From a thermal standpoint, we can go with lower capacity MPCs or longer decay time; criticality, using the lower capacity MPC or some alternate designs that can yet be developed; and then for stainless steel cladding, we've still got to study that one possibility is individual canisterization of that fuel.

As far as being ready to implement the MPC for storage, we're confident that a certified design of the MPC can be developed suitable for storage, and that it can be licensed as the design for storage in any one of several modes, and could very well be ready for implementation in 1998.  That's what the DOE would like to see.

That's all I have.

DR. VERINK:  We can open the question period again; again, the Board first.

DR. PRICE:  You didn't say anything about the MPC.  Are we going to hear about this later, with regard to emplacement in the repository?

MR. SEGREST:  Yes, you do hear about that later.

DR. PRICE:  Is there anything that you discovered in the material that you covered that would affect ultimately coming up with one standardized approach?

MR. SEGREST: We will come up with a lot of standardized features. There will be standardized transportation tests, but because of the variety of the fuel that is out there, there will need to be some differences in the designs. So one single canister would not work for everything, given the difference, for example, just in the dimensions of the BWR fuel versus the PWR.

We can have very standard approaches with respect to materials, structural designs with respect to the transportation cask overpack, the waste package overpack. There are a lot of standard features, standard issues, but we still need to have differences to accommodate the wide variety of fuel that's out there.

DR. VERINK: Other questions? Dr. Cantlon?

DR. CANTLON: Yes. Cantlon; Board.

You commented on extensive use of aluminum. Could you expand on that? I didn't follow what you were talking about.

MR. SEGREST: Within the design, there is an aluminum alloy that is a part of the design. It's excellent for heat transfer, and that is used--it's not as a structural member, but it's used within the design, the aluminum to contain the boron, as well as to help transfer heat away from the fuel and out to the shell.

DR. CANTLON: Where, physically, would it be in the MPC?

MR. SEGREST: It is within the grid structure.

DR. CANTLON: In the grid structure?

MR. SEGREST: Yes.

DR. CANTLON: All right.

DR. VERINK: Are there other questions from the Board?

(No audible response.)

DR. VERINK: Staff?

(No audible response.)

DR. VERINK: We could take one or two questions from the audience, if there are any. Anyone wishing to speak, kindly go to the microphone and identify your name and affiliation for the record.

Are there any questions from the audience?

MR. STUART: Ivan Stuart from Nuclear Assurance Corporation.

Alden, I keep seeing the need for burnup credit. Could you tell me why you need it, when Mr. Bernero's about to license a 26 PWR design?

MR. SEGREST: For burnup credit, the primary use of it will be in the repository for long-term criticality considerations. Also, with burnup credit, with the--with our design and the analysis we've done on it for the large basket, we need the burnup credit, and to go to a 24 element, we'll need it. The 12 element, we can do without it, but our analysis shows that for the long-term repository considerations and some transportation situations, we do need it.

DR. VERINK: Dr. Barnard?

DR. BARNARD: Bill Barnard, Board staff.

What do the contracts say about oldest fuel first, or five-year-old fuel? What can the utilities give the government?

MR. SEGREST: That question, I believe, is discussed and negotiated continuously. Ron, would you like to help me with that, please?

MR. MILNER: Yeah. I'd just mention quickly that the contract does say oldest fuel first, but that simply allows the utility its place the queue, if you will. They can give us any fuel that's five-years-old or older.

DR. VERINK: Dr. Langmuir?

DR. LANGMUIR: Langmuir; Board.

On that same issue, what do expect is going to happen? I think we're all aware now that the average fuel is maybe 28-years-old. What do you anticipate will be going to the repository?

MR. MILNER: What I would anticipate accepting from the utilities is probably their newer fuel. Certainly, those that have dry storage are not going to take it out of dry storage. We won't really have a final handle on that until we get down to the more firm delivery schedules, but what goes to the repository is another matter. It depends on whether you have an MRS in the system and what the cooling time is, and so forth.

DR. CHU: Yeah. Woody Chu; Board staff.

Following up on that, along similar lines, acceptance, as I understand your presentation, is just the deployment and the provision of the canisters to the utilities?

MR. SEGREST: Yes, sir. I'm not talking waste acceptance. I'm talking about acceptance into--

DR. CHU: Right. I mean, so that we have several steps along the way, with possibly man years in between.

MR. SEGREST: Yes, sir.

DR. CHU: Right. And so the first step, the one that you're referring to, is just the provision of the canister to the utilities and whatever technical problems you may encounter in that regard, and so that would you then satisfy the terms of the contract in the provision part, and then later you would have liberty in picking up whatever is at the various sites? I mean, you shall have satisfied the terms of the contract in the provisioning.

MR. SEGREST: If I'm understanding you right--

DR. CHU: Well, I'm not sure I understand. That's why I'm asking the question.

MR. SEGREST: If you're asking whether or not supplying canisters would be considered to satisfy the obligation to accept waste, I think canisters are part of the solution, but not the whole solution.

DR. CHU: No. We're talking about the five-year to ten-year. I'm following up on Bill's question, and as I understand the presentation, acceptance, in the sense he used it, and in the sense of the contract, is the providing of the canisters to each of the--

MR. SEGREST: No, sir. Acceptance, according to the way I was describing it, was accepting fuel into the canisters. The design of the canister will accept five-year-old fuel. I was not referring to the waste acceptance contract. I was referring to the way we've designed that canister, so that the majority of the fuel that is currently out there, five-years-old, can be accepted into a canister for storage.

MR. WELLS: I have a comment. I hate to do this.

From a technical standpoint, you might wonder what we did to make five-year-fuel possible, how we managed to get five-year-fuel into the canister for storage. We really didn't.

In the repository, we're required to keep the fuel cool in a hot environment where the whole repository heats up and everything's hot, and so to keep the fuel cool enough, we had to put in aluminum that was thick enough to take the heat out. Once we've done that for the repository, it's rational to notice that this thing works very well in storage at a very much lower temperature than it would otherwise have been. In designing for the repository, we have something that runs cool in the storage mode, and then the transportation design is where all the hard decisions had to be made.

So, in a sense, it's sort of just a freebie. You get to put five-year-cool fuel in that canister for storage, because when it's in storage it's cooled in the storage cask, which is ventilated, but you really paid for that in terms of the hard decisions in the repository design. So we have the capability of taking five-year-cool fuel and putting it in the canister, because that's a less demanding thermal environment than the repository.

DR. VERINK: All right, one last question.

DR. PRICE: One last question. Yesterday, many of the concepts which I think you're presenting today were indicated to us as part of key trades, where Ron Milner, you indicated that there were alternatives and there was a rationale and that you looked at these alternatives.

I'd like to ask you to expand on the term, "looked at," so that we could understand a little better how you arrived at this concept.

MR. MILNER: And my apologies for using terms loosely, but the trades that we looked at, looked at indicates that we had done an analysis and, depending on those results, we selected a preferred approach in the different areas. I think we probably need to provide you, at a later date, some of that more detailed analysis.

MR. SEGREST: There is an alternative cask canister analysis we did to consider MPUs, transportable storage casks, that's compared with the MPCs, and we did a fairly significant analysis of the overall life cycle considerations of those designs to compare with the MPC, and the MPC design did come out to be economically favorable.

DR. PRICE: I think we'd like to see those reports.

DR. VERINK: Dr. Bernero, do you have a question?

DR. BERNERO: Bob Bernero from the NRC.

Can you speak here, or will you speak later in the discussion of the repository aspects of the MPC? Did you do parametric analysis of the range of thermal loadings that might come out of the cask; that is, how high and how low a wattage loading?

MR. SEGREST: Hugh probably should answer that.

MR. BENTON: We'll speak to it later.

DR. VERINK: I think we're due now for our next speaker, who will be Jim Clark from the M&O, speaking on effects of prolonged dry storage on storage and transportation performance of MPCs and MPUs.

MR. CLARK: Good morning.

I support Jim Carlson in transportation, and in another capacity, I have an interest in this subject because I am the chairman of the Institute of Nuclear Material Management's committee on spent fuel storage.

In addition to talking on the effects of prolonged dry storage, I've been asked to put the emphasis on transportation, and to include consideration of the fuel integrity, and the way I'd like to do that is to summarize three recently-published studies that are relevant to this matter, and then to highlight what the Department, what OCRWM has going to answer some of the remaining questions.

The three studies I'll talk to are these: The Sandia Report, which apparently focuses on transportable storage cask, but has relevance to the MPC; the PNL Report, which surveys fuel integrity and looks at the mechanisms of degradation; and a recent EPRI Report that specifically goes to the canister concept.

The first report was briefed to the Board by Tom Sanders of Sandia in January. It is a comprehensive, systematic evaluation of the characteristics that are not only important to the transportable storage cask, but also to the MPC, and their containment, criticality control, heat transfer and shielding, and the containment of fuel integrity and the criticality are almost directly relevant to the question on MPCs.

The conclusion that came out of that report, that there were no long-term effects--not necessarily the word "prolonged"--there were no long-term storage effects that would preclude the transportation of spent fuel because of the integrity of the fuel considerations; furthermore, that they came to the conclusion that, in long-term storage, the regulatory regimes would change, and though they could conclude that the MPC-like canisters, or the fuel in the transportable storage casks could be transported after long-term storage, they provided a recommended evaluation process.

And that recommended evaluation process, which I indicate here, also has some of my comments in parentheses as they might apply to the MPC, or not apply. They were not able to reach a conclusion on the consideration, or at least did not offer one on the corrosion of welds, and the welds that we're talking about, where the weld's relative to the basket, the criticality control in the MPC, of course, would be the basket for the transportable cask. So that was an open issue.

The seal is not an open issue. It's relevant to the transportable storage cask in the MPC. The MPC canister goes within what we call the transportation overpack. The overpack provides that kind of containment.

The fourth part of the evaluation process was an admonition that, while they did their thorough evaluation, they looked at the expected conditions of storage, and point out the there could well be changes to that expectation, and that any reasonable expectation to be able to shift this after long-term storage, you must have detailed records of the fuels and the storage, not only specific to the device, but specific to the storage location.

The second report of interest here was a report done by Pacific Northwest Labs, published in 1992. It reviewed the mechanisms for degradation of the spent fuel itself. It indicated worldwide status, what experience was in the other countries, and what their plans for storage were, and it came to a conclusion relative to this long-term integrity.

With regard to the worldwide status, they looked at 13 countries, and indicated all that experience. You'll hear in the next paper the extensive experience in Canada. In addition to that, there are at least six other countries that are industrializing spent fuel storage, two of which I've put up here, Great Britain and Germany, and the purpose here is to indicate that there's a diversity of lots of experience, but there is a diversity of the type of fuel being stored, the type of tests being done, and the kind of environment that this experience has been accumulated under.

I call your particular attention to Germany, which has extensive experience in the kind of storage that the MPC would probably be in.

This PNL report, as part of it, looking at the degradation mechanisms and the experience, went to the conclusion--and I think that's literally their conclusion--that the LWR integrity for long-term storage in inert gas at cladding temperatures of 320 to 400 is considered proven by the country's survey. That is of interest, because that is, typically, the kind of storage environment that the MPCs, or at least this design of MPCs would encounter.

One of their other conclusions that I've put up there because of its interest is relatively few results are long-term storage in air of defective LWR fuels. The interest to that is, of course, our interest. Our responsibility is to get all the fuels, and so that somewhere along the line a small percentage of the fuels will be defective, and defective being more than pinhole leaks, more than hairline cracks, and we will be charged for accepting those fuels and transporting them.

You probably well know that, at present, there are no licensed transport casks for that kind of defective fuel, for defective fuel, unless it is canned, so there will be a further consideration of how those fuels are transported.

This is a very recently-published work in June of this year. It's a building upon work that Pacific Nuclear has been doing for EPRI for a number of years. It considers long-term storage, 20 to 50 years. It considers the Pacific Nuclear's stainless-steel cask, the kind they use in the canister, the kind they use in the NUHOMS. It also considers the carbon steel canisters, such as Sierra Nuclear uses in their vertical storage containers.

It went through a literature search of the specific aging phenomena; both radiation-induced, such as the potential for embrittlement, the potential for radiolysis of water to activate corrosion. It went through a thermal-induced embrittlement, looked at creep, look at general corrosion, and, while I don't have it up there, it did some calculations on fatigue cycles.

The specific conclusions of this report were that neither radiation nor thermally-induced embrittlement, that both of those pose little or no risk, and it comes to specific comparisons based upon, for example, the neutron fluence being orders of magnitude less than that which might induce it.

It goes through a specific comparison of temperatures in the canisters, versus the known temperatures. It came to a generalized conclusion that the only significant potential is corrosion; and, furthermore, broke that consideration of potential into the general environmental corrosion that might happen with the carbon steel canister on the outer shell, and intergranular stress corrosion of stainless steels.

It further said, essentially, with proper engineering, that there would be no significant effects identified which preclude transportation, and that is a very general conclusion, because it points out correctly that there is a lot of site-specific, device-specific considerations that have to go into it, and it triggers back to the Sandia recommendation that data be accumulated very specifically over the storage life.

I might say about these conclusions that they're being tested in the fires of regulatory review by the submittals of Pacific Nuclear, by the cask licensing of GNS, by the final reviews of the transportation storage casks.

With regard to what OCRWM had going and is continuing with regard to this question of integrity during long-term storage, there has been performance testing of six systems, seven casks, over the last several years at Idaho, at H.B. Robinson Plant at Morris, Illinois, and that performance testing has been how to load the cask, how to handle the cask, what the radiation environments are, what the heat transfer characteristics are, and they generally have been used to develop and validate the heat transfer and shielding codes, both by PNL and Oak Ridge National

Laboratory.

There has been, recently, a final report going through peer review on the oxidation of spent fuel in air, being done for a number of years by PNL. It involves laboratory experiments, oven-type tests at high radiation, $10^5$, various temperatures, and in air, and I've seen only the executive summary, so I have a limited characterization of it, but as you remember, there was an interest because of the radiation degradation of some seals in the oven, some contaminant in the air, and this report addresses the potential degradation of uranium-oxide fuels exposed to air with slight contaminants. So I expect that'll be out in November, and will add to the background knowledge.

Starting in FY 94, there has been an extension of the work that OCRWM has going. I've chosen here to call it a new project. Whether it's a new project or not, I guess, is in the eye of the beholder, but, in any event, it starts in '94, will go for at least five years, and the purpose is to confirm the long-term dry storage can be done safely; to provide design information to the MRS, to the ISFSIs of commercial reactors, and for this dry transfer system.

It'll use two existing loaded casks at INEL. I believe one of them will surely be the VSE-17, which consolidated fuel. I'm not aware of the choice that's been made on the metal cask, but it will be a metal cask like the

NC-10 or the GNS, that has loaded fuel.

It will continue the routine cask monitoring that's gone on on heat transfer and shielding for a number of years, but will now start what I've called enhanced monitoring.

That enhanced monitoring will initiate this year with gas sampling on a nominally quarterly basis. The actual protocol is being developed by OCRWM, in consultation with EPRI, who has been utilizing comments from its utility members. In addition to that, the plans will go forward in FY 94 to remove fuel in FY 95 for inspection, so the plans and equipment will be generated this year, and what we presently envision is that that will be to take the fuel out at the test area north of INEL to monitor, for example, the crud, the corrosion products that are on the assemblies, an issue that has been relative to the design of fuel handling facilities.

It will measure seal integrity of these casks over time, and will include the inclusion of sample coupons, both metal and concrete, for potential radiation and thermal damage.

With that, I'll entertain questions.

DR. VERINK: Any questions from the Board? Dennis?

DR. PRICE: Price; Board.

I wonder if you would help me on these things. I think you said something about it that I probably didn't quite catch.

For the Sandia report, we're talking about the effects of prolonged storage, and I'm trying to figure out, for each one of these, how long is prolonged, and for the new study that OCRWM is doing, how long is prolonged? Is it 100 years or 40 years? I know in the foreign studies, I looked through and it said two years was the experience that Germany had, so I was just trying to get handle on this.

MR. CLARK: Dr. Price, I inherited the term "prolonged." I use the term "extended."

DR. PRICE: Yes.

MR. CLARK: The evaluation that Sanders in Sandia did, in my recollection, was a term of 20 to 40 years. The work that was done for EPRI by Pacific Nuclear talked to the term of 20 to 50 years of storage prior to transport.

One of the characteristics of the worldwide experience is that some of the tests weren't done for a long period of time. The test on fuel rods in Germany, when this report was done at the end of 1991, had two years of experience on it, so those were the time frames there, but when I look at extended storage, I look at it for at least 20 years in these reports. Some of the reports talk about going further.

Pacific Nuclear, for example, on fatigue analysis, went through a 50-year daily cycle, diurnal cycle evaluation in order to make that, so they looked on some things out to 50 years. I don't know that any of them looked at 100 years.

DR. PRICE: And what's the new study time frame?

MR. CLARK: Well, it's being formulated. The commitment is get it started with a reasonable program and do it at least five years, until you can reach conclusions on the safety. So I think that--

DR. PRICE: What period of time are they looking at to conclude, about 50 years of storage, or--

MR. CLARK: Well, the commitment, because of budget, is '94 through the year 2000, which is six years, and the data will tell how much more has to be done.

DR. PRICE: Yes. I don't think you understand me, though. What's the goal to look at the safety of prolonged storage over what period of time? Is it 50 years, or--

MR. CLARK: The period of time hasn't been specified how far to extend the six years of hard inspection. I think that's yet to be determined.

DR. PRICE: Yeah. I guess I was looking for projections. What are you trying to project to off this--off what you find in this study? Maybe I'm not understanding something.

MR. CLARK: Well, based upon what I've seen, you can clearly, if you get five years of data, make extensions to 20 years. How far, more reasonably than that, I don't know.

DR. VERINK: Other questions from the Board or staff? Yes, Dr. Cantlon?

DR. CANTLON: Cantlon; Board.

Since the burnup is not uniform in the full length of the fuel rods, are these new studies planning to look at different positions on the fuel rods?

MR. CLARK: I would think that that's a consideration that ought to be put into it. It's so formative right now. The commitment has been made to do it, the budget has been committed, the general ideas have been put together, but the specifics will be laid out in '94.

DR. CANTLON: How old is the stored fuel that you'll start with out at INEL?

MR. CLARK: It came at--the GNS fuel, I believe, was put in in '85, so it's at least 10, probably 15 years, but we could give you a specific on that. Jeff, do you know?

MR. WILLIAMS: Yes, that's correct. I'd just confirm what he says as far as age of the fuel.

DR. VERINK: We could entertain a couple of questions from the audience, if there are any.

MS. THORPE: Good morning. My name is Grace Thorpe, and I'm with the National Environmental Coalition of Native Americans.

How much will one of these casks cost our taxpayers?

MR. CLARK: The test cans at Idaho?

MS. THORPE: Well, are you--

MR. CLARK: These casks that were--

MS. THORPE: Yeah, what you're projecting here.

MR. CLARK: They presently exist. They were put there under a cooperative program with the Department of Energy and the utilities. How much the cost, nominally, at that time, probably 700,000.

MR. WILLIAMS: Yeah. That was a cooperative agreement where, I believe, 75 per cent of the costs were paid for by Virginia Power in building those casks.

MS. THORPE: And that was $700,000?

MR. CLARK: That's a pure guess. We could get you-- because these were early casks.

MS. THORPE:

DR. VERINK: Are there other questions?

Yes, Dr. Rao?

DR. RAO: Mohan Rao, Ontario Hydro.

I would like to add a little bit from the Canadian experience here. In terms of how long these tests have to continue, I think the Canadian understanding is the programs don't cost all that much, and if you keep it going, it gives some kind of an advance indication if problems do creep up as we go on storing the fuel, but the problem is if you ask the scientists how long this fuel is going to last in dry storage, that's where the problem is. We are limited by the amount of time we have the experience, and it becomes a judgment call.

With regard to Canadian fuel, we have been saying, based on the optimism rather than scientific validation, the fuel will last about 100 years in dry storage, but if the fuel has got some internal defects which go unnoticed and you don't can them, then probably you are limited to something like 50 years. This is purely a judgment call at this stage.

DR. VERINK: Any further questions?

(No audible response.)

DR. VERINK: All right. Let's take our break now, and reconvene at--oh, pardon me. Steve, okay.

MR. FRISHMAN: Steve Frishman, State of Nevada.

Just a question in curiosity. In referring to the PNL-8072 conclusions, your first bullet is LWR integrity for long-term storage and inert gas, 320 to 400, considered proven by countries surveyed.

What's the significance of the statement, "considered proven," and also, it only indicates that Germany's two-year study seems to be the only one that even deals with that condition.

MR. CLARK: They surveyed 13 countries, including Japan and countries that would make a choice on how they're going to store it. The conclusion there is literally out of their report, so it's subject to interpretation.

MR. FRISHMAN: Well, I'm wondering, what is the significance of the statement "considered proven" for any work that's going on currently in this program? Does it mean anything, or is that their language and their own conclusion, and you're just restating their conclusion?

MR. CLARK: I'm restating their conclusion, but the importance is that those characteristics are very similar to what we would use for dry storage.

MR. FRISHMAN: It doesn't have any significance in terms of--it elevates itself to be considered a working assumption, or is everything else you're doing still trying to prove this same thing?

MR. CLARK: That is an aside that came out of the vast experience overseas. We believe it is proven as well, and, of course, we're going to the NRC with licensing actions by various vendors on those characteristics, light water at those temperatures.

MR. FRISHMAN: All right. So you're using this as primary basis for--

MR. CLARK: No. That's a point of information.

MR. FRISHMAN: Okay. What I'm trying to sort out is whether there is any real significance to this program of the phrase "considered proven," or whether it's just, you're saying something that they said, and then you're going on with your own work anyway?

MR. CLARK: We're saying something that they said. We have parallel efforts of our own work.

MR. FRISHMAN: Okay.

DR. VERINK: Let's take our break now, and reconvene at ten.

(Whereupon, a brief recess was taken.)

DR. VERINK: Our next speaker will be Dr. Mohan Rao, from Ontario Hydro. His topic will be: "Canadian Interim Storage Plans," including how the plans are integrated with the permanent disposal.

Dr. Rao?

DR. RAO: Good morning.

In Canada, we are avid watchers of the American scene, whether it's NAFTA or the health care, or--and including the waste management, and it's a great opportunity for us to participate in this panel, and I want to thank the Board for that.

The Canadian program, I'd like to just to go in in a very short way. We've got seven CANDU stations. We usually build multi-unit stations. What you see here is the Pickering, the Canadian station. It's got eight units, eight PHWS. We have three major nuclear sites in Ontario Hydro; Pickering, Bruce, and Darlington, and there are two more stations with other utilities in the country.

The fuel bundle comes in pretty much one standardized design. It's a zircaloy bundle. It's about, oh, a foot and half long, weighs about 20 kg, and, unlike the American program, we don't worry too much about the diversity of the fuel bundle, fuel design geometries.

In terms of quantities, we have about 17,000 Mg of fuel, which is quite comparable with what you have. I think, if I remember your numbers right, you have about 25,000 Mg of fuel. You may wonder why it is so. On one hand, Ontario Hydro is the second largest nuclear utility in the world, next to EBF, but that's not it alone. Our bundles produce much less heat than U.S., so even though you have a much larger number of reactors, we end up with nearly the same quantity of fuel.

Our main focus in the past has been storage of this fuel in wet pools, but, slowly, we are switching into dry storage now. As you can see, we have 700 Mg in dry storage. There are two basic designs, one developed by AECL, Atomic Energy of Canada, Ltd., which is called a dry storage canister. Development of this has been going on for nearly a decade and a half, and is being used at this time for storing fuel from the retired reactors, like Douglas Point Nuclear Power Demonstration Reactor and the research reactors, and the second design is what Ontario Hydro has developed.

We call it the dry storage container, or the DSC.

This one holds about 400--384, to be precise--fuel bundles. It is made of concrete. It has got inner and outer steel liners, and we are slowly getting into bringing this into use as an alternative to wet storage.

The Canadian plan for used fuel at this time is disposal. Actually, that's what it looks like. We are hoping that everything goes well. We should have a disposal in service by around 2025; until then, is interim storage, but should the disposal get delayed, we are looking at extended storage, what you see as long-term storage, as a contingency plan.

The disposal concept, per se, is putting the canisterized fuel, fuel in canisters, in titanium containers; that is, not the concrete canisters, in the Canadian Shield, 500 to 1,000 meters below the surface. What you see here is the so-called Canadian Reference Concept, which is going into hearings next year.

Now, in terms of integration of storage with disposal, there are two broad approaches we are looking at. One is integrating the wet storage into disposal. This is by using metal casks. We de-fuel the base, put the fuel into metal casks, and the metal casks go to the disposal site. There, the fuel is taken out again and put into the corrosion-resistant containers, and then it goes into disposal.

The other broad option is what we have just started looking at for the so-called DSCs. In this case, we are looking at DSCs--I don't want to use the precise word, MPC, because it may not mean the same to you guys, but, roughly, I think that's what we have in mind; the multi-purpose container. We don't handle the fuel again and again. From the wet base at the stations, it goes into dry storage containers, and from then on, you handle it as a container.

The concrete canisters, which I showed, they are being used, as I said, at the retired station. Here's a picture of the storage of these canisters at the Douglas Point Nuclear Plant, and here is what we are doing with the DSCs.

This is at the Pickering Station. What you see here is our dry storage container storage, so we will euphemistically call it the Canadian MRS, because it's the dry storage, and it fits in between now and the disposal time, and this construction started about a year ago. What you see at the front is the operations yard, where the DSCs are looked at, sealed, and all that. It's a two-level; office is on the top, and what you see here is the first phase of the DSC storage yard at Pickering.

All together, we have plans right now to build for about ten years of storage. That's phase one. But, later on, we'll be building much more as the Pickering continues to operate.

Here is an artist's drawing of the facility. This is the operations area, and this is the storage, expected storage site.

The dry storage container, just to show you some of the details, as I said, is concrete, has got steel liners inside, as well as outside. The concrete is a special high-density concrete, specially developed for this purpose; holds four fuel modules. Fuel bundles are handled not one at a time. They're handled in modules of 96, and one of these DSCs hold about 384 fuels in four modules.

The lid is sealed for safeguard purposes, and, also, what you don't see on this picture, there is a little pipe that goes around the fuel in two different directions, into which an optical fiber is put in so IEAE can check once in awhile if they want to see whether the fuel has been tampered with.

So, the DSC, as a storage system, is a licensed system, and we're building it. Our next thing to look at is DSC as a transportable system. That work--we are just completed. It went on for the last three or four years.

For the purpose of storage, we took up demonstration programs with two DSCs. We built them, we loaded them. This is loaded under water instead of above water, and they're dried after that, as you can see here.

Afterwards, the DSC is taken out, dried, and taken to the yard, and we have done all kinds of tests on monitoring of the releases, and things like that.

What you see here is a picture of the loading of one of the prototypes of the DSC under water. Here's the loaded DSC, sitting on a trailer bed before it's moved out.

Now, coming to transportation, the work has been going on, and it needs some transportation overpacks to make it qualifiable to the international standards. What we have done is put a--this one is gone, so we'll have to deal with one.

What we have has got the foam-filled impact limiters, has got an additional armor to take the drop and punch tests I'll show you in a minute, and we have done all the IEAE requirements, the requirement tests, the torture tests, as we call them, as well as this drop analysis, to make sure, with the computer models, we can validate whatever we observe.

Here's a picture of the DSC overpack. What you see here is the foam-filled overpack. What you see here is the armor. Now, with this armor and the overpack, we have qualified them. We just finished one series of tests about two weeks ago. Here is a DSC being dropped. Here is a damaged overpack. We got that overpack--the concrete will get a little bit of the beating, even though, one year ago, we noticed it's still qualifiable from the regulatory standpoint, but our engineers were not happy enough. They wanted to develop this armor and test it again.

Now, in this case, we see the damage on the overpack, the foam-filled container outside. Here's another view of the damaged overpack.

So, as far as the transportation is concerned, I think we are quite happy. Now we are prepared to direct the resources from storage and transportation research on the DSC to the disposal end of it, and that's where we feel there are a number of issues that we have to identify.

There is a three-year scoping committee which we established to look at the broad view, what the strengths and weaknesses are, and identify an R&D program, and at this time, we think, by that time we would have gone through the concept hearings on disposal. We'll know whether geological disposal is acceptable to the public, and the next stage would be the optimization, and this particular program can fit into that optimization phase on the geological disposal program.

Well, the main benefit we'll see in using DSC for disposal is we can get rid of the so-called, the titanium container, which we have in the reference plan, which needs extensive surface facilities at the disposal site; something like a $2 billion capital program to build all those facilities. Now, with the DSCs, you don't need that plan. Instead, of that, DSC may have to have some overpack for disposal purposes, and that will be one part of the R&D program that we'll take up on the DSC.

The disposal key conditions, this is for the reference concept. Here I'd like to mention a little difference between, I think, the American state of things.

The Canadian regulations are less restrictive. They went to the R-104, which is our regulatory guide. It specifies the risk criterion for disposal, but it doesn't come specifying each individual component of the container or the backfills or the geology, et cetera, so we have a little bit more flexibility in matching a design to the site, I think, and so these conditions which we have for the reference concept, the 500-year containment, 13 MPA pressure, which is the hydrostatic pressure and the buffer swelling pressure, 100°C temperature, the 5 W bundle heat based on a ten-year cooling.

All these are, to some extent, flexible, and we can adapt the DSC to suit a longer cooling period, different kind of buffer/backfill element, different kind of containment requirement, and the pressures.

I don't wish to go into the details of this thing, but I'd like to highlight a couple of things that seems to jump out, of the need for R&D, because we've got this DSC.

One is the mechanical handling element. DSCs are pretty big, and the typical, conventional way of handling, with a head frame may not be the best way to go. We may have to look at other ways of handling it, like a ramped access or things like that.

The reference concept looks at putting the containers in boreholes in the tunnel. We may have to get out of that concept and look at interim placement of the DSC in a vault. In terms of the other items, they are pretty much what you would expect in an R&D program for the DSCs.

I'd like to highlight the hydrogen generation issue. The Canadian Reference Concept does not look at gas generation in the vault, because the thinking goes like this: Everything is designed without steel, so there is not much of corrosion in the vault, so we expect things like hydrogen gas generation may not become an issue with the reference concept, but with the DSCs, it's a different thing. There's so much of the rebars and steel there, so we may have to look at the gas generation in the vault. Since our present modeling program don't include it, that's a major R&D thing that we'll look at.

Performance and cost issues, the DSCs, as a storage system, we have already looked at the costs. They compete very well with wet storage, but whether a DSC with the additional things that you are to put on them for the sake of disposal, whether that will compete with our reference concept, we haven't got all the answers yet. We'll have to go through the R&D program, then look at our performance assessment, the cost, the systems cost, and see how well they fare.

So, just to conclude, I think that's the major points I wanted to make. It's licensed for storage. We think it's transportable. We were licensing it for transportation as well, and we need to go with a sort of fairly comprehensive R&D program for qualifying DSC for disposal, and that's where we are at.

DR. VERINK: I understand that you've been considering other materials besides the titanium that you mentioned. Is there a parallel path for any of those, or is this only going to be done on the titanium?

DR. RAO: Okay. In the Canadian Nuclear Fuel Waste Management Program, there have been a number of alternatives for the corrosion-resistant containers that have been looked at, but two front-running ones are the titanium container and the copper container.

Now, for the purpose of the environmental impact statement, the referenced container is a titanium container. Now, the copper container is there in the back pocket. A lot of research has gone into it, but that's not the reference concept.

But in terms of the systems factors, whether it's a titanium container or the copper container, things are the same. You have to put the fuel in metal casks, then reload again. All those things are there. So DSC is a clear alternative which we want to look at in the optimization phase of the program.

DR. VERINK: The hydrogen sensitivity might be a little different.

DR. RAO: Pardon me?

DR. VERINK: The hydrogen sensitivity might be different.

DR. RAO: Right.

DR. VERINK: First, the Board. Any questions from the Board?

(No audible response.)

DR. VERINK: Staff?

(No audible response.)

DR. VERINK: Any questions from the audience or the panel?

(No audible response.)

DR. RAO: If I may add one line about the previous speaker's talk, we have been involved jointly with the EPRI program on the dry storage durability experiments, and we have those programs going as a sort of a long-term program. I think you mentioned about $700,000 on it. We spend something like a million dollars a year on that part of the research. We've got prototype dry storage containers loaded with the fuel which we are monitoring.

DR. VERINK: If there are no further questions at this time, I think we'll pick up the time, then, on our schedule so that you'll have more time for discussion at the end.

The next paper will be presented by Dean Stucker, "Interactions of Repository Design MPC/MPU Design."

MR. STUCKER: Good morning. My name's Dean Stucker, and I'm the Field Engineering Branch Chief for the Yucca Mountain Project Office, and I'm here to discuss the interactions of the repository and multi-purpose canister designs. I want to discuss some the challenges and risks associated with those interactions, and I think that the challenges and risks that we want to talk about today are really related to the initial acquisition of some of the initial MPCs related to the overall MGDS design process.

Because of where we are in the repository waste package process, many of the criteria specifications needed to meet 10 CFR 60 requirements will be established or validated during the site characterization process. Until those have been established or validated, we're taking a conservative approach and establishing the criteria constraints in a conservative manner. Those assumptions also have to be factored in with costs. The conservative assumptions need to be factored with appropriate cost.

I'd like to talk a little bit, get into a little bit of the detail of what our MGDS design process is. You'll hear me talk about the repository waste package or MGDS process. I prefer the MGDS, mined geologic disposal system, because it has a connotation that it is an overall system, versus a single element of that system.

Our process is laid out in phases. We have completed the SCP conceptual design, which is in our SCP, and we have just initiated the next phase, which is our advanced conceptual design. When this phase is completed, we'll start our license application design phase, assuming that a determination of site suitability has been made, and at the completion of the license application design phase, we'll submit a license application, and then we'll go into a final procurement and construction design phase.

Maybe I misstated this. Before we submit the license application, at the conclusion of the license application design phase, a determination of site suitability will have been made. If the site is determined not suitable, we won't go forward with a license application and look at alternatives.

There are three key components to the MGDS design process, and they're shown at this level, at this level, and at this level. I think you can caveat it by saying that the activities or products, the three activities or products of the design process are--and I caveat this bottom one as the scientific basis. That's the testing, the performance assessments, the analysis. The scientific basis for the design is shown at this level. The design input, design requirements, criteria constraints are shown in these upper boxes, and, of course, the design output, the architecture or configuration is shown with these output phases.

It's important to note where we are within this overall process. We have just initiated the conceptual design, and because of budget constraints, we're not very far along in the advanced conceptual design, and I think therein lies some of the challenges and risks with the MPC process. The MPC process will, of course, go way beyond the repository process, and what we're looking at is the very early initiation of a potential MPC, making those conservative assumptions, because we really have not determined the scientific basis of the design input. We're making those conservative assumptions for those potentially early MPCs.

I've listed some of the key criteria or specifications that will be needed to meet 10 CFR 60, potentially related to the MPC here on the next couple of view graphs. Of course, thermal loading is a very important driver, the criticality, containment, potential filler materials, the container temperature, the basket, and some of the other items of the waste package; and related to the repository operation, other key drivers are concept of operations, emplacement mode, backfilling, retrieval strategy, drift size, ventilation requirements. I'll talk in detail about some of the more important ones there.

Of course, Hugh Benton will talk exclusively on thermal loading next, and the thermal loading is planned to be extensively investigated during the site characterization process. Because of its importance, and its possible relationship to the early potential MPCs, we have initiated a study that is looking at, are there ways that we can accelerate the start of some of the in situ testing related to thermal loading, and accelerate some of the performance assessment or other scientific basis that will lead to establishing what our final criteria is for the thermal loading.

Related to criticality control, 10 CFR 60 is very specific on what the requirement is. There are criteria that needs to be established on how we meet that if we do go forward with a large MPC. We are assuming burnup credit as part of that criteria to meet this 10 CFR 60 requirement.

Related to containment, containment not less than 300 nor more than 1,000 years after permanent closure, the way that we are approaching that is right now we are looking at containment to be well over 1,000 years for the waste package. If we're going forward for the MPC, the credit for the containment will be provided by the overpack, or the disposal container around the MPC.

Of course, the container material will have to be qualified material that meets the requirements. The closure must consist of a full-penetration weld at least the wall thickness, and that, again, is for the overpack or the disposal part of this.

As far as filler materials, they could perform several functions. We haven't, again, with where we are in the process, we haven't determined what or how or if filler materials will be used, but they could perform several functions; stability, assist in heat removal, provide some chemical buffering, assist in criticality control, and the current MPC designs would allow for the possibility of adding filler material if, as we go through the process, we determine that it's needed.

I kind of lumped a bunch of these at the end, under concept of operations. The initial look that we did with the MPC designs, the conceptual designs related to the repository waste package did look at some early stuff. We looked at the development, emplacement, and retrieval operations, heat output, shielding requirements. We looked at remote handling of the waste packages, looked at waste transport, radiation levels, and factored those in, provided some of the criteria to the MPC conceptual design, and I think that kind of concludes.

I went through that very rapidly and left quite a bit of time for discussion or questions.

DR. VERINK: Are there questions from the Board? Dr. Cantlon?

DR. CANTLON: Since you have, in your last overhead, talked about remote handling, you don't have, then, self-shielded canisters; is that correct?

MR. STUCKER: The concept right now is that they wouldn't be fully shielded, and so additional shielding would be required in those areas.

DR. CANTLON: Are you talking about drift emplacement or hole emplacement?

MR. STUCKER: We're looking at a lot of different concepts. Drift emplacement is one. Our reference case, of course, is laid out in the first SCP, which is borehole emplacement, but we are looking at a lot of different concepts, and to tie in with what's going on with the MPC, one that's being evaluated right now is the drift emplacement.

DR. BARNARD: Bill Barnard; Board staff.

Dean, you mentioned that you were considering containment to be well over 1,000 years. Could you be more specific? Is that 5,000 or 50,000, 100,000?

MR. STUCKER: Well, in order to meet the thousand-year criteria, the design will have to be well over that to assure that we meet the minimum of 1,000 years. Where we are in the process, we haven't determined as to what the exact design criteria will be for how many years, but right now, we're carrying it as well over 1,000 years, and that ties into, again, we're very early in the process for the overall repository waste package design.

MR. McFARLAND: Russ McFarland; Board staff.

Dean, you made a comment that you are currently considering options to move ahead on thermal testing. Would you briefly mention what those options are you're considering?

MR. STUCKER: Yes. We just initiated a study and are just getting into the details of what that study should be, but we're looking at how we could accelerate some of the in situ tests related to thermal loading, what could be done to start those earlier, and what the costs might be associated with several different options of starting that earlier.

Since we have just started it, I don't have anything I can lay out as far as what the options might be, but we think that there may be some advantages and some options that could help us get started earlier with some of the in situ thermal tests.

Also, related to the performance assessment side, we're looking at, again, some of the thermal-loading studies that are currently going on to be accelerated to give us some early feedback.

DR. VERINK: Bill, did you have a question? Dr. Price?

DR. PRICE: Is it a fair characterization to say that the uncertainties that exist regarding the repository are being reflected in the MPC early concept designs so that, perhaps, the selection of materials, and so forth, is basically focusing on its dual-purpose characteristics; that is, storage and transportation, rather than its tripartite role; storage, transportation, and disposal?

MR. STUCKER: Jump in and correct me if I misstate something, but my understanding is probably the internals of the current MPC design are looking at the long-term repository aspects, but the material of the container itself, we aren't looking at taking credit for that, because we're not far enough along in the design process to say we absolutely know what we want the container to be constructed out of. Therefore, for the first ones, if we go down this path, would have a--the overpack would take the full performance requirements for the containment material.

DR. PRICE: So, as I understand your answer, you view that there may be some reassessment down the line somewhere that may affect the canister materials and the canister design as these uncertainties become clearer, but for the present interim storage needs, you would go with, perhaps, a dual-purpose emphasis; is that correct?

MR. STUCKER: I think it might be better stated that if you put up whatever the MPC design acquisition process is, the early ones, the first initial few, we're looking at what criteria can we put in there that we know that are good, conservative assumptions, but as that process for the MPC would unfold, there's a point down here that you'd be acquiring MPCs, and you would assure that they meet whatever the requirements are that we have finally established and validated through the site characterization process.

So, future MPCs, if we go down this path, you may make the container out of material that we would definitely take credit for, but at this point in time, we think it's probably more cost-effective to look at the containment being just within the overpack.

DR. PRICE: So you're going to rely on the overpack at this time for compatibility with the MGDS; is that a fair statement?

MR. STUCKER: Right, and I think that just goes into being cost-conscious, not knowing what that material should be; go forward with a conservative approach in that area.

DR. VERINK: Dr. Cantlon?

DR. CANTLON: What provisions for corrosion tests are in your assumptions here?

MR. STUCKER: Again, if you look at this process, the scientific basis--I might back off and say the responsible design organization for carrying out the design, of course, is our M&O, who is also the responsible design organization for an MPC, if we go forward with that.

We're relying very heavily on the labs and the USGS to provide the scientific basis. The testing, lab testing and actual site characterization in situ testing will be carried out for the site characterization period, which is many years, and there are tests, there are corrosion tests being conducted right now in the labs at Livermore, and plans are, as we go through this process, to enhance those where needed.

MR. VERINK: Dr. Di Bella?

DR. DI BELLA: Carl Di Bella, Board staff.

Dean, regarding fillers, do you have any sort of plan of investigation or time table for what you're going to do with the filler area yet, and, if not, are you going to be developing one soon?

MR. STUCKER: Again, since we're just in the very early stages of the advanced conceptual design, we do have plans to look at what might be needed, what might be the purpose of a filler material. I might ask Hugh Benton if he can elaborate on any of those.

MR. BENTON: We will be developing a schedule for how we're going to look at the need for fillers.  The fillers may be more required for criticality control than for any other reason, and we do not yet--we haven't advanced the design far enough yet to decide what the odds are that fillers will be required, but we will be developing that in the coming months.

DR. VERINK:  Yes, Dr. Åhagen?

DR. ÅHAGEN:  I have two questions.  One is from yesterday's presentation, this preliminary evaluation of the costs and the benefits between the MPC concept and the two concepts that are falling right behind.

Have you done any analysis of what the effect would be if you had to leave the MPC concept for another one that didn't cost that much, what that impact would be in terms of cost; and the other, if you consider a staged licensing approach--I read a thing on the way over here that, I don't know what the status is, perhaps, but one of the significant impacts of cost is what date can you do the investment?

MR. STUCKER:  To answer the first part of the question, we haven't--I don't think there's been detailed cost estimates on what would happen if we didn't go with the MPC.  You have to understand, the MPC is only one concept that we're looking at, amongst a family of concepts here in the early part of our design, so we haven't looked at what, you know, if we don't go with that, what the impact would be.

Can you state the second part of that?

DR. ÅHAGEN: Yeah, the second part is the date of investment.

DR. VERINK: Could we have an addition here from another on the same question?

MR. WILLIAMS: Yeah. This is Jeff Williams with DOE.

On the first question, yeah, we are looking at the contingencies of if an MPC doesn't work, and the study is still in the preliminary stages. I think the dollar value of it, if you had to take them apart or throw them away, was on the order of $400 million addition to the system cost. There could be less cost to that if you could modify the MPC to make it work, so we are looking at that. That information isn't quite available yet, but it should be soon.

DR. ÅHAGEN: The other question was the impact of the date of investment. I don't know how you calculate your fee and your funding, but if you calculate the real interest, the date of investment becomes very important in these operations.

MR. STUCKER: Jeff, you may want to address that.

DR. ÅHAGEN: So that if you go to a phased licensing approach, you would delay some of the major investments, and that will have a significant impact on your costs, because you will then gain real interest on the money you have in the units, and so I wonder what that impact is if you go to a phased licensing approach, and if you have taken that into account.

MR. STUCKER: I don't think we have taken it, you know. I think there are some things being looked at for a phased license approach, but that's at a higher level than at the project office, and we haven't, I know, within the design process, looked at what that impact might be.

DR. ÅHAGEN: I have a last technical question. That's the technological gap in the welding. We have a big discussion going on right now, what do we know, or with what certainty can we close our top lid on our canisters? We're right now initiating a very big technology program--too late, I would say. We should have started that several years ago, but the major concern is now if we can meet the performance goals of initial canister damages, for example.

I mean, what is the technological gap in closing these MPC canisters compared to the temporary lid concept?

MR. STUCKER: Well, I think it--again, tied back into what our process is, it would get to the MPC concept. We're taking the credit for the containment, the credit to meet the 10 CFR 60 requirements would be overpack, the disposal canister over the MPC, and that's where the critical weld would come into meet the long-term 10 CFR 60 requirement, where the closure of the MPC, that, at this point in time, wouldn't be needed to meet this 10 CFR 60 requirement. It would be needed for the storage and transportation aspect, which is a short term compared to the disposal part of it.

DR. VERINK: Okay. Well, I think we'll have to conclude this paper and start on the next one. Thank you very much.

MR. STUCKER: Okay. Thank you all.

DR. PRICE: Could I ask him one real quick question, just real quickly?

Do we face the possibility that if heat-loading requirements for the repository were such that you had to do a lot of repackaging of the MPC, that we're going to get into sufficiently more handling, that it's going to obviate the value of the MPC?

MR. STUCKER: I think we'll get into some of the thermal-loading discussions. Potentially, there will be a higher cost if, because of the thermal-loading question, when that's answered, you have to handle numerous units, numerous waste packages, but as far as the storage and transport, you still may be able to use a high number of units in the storage and transport.

I don't know if that answers the question, or maybe Hugh can elaborate on it.

DR. PRICE: I'm told I should have saved my question until after your presentation.

DR. VERINK: All right. The next presenter is Admiral Hugh Benton from the M&O, "Compatibility of MPC/MPU Designs with Repository Thermal-Loading Strategies."

MR. BENTON: Good morning. I'll be discussing the effects of the multi-purpose canister on the thermal loading in the repository. We'll look at the MPC implications on thermal loading, at some of the design criteria that are related to thermal loading, what the thermal-loading decision strategy is.

The strategy is not schedule-driven; however, the strategy has embedded in it the need for certain scientific tests which we expect to be developed on the schedule, so the schedule is important. And then, finally, we'll look at the decision risks of proceeding with an MPC under the assumption that it will be a tri-purpose canister, without knowing everything we need to know about the thermal loading.

Now, with or without a multi-purpose canister, thermal loading is an extremely important issue for the repository. It affects both the magnitude and the content of the site characterization. It affects how many acres we need to characterize, and it affects the specific tests that would be needed to be done in order to determine whether the site would perform properly under whatever thermal loading is selected.

The material selection, as well as the design of the waste package, is also affected, since the thermal loading and the material will need to be coordinated such that we get the maximum life out of the waste package.

The repository design, the length, obviously, of the drifts, even, perhaps, the diameter of the drifts, the operation of the repository would also be affected by the thermal loading.

So all of this, along with many other things, of course, affects the overall system performance and, therefore, its ultimate licensability.

Now, there are factors affecting the thermal response of the waste package--and I'm using the term "waste package" to mean multi-purpose canister, plus its disposal container surrounding it--the thermal loading, either expressed as areal mass loading, the number of metric tons of uranium per unit area, or as areal power density, the number of kilowatts per unit area, are certainly key factors.

The waste package size, the heat output of the waste package, which is a function of the waste package capacity, plus the heat output of the individual assemblies in it.  The decay heat of the spent nuclear fuel is governed by how long it has been since it was discharged from the reactor, and its initial enrichment.

The materials of fabrication, although the thermal output of the assemblies affects many parts of the system, as it's currently envisioned, the repository, the need to get the heat out of the assemblies and into the repository environment, which is a relatively poor heat sink, is probably going to govern materials of fabrication not only of the disposal container, but of some of the internals of the multi-purpose canister, since we need to be able to have good heat conduction throughout the system.

Of the two primary types of designs for criticality control, either the flux trap design or the burnup credit and Poisson design, these have different thermal characteristics. In general, the burnup credit design will give us better heat conduction and better ability to remove the heat from the assemblies.

And, finally, the drift size is another factor affecting thermal response, in that the larger the drift or the larger the borehole, the more area of rock we have to dispose of the heat.

The thermal loadings can be looked at in three general regions; low, medium, or high thermal loading, low meaning with a temperature below boiling throughout, the medium region including the SCP at 57 kW/acre, where the repository is relatively hot, and you would expect the waste package to stay above boiling for maybe on the order of at least a thousand years, and then a high thermal loading, which has also been known as the extended hot or extended dry, in which the waste package must stay above boiling for many thousands of years, maybe 10,000 years.

Now, of course, these packages are all relative. We could say that this is a warm, because, clearly, it's got to be well above ambient, and it is, in some respects, that could be called reasonably high, and then the SCP is considerably warmer, and the extended hot would be much warmer than that.

The MPC with its disposal containers could be of any size and fit in either the medium or the high thermal-loading regions. However, only a fairly small MPC, one which did not hold too many assemblies, would be needed for the low thermal loading.

For emplacement mode, any of the emplacement modes, either the vertical or horizontal borehole, the horizontal borehole containing only one waste package, or a horizontal borehole which contained several waste packages, or drift emplacement, any of those would be suitable for the low or medium thermal loading. However, for a high thermal loading, since, in order to achieve that we have to concentrate the heat, we would need the large waste packages in a drift emplacement, or in a large, horizontal borehole.

For the emplaced area, for the medium range, the SCP, the area required is about 1250 acres. For a low thermal loading, it might be of the order of about twice that. For a high thermal loading, the area required would be of the order of about half that.

Pictorially, that would look, for a high thermal loading, something of the order of 630 acres. This sample here used 22-year-old fuel, with 42 GWd burnup. For the particular fuel, the mid-range of thermal loading would require about 1300 acres. If we went to a low thermal loading of only 25 kW/acre, then the amount of area required would be about 2900 acres.

If it is determined that the best thermal-loading strategy for the long-term performance of the repository is a low thermal-loading strategy, where the temperatures are kept below boiling, then there are certain implications of having a large multi-purpose canister.

If you have a large multi-purpose canister with the design base of steel in it, fuel that has not been pre-cooled for some decades, then significant portions of the rock will be above boiling. That's going to occur in the immediate vicinity of the waste packages, and that will obviously reduce the overall effectiveness of the cold strategy, of the low thermal boiling strategy, and whatever deleterious geochemical effects occur because of an above-boiling condition, will occur in the vicinity of those waste packages, even though you have selected as your overall strategy low thermal loading, in order to avoid those deleterious effects.

The models to date would indicate that there would be a significant water reflux of water and water vapor proceeding from the area of the hot waste package, and then proceeding over into the areas where the waste packages are cooler, or the spaces between the waste packages, and so you would have water moving in the immediate vicinity of the waste packages, and probably condensing in areas where it could affect the long-term performance.

Since these large waste packages are going to be spread very far apart in order to achieve a low thermal loading, you're going to have large temperature variations along the drift.

The design criteria was, of course, given to us by 10 CFR 60, and Part 60.133 discusses the performance under thermal load, and requires that we consider the thermomechanical response of the repository. Similarly, 113, in discussing the need for substantially complete containment for 300 to 1,000 years, also requires that we consider the thermal characteristics, the thermochemical, geochemical characteristics of the site.

We are using these temperature goals, 350°C to protect the fuel element cladding, and allow us to consider that as a barrier to the release of radionuclides; 200°C one meter into the rock is intended to protect the rock, the mechanical stability in the rock.

Criticality is less directly related to thermal loading, but this is an absolutely key design criteria. The life of the waste package, which does relate to thermal loading, will have an impact on how we handle the criticality issue.

Finally, subsurface operations, both the operability during the pre-closure period, the weight constraints of the waste package--which have not been finalized--will be considerations. During the emplacement period, we would need to have the access drifts reasonably cool, but we're assuming that this can be achieved through ventilation. Radiation shielding is another criteria which could have an impact on thermal loading if the radiation shielding results in a poor heat transfer throughout the waste package.

Now, for a 21PWR MPC in a 25-foot drift, at the SCP range of 57 kW/acre, these are the temperatures that we would expect to see throughout time, this being a log scale out to 10,000 years. The peak fuel temperature is calculated by two different methods; an effective conductivity method, and a Wooten-Epstein method. At this point in our conceptual design phase, we think these are pretty close. They are complementing each other, they are tending to reinforce each other. We will, in the coming months, be developing a much more detailed model of the heat transfer of the individual assemblies, modeling each rod, and that will determine where the actual line should be.

You'll note that the peak fuel temperature, the peak cladding temperature occurs quite early in the process, maybe in about the first or second year, and then, at each successive barrier to the heat as it goes out, the peak occurs later. So, the peak at the surface of the waste package may occur in about ten years. The peak in the rock wall may occur about in about 100 years.

I'll discuss a little bit about the decision strategy for thermal loading. The goal, clearly, is to develop an overall system for disposal of the waste so that all of the various elements of the system will contribute to meeting the requirements. That's not only all of the parts of the MGDS, both pre-closure and post-closure, but also, the other parts of the system, such as the monitored retrievable storage and transportation.

We want to make appropriate use of the repository waste heat, and what particular strategy is selected will determine whether the appropriate use is to develop ways to get rid of the heat as well as we can, so that we can have a very low thermal loading, or whether the appropriate use is to hoard the heat so that we can heat up the rock and develop a high thermal-loading strategy, which might keep the waste packages away from aqueous corrosion for extended periods.

The thermal-loading decision requires integration and a systems engineering approach to the site characterization and design, performance assessment, and, also, the MPC studies, and all of these are being done through an extensive thermal-loading study, really a series of studies which is being done by MGDS systems analysis, and the thermal-loading study is using inputs from the laboratories, the modeling and code development, as well as the field testing. This is both the large-block test that has been discussed before with the Board, and the EBS field testing, which will occur later.

Performance assessment calculations will be folded into the thermal-loading study, as well as the MPC design studies, the conceptual design, and, eventually, the final design.

This diagram has been shown by systems analysis to the Board before, so I will not dwell on it. Here we have the implementation activities of the MPC, the feasibility study and the conceptual design having been completed. These are being integrated through the system-wide studies with the activities which are occurring in Las Vegas and out at the site, site characterization, the modeling which is being done there and at the laboratories, and then these are being integrated with the MGDS systems studies, and, particularly, the thermal-loading studies. This is an approximate time scale of where these various activities will occur, reaching an eventual decision on what is the best strategy.

And, what are the risks if the strategy turns out not to be optimum for the MPC? A large MPC, one holding 21 or 24 PWR assemblies may have some implications for thermal loading, but we are looking at this, at this point, very conservatively.

First of all, our design goal is not to require additional blending or tailoring of the fuel at the repository, so we want to be able to assure that whether or not we have an MPC, we do not require lag storage and additional blending of the fuel before it goes into the waste package.

If that tailoring can be done at an interim storage site, or at the reactor sites, either by tailoring the fuel age requirements through differential loading, or by leaving the center assemblies open, then we will be able to accommodate virtually any size MPC under virtually any thermal-loading strategy.

If the thermal-loading strategy turns out to be high, then we see no risk of not being able to accommodate any size MPC. If the thermal-loading strategy turns out to be low, we are not able to do either of these so that we have large, hot MPCs in the system, then in order to accommodate a thermal-loading strategy of low, we would need to pre-cool that MPC for some period of time, which could be on the order of 20 to 50 years or so.

So there is a recognition that proceeding with an MPC in advance of a thermal-loading decision has some risks. It's less flexible if we're going to minimize local boiling. We're not going to know the scientific background of a thermal-loading decision until the time frame of '97 to '99, and if we wind up with a low strategy and large, hot MPCs, they may have to end up to be dual purpose.

But, by that time, we'll only have on the order of one to two hundred MPCs that will be in the system, and so, in worst case, if those had to be modified or even unloaded, it would not have a major impact on the program as a whole.

Subject to your questions, that's all I have.

DR. PRICE: May I now offer my question that I did before?

MR. BENTON: Yes, sir.

DR. PRICE: And that is, given the worst-case situation where you had to use it as a dual-purpose canister and had to repack, would that obviate much of the advantages that would, in fact, have been proposed or programmatic in management for the MPCs?

MR. BENTON: I would, if I could, like to refer that to Alden.

MR. SEGREST: Of course, the greatest benefit for the MPC is if we can use it for all purposes. We have performed some risk analysis, such that we'd only be able to use it for two purposes, and, as you would expect, only being able to use it for two purposes does negate some of the benefit. However, because of the various benefits without reactor storage, the possibilities of not having the MRS, the possibilities of delays in various elements of the system, the MPC still looks good, and the risk is calculated, and we believe the risk is relatively low.

I believe the overall risk to the system is to the tune of about $400 million, $400-500 million if we reach a point--and it might be '98 to 2000--identifying that the cans that have been developed and deployed are not suitable for disposal.

MR. BENTON: I would think it unlikely that, at that point, you would have some set of conditions which would make further use of the MPC have to be dual purpose. I would think that either through interim storage, or through some other system, mechanism, you would be able to accommodate a tri-purpose MPC. Dr. Starr, yesterday, mentioned the advantage of interim storage as a means of being able to control the thermal characteristic of the repository, so if we have an interim storage capability, then, clearly, the MPC will be used.

DR. NORTH: Warner North; Board.

I'd like to pick up on that theme and ask if you've done some sensitivities with the respect to the length of cooling of the fuel with a large MPC, with respect to the problems you mentioned for, let us say, a low temperature repository scenario with the lumpings of these large containers and the local heating effect.

What happens to the magnitude of that problem if we delay closure of the repository and continue ventilation? Do we largely eliminate the problem, or do we find that still, after 50 years or 100 years of additional cooling, we still have a problem? Has that investigation been done?

MR. BENTON: The investigation has not been done quantitatively. We are just getting started on those kinds of thermal analyses. I think, clearly, the time frames you've mentioned, 50 to 100 years, the heat output will be well down, and any kind of thermal problem will--of too much heat will be gone.

DR. NORTH: I think one has to be careful of that conclusion, depending on what the thermal-loading requirements are, because at a certain point, the actinides start to dominate the heating, the decay doesn't fall off so fast. That's the area I would like to see carefully investigated from the point of both the repository design at the MPC issue, as well as the performance assessment.

So, for those that are listening in DOE and the M&O, put that on your list of things that I'm going to continue to ask you about as long as I'm on the Board.

MR. BENTON: Well, we definitely agree with the importance of doing that, sir, and we will get to that as quickly as we can, but these analyses take quite awhile.

DR. NORTH: Understood.

DR. VERINK: Thank you.

DR. NORTH: I find it interesting, just to continue a comment. We, on the Board, became worried about these issues a few years back, and we're delighted to see the program now doing the kind of analysis that we felt needed to be done.

DR. VERINK: We'll take a quick one, and then we'll have to go on.

DR. LANGMUIR: Hugh, it looked as if your analysis of thermal loading, as it would give you the low, medium or SCP, or high consequence did not consider, or you weren't evaluating the effects of passive cooling systems, like heat pipes, designs that would allow ventilation naturally to occur.

Have you thought about those things? Is that part of your analysis of what could ultimately control it?

MR. BENTON: We have certainly thought about it. We are using the models that are being developed at Lawrence Livermore. They do not include large heat pipe effects because the Lawrence Livermore people, at this point, do not believe that that will probably occur.

As those models are further evaluated, certainly, if heat pipes are going to happen, then we will definitely have to evaluate those, because that will interject a variability in the thermal loading, which might be quite severe.

DR. LANGMUIR: I was thinking of the other kind of heat pipe, as well; the engineered heat pipes that one could install.

MR. BENTON: We have not considered that. At this stage, we have not considered that; artificial ventilation of any type. We have made, at this stage of our conceptual design, a conservative assumption that perhaps the NRC would not consider any type of ventilation sufficiently reliable, and that's what we would depend on to keep the repository at whatever thermal loading we had decided was optimal.

MR. SATERLIE: Hugh, I wonder if I might amplify on that, just briefly. I am Steve Saterlie of the M&O, and I'd like to let you know that the subsurface people at the M&O are doing some studies on ventilation, and, to date, the first preliminary studies have just looked at active ventilation concepts, but they are working with one of the professors of the University of Nevada, Reno, and I'm sure that they are planning to continue those studies on the various ventilation concepts, so we are looking at that.

DR. NORTH: The professor you mentioned is George Danko?

MR. SATERLIE: Yes, it is.

DR. VERINK: Well, thank you very much. I think we'll have to move along to the next speaker now.

The next speaker will be Jeff Williams, and he may have some additional help from Dean Stucker. The presentation is, "Compatibility of Existing Interim Storage Systems with the Waste Disposal Handling System."

MR. WILLIAMS: I'm going to talk about compatibility of existing interim storage systems. We've heard a lot about those from a number of speakers today.

First, I'm going to tell you about how much interim storage is anticipated over the life of the system, and then I'm going to tell you a little bit more about the existing technologies that are present, and then touch a little bit on the future technologies, and talk about how they're compatible with storage and transportation, and then I'm going to ask Dean to say a few words about compatibility with the repository, or the existing storage system.

This is a graph that we've developed through a number of the system studies that we've done over the past years, that basically shows a comparison of out-of-pool storage requirements if you have an MRS, if you don't have an MRS, depending on what the size of the MRS is. Basically, what it shows you is that if the federal waste management system starts to pick up fuel in the near term, 1998, accept fuel either in an MRS that happens to be a small MRS, or a larger MRS, you can reduce the amount of out-of-pool storage quite a bit. But if you don't have a repository until the year 2020, you have no MRS, you will generate up to about 30,000 tons of spent fuel at the reactor sites.

This is of interest to the vendors. At $50 a kg, it turns into a cost of $1.5 million market for on-site storage, so you can see why there's a lot of interest from the vendors and why there's a lot of different technologies being developed.

I think you're probably aware. This is just showing you where spent fuel is stored today. We have the Palisades reactor up here that Mary Sinclair talked about; Surry in South Carolina; H.B. Robinson; Oconee; the Fort St. Vrain reactor has been shut down; and INEL, the DOE facility. Calvert Cliffs, there's no fuel stored there yet; however, it's licensed and it should be soon.

We'll talk a little bit about the technologies. I think you've heard quite a bit about them the last day and a half, so I'll go through them rather quickly, but, basically, we've got metal storage casks at Surry. We've got two varieties of horizontal concrete storage modules at H.B. Robinson and Oconee. We have the vault at Fort St. Vrain, and we have the vertical concrete casks at Palisades.

You've seen a couple of these pictures before.

This is the Surry metal casks at the top. This is the movement of the Surry metal casks. This is the Oconee horizontal concrete storage module, into which a canister is emplaced. The canister is loaded in the reactor, and it's transferred by a transfer cask, which is then mated up with the storage module. The canister right here looks similar to some of the design drawings, I think, that Ron Milner showed yesterday about the MPC. This one has 24 PWR assemblies. The MPC had 21 assemblies. However, there are several differences between this canister and the one that's being designed for the MPC.

This, again, is showing the canister that I just showed is inside the transfer cask. It's pushed by a plunger into the concrete module.

This is the Fort St. Vrain vault. It's the only stand alone ISFSI, independent spent fuel storage installation, that exists today, and it is not supported by a reactor license or reactor pool. Now we go inside to the vault. The spent fuel is beneath the floor right here. This is the fuel handling machine. Alden talked a little bit about it.

Again, this is, I think Bob Bernero mentioned this is not like other reactor fuel. It's the only reactor in the country, commercial reactor that uses a high-temperature gas reactor, and the fuel there is carbon blocks that are stacked six high and placed into these canisters. Right now, these canisters are stored in the vault, and they are also not transportable; however, there is an effort on the part of Denver to get those canisters transportable.

This here is the VSC-17, the vertical concrete cask that was tested out in Idaho. It's a precursor to the VSC-24. This one was tested prior to the license, or the certificate that NRC granted for the VSC-24. This is what it looks like when it's finally constructed with the concrete all around it.

Okay, I just wanted to show you the diversity of things that are out there today. This one talks about dry storage that is in use today. There's a little bit of an error here on the Surry information. There's three different casks out there today. There's a GNS cask, a Westinghouse cask, and a Nuclear Assurance cask.

Then we have the concrete technologies. Again, there's two types of the NUHOMS. There's the 7 PWR element that was developed for H.B. Robinson, and then there's the 24 element, so they've got quite a bit of different size in the canisters; then the modular vault, and, again, the VSC-24 that I mentioned before. These are storage technologies that are in use today.

Now, there's several other technologies, and this list isn't all-inclusive of things that are also being considered in order to make up that $1.5 million market. Right now we've only--there's less than a thousand tons stored, so there's a big market out there for other things.

Trans Nuclear has a metal cask called a TN-24 that was just placed on the--given a certificate under the general license procedures of NRC. There's a different variety that's being considered at Prairie Island, called a TN-40, another metal cask. B&W has developed a different type of vertical concrete cask called the CONSTAR. AECL has developed a vault called MACSTOR. The B&W and TN-40 are before NRC for review. The AECL is not.

Foster Wheeler has developed a different type of vault for light-water fuel, which is called an MVDS, and it has an approved possible report by NRC; however, they haven't gotten a contract yet to do the reactor to build it on site. Burns & Roe also has a concrete vault storage design. GNS has their CASTOR X cask under review, and I've also left off a few by NAC, Pacific Nuclear, Sierra Nuclear, some of their other designs.

Now I want to talk about, how compatible are these with the existing systems? These were all designed for storage, and none of these concepts that I just talked about are licensed for transportation. I've got a statement up here that says they're unlikely to be licensed for transportation; however, I think I need to qualify that, and

I think some of the vendors may not like that statement. However, what I'm getting at is, under the current licensing procedures and practices by NRC, it doesn't seem likely. Right now, NRC does not allow moderator exclusion, and they haven't allowed burnup credit, and it's possible that they could allow a one-time shipment of these technologies; however, that's uncertain right now. Nobody has applied for that yet.

The moderator exclusion requirement really is applied to transportation casks, because of the possibility of a seal failure. We're talking about a metal canister that's welded. It would seem to me that it may be something that NRC would consider. However, we don't know that yet.

So, if they're not licensed for transportation, they would need to be unloaded and returned to the fuel pool, and NRC requires an evaluation of that process, and that was done at Oconee, and they determined that you can cut open a NUHOMS canister in the spent fuel pool or in the transfer cask. They looked at three different ways to do this, and it can be done, and NRC licensed it on the basis that you could return it and open it up.

Okay. Now, the next thing I want to talk about here is the new dual-purpose technologies. I think Bob Bernero mentioned these. There's the Pacific Nuclear one that's being looked at for Rancho Seco, and then there is the

Nuclear Assurance Corporation one, and with regard to Rancho Seco, the DOE did commit that once these are licensed for storage and transportation, that we will take appropriate action to include it as an acceptable waste form.

Today, DOE has the position on the NUHOMS canister that it's not a standard waste form. However, we have made a commitment that we would take these, once they're licensed for storage and transportation, to be an acceptable waste form, and it would seem to make sense that if the other existing storage technologies got certification or a one-time approval from NRC for transportation, that DOE should also consider those as acceptable waste forms.

However, there is an outstanding issue, and that's one of equity. If you have ten or twelve reactors out there that have developed canisters for storage, and DOE has to accept them, we need to look at the issue of the additional cost to DOE of accepting something that was built at the reactor site, but that shouldn't be a very big deal.

The next thing we looked at--this is relatively straightforward--is the compatibility of these storage technologies with the MRS. Basically, all of these can be used at the MRS. I think I briefed the Board a couple years ago on how our MRS design was designed around the existing storage technologies. We looked at, in the MRS conceptual design report, we evaluated vaults, metal casks, NUHOMS, the vertical storage concrete casks, transportable storage concept. However, we haven't looked at--we haven't looked completely, not fully evaluated what that does to the MRS facility in terms of a receipt. We don't think it will be too much of a problem.

Back in 1989, we did do an evaluation of most of the canisters, NUHOMS canisters at an MRS facility, and it added additional cost, but there was not any insurmountable problem.

Some of the technical issues related with these compatibility goals are burnup credit and criticalities is beyond several volumes, actually. NRC may allow you to use burnup credit if you're able to measure the burnup of the spent fuel. Once it's sealed in a canister, that's a problem, to try and measure it once it's sealed. However, you could go back to look at the existing records, and whether NRC will allow that or not, we're not sure.

Again, I mentioned moderator exclusion for criticality control. We see it's possible that the NRC would look at that for a one-time shipment.

The transportation structural criteria is a concern, such as the use of modular cast iron from this transportation cask. The NRC has certified modular cast iron transportation in this country.

Regarding the spent fuel characteristics, I think we've talked quite a bit about that. There are a variety of spent fuel characteristics out there, and when DOE develops, such as a multi-purpose canister, we need to consider a wide range of the spent fuel characteristics, and develop something that is best for the entire system, rather than on a site-specific basis, the way some of the storage technologies are developed. So, in terms of standardization, I think you all even touched on that. There is a variety of different fuel, and it may not be best from an economic standpoint to develop one canister that would accept every-- as I think Bob Bernero called it--cat and dog that's out there.

One other compatibility issue that we looked at was are the existing storage systems compatible with our MPC? And this past summer, we took our MPC conceptual design and sent it out to these vendors, and we got a response from those vendors right there.

Basically, what we were asking them is, what type of modification would they need to do to their storage technology to make this type of MPC workable? And we got responses back from all of those, and there was really not any major impact on any of them. I think for vaults, there was a larger impact and we need more evaluation, than such as Pacific Nuclear NUHOMS or Sierra's concrete casks.

In summary, I wanted to, before I get into Dean's presentation here, say that there are several technologies that are available. The amount of dry storage will increase, and will increase quite a bit if DOE doesn't begin to take fuel away from the reactors soon. An MRS, I think I showed, would reduce the amount of burden at the reactors. It's also anticipated that, as a result of this increase in spent fuel storage required, that there will be new and more different types of storage technologies that will be developed.

The existing at reactor storage technologies are not compatible with the DOE program. I think that needs to be qualified, as the statements that I said in the past, we could get one ton shipment approval from NRC; and finally, that we need to take appropriate action to make any anticipated transportation/storage technologies an acceptable waste form for the DOE program, and I think I'll turn it over to Dean, if you want to hold questions until Dean finishes up with this.

MR. STUCKER: I just wanted to point out that most of the interim existing storage units are not designed to meet the 10 CFR 60 requirements; therefore, they wouldn't be used for the disposal site. We would need to accept any of the systems that were transportable to the repository, and they would be re-looked at or repackaged into a waste package that was acceptable to meet 10 CFR 60. I have a couple of view graphs, just to point out some of the concerns.

If there were a variety of waste packages or overpacks, there is some concern that you really don't have standardization, and it would add to the cost and the complexity of the overall system.  It would really increase the complexity of the overall system, so, right now, those systems are not designed to meet the disposal requirements, and we would accept at the repository any transportable casks that, in the future, that were licensed, and we would repackage them to meet the 10 CFR 60 requirements, so I'll leave it at that.

Do you have questions to Jeff or me?

DR. VERINK:  Are there questions from the Board?

(No audible response.)

DR. VERINK:  Staff?  Oh, Woody.  All right.

DR. CHU:  I have a question for Jeff on the one and a half million dollar market for the vendors.  The assumption for that is that is the operating cost.

MR. WILLIAMS:  What I did on that was just a few minutes before I walked in here, was take $50 per kg--

DR. CHU:  No, I meant the chart, the very first chart that you put up.

MR. WILLIAMS:  Oh, how we arrived at the curves?

DR. CHU:  Yes.  That's the no new orders and something?

MR. WILLIAMS:  Yeah, no new orders, OFF, acceptance, then you look at each one of the different cases to determine where the acceptance is.

DR. CHU: Right. So that if a plant has been shut down and it desires, as Rancho Seco is now desiring, to move its fuel out of the pool, that kind of fuel is not in the graph; is that correct?

MR. WILLIAMS: That kind of fuel is not in the graph?

DR. CHU: It does not include--when you, in the first chart, it is for the out-of-pool requirements, dry storage requirements.

MR. WILLIAMS: Yeah. What that does, it takes the amount of spent fuel that's generated each year throughout the system, and then it looks at pool capacity, and then it goes reactor-by-reactor, and then calculates how much out-of-pool storage is generated, or is above that pool capacity.

And when that was done, I think when we ran that analysis, probably Rancho Seco was included as an operating reactor, so it probably would have ran out of pool space, I don't know, I'm guessing, 2015, 2020, so that would have been included.

DR. CHU: Right. So in the years 2015, 2020, there will be a non-trivial number of reactors that will have had their operating licenses expire, and if they don't renew, and if, also, if they want their fuel out of the pool, then that fuel will be above and beyond what's shown on the graph?

MR. WILLIAMS: Yeah. You're exactly right.

DR. CHU: Thank you.

DR. VERINK: Anybody else have a question?

DR. NORTH: Warner North.

I'll put this in the form of a comment. I find the last presentations do a good job of laying out a number of dimensions of the systems analysis problem, and I'm very pleased to see that. But, on the other hand, there's a lot of work to be done, because the diagnosis, really, is only in the first part of it. The scenario that Woody Chu just described, of supposing we have accelerated shutdown, so there are lots more Rancho Seco-type cases, we might have a much bigger bump on your first graph, so, yes, there's a market there, and, as you point out, there are a lot of entries in this marketplace now, and they're not compatible with the DOE program.

So, I'm encouraged about the diagnosis, but, on the other hand, I think we've got a fairly sick patient who needs a lot of intervention, and I hope the program will recognize that and act accordingly in terms of moving the systems analysis process forward toward establishing conclusions for how the government's going to behave. Perhaps the direction that needs to be explored is more industry/government partnership, a theme of Dr. Starr's remarks yesterday.

So, let us not be at all complacent. There is much work to be done.

DR. VERINK: Any other comments? Yes?

MR. STUART: Ivan Stuart from Nuclear Assurance Corporation.

I'd just like to make a comment to Jeff. On one of your charts you showed at the bottom, MPC's kind of small impact on existing storage designs. I know you've asked us that question, too, and we told you that, but I think that answer is somewhat misleading.

You must understand that while you asked, would it make much of an impact on the MRS designs that you asked us to quote, those designs were all different than our standards, so you changed our designs from our standards to be compatible with your MRS, as you defined it back in '92, and now you're throwing in the idea of would a canister added to that make much difference, and the answer is no, because you've really disrupted things anyway, and so it's a little bit misleading answer, and I'd like to take Alden's position of, please don't ask me or tell me that this is an easy engineering problem, because all of these changes means a significant re-review with NRC, and so your conclusion is a little bit misleading.

There is a significant effect for all of the vendors, I believe, when you say new specifications and new canister for those designs that currently don't meet transport.

MR. WILLIAMS: I think that's probably a fair statement and yours probably needs more revision than some of the others.

MS. SANDERS: I'm Jan Sanders with Peace Action.

A couple of the speakers this morning referred to retrievability, and I wanted to clarify the purpose or the need. Is it for safety, is it for reuse, is it examination? Why is retrievability an element?

MR. WILLIAMS: Are we talking about at reactors or at the repository?

MS. SANDERS: I think two different speakers referred to two different places. One was the long term.

MR. STUCKER: We have a retrievability requirement in 10 CFR 60 where it's both sides, and that's both for potential, I think, of economic recovery or for recovery if we need--if we find that we don't need a requirement, that we have to adjust something, and there is a strategy that's laid out in the SCP, and that strategy is being reviewed right now as part of the advanced conceptual design phase of our overall process.

MR. WILLIAMS: And for at reactors, there's a retrievability requirement as well when it goes into storage, and that's so that it doesn't become a disposal facility. Basically, NRC requires that an applicant be able to show that he can remove the fuel, so that it's transportable off-site from a reactor.

MS. SANDERS: Okay. One other question having to do with the thermal process and the graph having to do with the heat over the long, extended period of time. There was attention given to the identification of the peak periods, but I didn't really catch the scientific information that would assure the decline in the heat in the rock and various places. I'd just like some reference to a scientific study that would indicate that it's going to deplete.

MR. BENTON: We can show you some additional information in detail. I'd be glad to do that after the meeting.

MS. SANDERS: Okay.

MR. BENTON: But the models are fairly specific as to what will happen to the heat, and its decay over a period of time is quite well known.

DR. NORTH: If I could add a bit of clarification--Warner North, Board--on that.

The source term for the heat; that is, the decay of the radionuclides is extremely well known. That's probably the best known part of this problem from the point of view of the science. What happens when you put that heat into inhomogeneous rock is less well known. How well is it going to dissipate? What is going to happen to the water in the rock, some of which may go to water vapor instead of liquid water, and, in particular, are we going to cause it to vaporize, boil, and then have it drip down a crack in the rock?

These are the issues that will be the focus of the thermal-loading studies to occur in the future, and at the moment, we know relatively little about what the answers are going to be.

MS. SANDERS: Thank you very much.

MR. SATERLIE: I wonder if I might clarify a couple of points she made. I'm Steve Saterlie, again, with the M&O.

As far as her first question is concerned, about retrieval in the MGDS repository, that is the requirement, and one of the reasons for doing that is there's a period of time of about 50 years or longer when we're going to be monitoring those waste packages, and trying to assure ourselves that we haven't made some mistake, or that the waste packages are, in fact, surviving as we anticipate that they will do that.

The retrievability requirement is levied on us so that if one of those waste packages starts to fail, for whatever reason, that we can, in fact, retrieve it, repackage it, or we can retrieve these and reposition them if we find that there are problems developing, or ultimately retrieve them all if we find out that our concept is, in fact, wrong.

As far as the other issue, I second what Dr. North said, is that we are, in fact, doing those studies now. That is being looked at, and as information becomes available from the site, we'll have a much better understanding of how that heat will be operating in the rock and what it will do.

MS. JENKINS: Sarah Jenkins, Wisconsin Public Service Commission.

And information that I'm receiving from WEBCO in connection with the Point Beach application for it is he indicates that if DOE delays taking waste, their intent, on an economic standpoint--the difference being in excess of $6 million storage of fuel costs--they would, at about year six, after shutting down a plant, unload the pool into dry casks, because the cost of operating the pool is that six-plus million dollar difference, and it's just--if there is an extended period of storage time, they don't want to eat those costs.

MR. WILLIAMS: Yeah. We didn't really address that today. It wasn't on the agenda for the TRB, but that's something that we have addressed in the overall system studies that we've done. We used costs on the order of $4 million a year per pool year to calculate what does delayed acceptance do, and it runs into the billions of dollars for the whole system. Some utilities have told us that that number is way low, the $4 million a year, it's as high as $20 million a year.

We have used the lower number, the $4 million a year. That's based on an in-depth study of all the different costs, the utility costs, insurance costs, the security, and so forth, and it does get to be quite significant, and it really wasn't covered here.

DR. VERINK: Jeff, could we now call on you to take Ron Milner's spot here and give us a summary?

MR. WILLIAMS: I'd do a summary, except Ron left me a view graph, and I'm not sure...

Basically, the Board's invited us here to talk about the technical challenges to interim storage. One point is that we don't believe there are technical challenges to storage itself. It's been done, it's been done dry, it's been done wet, it's been, as you've seen, sideways, vertical, a lot of different ways. The NRC has put out their waste confidence rule-making. Basically, there has been no incidences related to spent fuel storage.

There are several issues, though, related to the integration of the system, and then, also, the MRS, and what we do in the interim, basically, the MRS siting issue remains to be the key institutional issue.

There's several unknowns, such as the MRS host conditions are unknown. We've had some host communities that say they want a certain technology for the MRS, and those things are still unknown.

There is a challenge to integrate an

institutionally-acceptable approach into a safe, environmentally sound, cost-effective system that meets currently existing storage and transportation requirements, without precluding disposal requirements, and we believe that the new MPC development approach is a possible way to address some of these things, and to integrate all parts of the system, and that's the summary remarks.

DR. VERINK: Now, this forms a basis for any final questions that anyone may have.

Yes, Don?

DR. LANGMUIR: Jeff, this is kind of unfair to ask you; Langmuir, Board. But those who presented the material yesterday--my question really would be better addressed to Lake Barrett and to Ron Milner, who obviously aren't here, but you're sitting right behind Ron's sign, Jeff, so I guess that makes you the one.

We were presented yesterday a rather quick discussion, preliminary evaluation of the alternatives among the different kinds of casks and canister systems, overall systems by Lake, which was then followed by Ron's presentation of some key trades, he called them, which we read, I think I read as assumptions inherent in the calculations of those costs. Among the assumptions was ten-year-old fuel, and so on, a host of things like this.

My sense was that major costs built into this were over-design, which was felt needed for the analysis of the MPU approach, and throwaway costs, which were built in as well. I didn't think we heard enough about what throwaway costs meant, and why they were necessary; whether there weren't some choices there that might allow us to keep things and reuse them, since that was a very major cost factor in those whole analysis.

I presume we're going to hear more about this in the future, that there are some documents available to us that the Board will get to read and see and hear discussed, in which the assumptions are spelled out in more detail, and the pros and cons, sensitivity analysis, and so on.

Can you talk to that issue?

MR. WILLIAMS: Maybe I can try. Basically, the one chart you're looking at, the first chart is trying to address the different options that were looked at, and that we've looked at over the years in various different system studies, and I briefed the Board on January 6th last year about the system studies that we did, the first thing, the feasibility study--that's what we called it--for the MPC, and basically, it was building on that feasibility study where we looked at those concepts, and, based on that, we felt that the MPC concept was better than the other ones.

However, we wanted to verify that, and through this last process we've gone through over the last six to eight months, we've done another study called the alternative cask/canister study to address those issues in more detail, and that report is still under internal review. It wasn't one of the reports that was stacked up on the table there, but it should be done shortly, and it would address, I believe, some of the issues that you're talking about.

Also, the key trades that you referred to in Ron Milner's presentation refer to the MPC design itself, not the trades between MPUs and TSCs. They were things that once we decided we could forward with an MPC, they were things that were necessary, or assumptions that we were trying to make as we moved forward with the MPC design.

Maybe you need a follow-up to that.

DR. LANGMUIR: Okay. Those assumptions were part of MPC, but we never saw the assumptions in the overall analysis, and choices that were made, and, again, the over-design features which were mentioned were necessary in the MPU analysis, which made it a very expensive one, approach, and the comments that throwaway costs were major considerations in the overall choices, and why they were necessary was raised from the audience yesterday.

MR. WILLIAMS: Right. I guess I'm not able to speak to the details of those assumptions in that study. However, I believe that in the September, or the January time frame, that when you get the systems briefing from Dwight Shelor, that he will address those in more detail.

DR. VERINK: Yes, Harald?

DR. ÅHAGEN: I still can't really believe this cost issue. I went through the figures on CLUD, wet storage, which is today considered to be one of the most expensive options, and for the 30,000 maximum tons you were talking about earlier, I got a cost of about two billion dollars, taking the marginal cost for CLUD for the whole system. You would have to build five CLUD facilities, and you don't tell here what the lowest life cycle cost for the MPC is, so there's no comparative figure, and the additional costs for the other options in that perspective seems to be very high to me.

Do you have that lowest life cycle cost for the MPC? What is that figure?

MR. WILLIAMS: What is the figure of the lowest? That's also in another report that is still preliminary, that Dwight will cover in January, okay?

We took some preliminary results, and I think Lake mentioned there, they're still under review, but we've reported on total life cycle costs in the past. I think the latest figure is the 30-32 billion for the total life cycle system cost of an entire system, includes D&E, repository, MRS, transportation. The costs of the canisters themselves range from $300-500,000, in that range. That's the internal canister. I'm not sure if that's getting anywhere close to what you were asking.

DR. ÅHAGEN: You mentioned another figure, $700,000 for a ten-ton dry cask, or something like that?

MR. WILLIAMS: That came about from the--they were asking about the Surry canisters, and maybe--I think that was a guess that Jim Clark got.

MR. CLARK: Right. That was in response to the woman's question about an early cask that was in the development program in Idaho.

DR. ÅHAGEN: So if you use the 30,000-ton maximum need, that also ends up being around two billion dollars.

MR. WILLIAMS: Harald, on the MPU, I did want to mention that that does need to meet the requirements of 71, 72, and Part 60, so it's a throwaway thing that you're bearing at it, but it's a very sophisticated design and costs a lot of money.

DR. VERINK: Any other questions or comments?

DR. NORTH: I'd like to put in a comment aimed toward the January meeting. I think it would be very useful for us to see the backup or preliminary evaluation as it appears on page 12 of Ron Milner's presentation yesterday, and to the extent that we're going to see similar things in January, I would find it personally very useful to have the details accessible, either at the meeting or before the meeting.

It's nice to see a set of bottom-line results and realize that an analysis was done leading to those bottom-line results, but, frankly, we'd like to see the details of how the calculation was made, what assumptions were made on the various cases, so that we can think about it, and perhaps do a little homework before we come to the Board meeting.

Moreover, there are lots of other interested folks that would like to see those calculations as well. I must correct myself. Don Langmuir points out that was page 12 in Lake Barrett's presentation, rather than Ron Milner's presentation, for the record.

MS. TRIECHEL: Judy Triechel from the Nevada Nuclear Waste Task Force.

I wanted to just bring up a few things about public participation, and I don't know how involved or how excited about public participation this Board is at this meeting, but I know Dr. North has pounded on DOE a few times in Nevada about having that happen, and I saw Dan Metley, who was the tsar of the trust and confidence sessions that went on, but I think that there are a couple of problems that the Board or anybody else who is concerned about this has to realize before real public participation happens, and I think real public participation is very important.

But one of the things we pointed out in Nevada was that you had to have some sort of common goals, and I'm not sure that the public really shares a lot of the goals with DOE or the industry, or with others who are involved in that. I'm not sure that they don't, but I think that needs to established, whether or not the public and the agency, the Department are going in the same direction.

The other thing gets back to the public trust and confidence, and that's real hard to engender, when most of the time what we hear from DOE is, that was then, this is now. If people take a look at any previous DOE actions, particularly in regard to nuclear waste, they see a lot of problems with what's gone on, and they're not seeing a lot of evidence of success rates.

And one of the things that we continually hear is that there's no problem that isn't solvable, and to the logic of the public, that's not necessarily true, and there's tremendous confidence put out there by Department of Energy people, by their contractors, by others, that there's really no problem anywhere. The only problem is you, the public. The technical stuff is really easy. We've got this all ironed out, we've had it for years. We can do anything. We can do MRS, we can do MPC, we can do Yucca Mountain, or we can do anywhere else, and people don't necessarily believe that, and they don't want to be caught with being the problem, so I think that might be something that you'd want to level, and we hear from other foreign presentations much more willingness to admit that maybe this won't work, but we almost never hear that from the Department or from its contractors.

And, one of the things that's also very difficult for the public are that all the balls are up in the air. You're talking about things like whether or not Yucca Mountain is suitable. Nobody knows that. When people in Nevada see an earthquake that makes the mountain jump, they assume that that's probably something that would tend to make it unsuitable, and the Department of Energy says, "No, it was a blessing, because the greatest thing we could do is have that earthquake, because now we know, you know, what we need to do," and a lot of those things just don't ring true when it comes to the public.

You talk about MPC. We don't know what it looks like, we don't know if it's possible, we don't know if it'll work, but it's all written into the whole scheme of things, as is MRS, as is rail transportation, and there is no railroad to Yucca Mountain. There is no railroad to an MRS, because you don't know where it is, so you don't know if there's one or not, and there's a whole lot of money out there, and the ratepayers, who are the public, who are asked to participate, pay a lot of money, but if they come to a meeting like this, or almost any of the other meetings that are held, they're the only ones sitting there who aren't paid to be there, who don't have a hotel room, who don't have an airline ticket, and it makes it real difficult, because the dual message that you've got to take the grocery money to get there, and that you're the problem is not one that's going to foster a whole lot of involvement.

So I think those things should really be thought about and kind of put into the mix, and I'm not sure which Department does that.

Thank you.

DR. VERINK: Any other comments or questions?

MR. SHELOR: Dwight Shelor, DOE.

I'd just like to offer a little bit of clarification. When we talked about the approximate cost of the storage casks that was used in the dry storage demonstration program in Idaho, I believe the $700,000 number was the anticipated cost on a production run of about 100 units. The actual cost in that demonstration program was probably between 1.2 and 1.3 million.

DR. VERINK: Any other comments or reactions?

MR. FRISHMAN: Steve Frishman, State of Nevada.

I'd like to go further with the question of what the MPC unit cost is, because in the last MPC so-called stakeholders' meeting, we were talking about those unit costs and the estimates, and that meeting took place about three months after an initial, or a draft report came out. It said the unit cost, as they looked at it then, was on the order of, I guess, about 360,000 a copy, and by the time we were getting to the meeting and some modifications, such as depleted uranium shields, or shield plugs, I think we were talking then a unit cost on the order of about 432,000 estimated at that time, and the need for approximately 10,000 copies, so that ought to give you a figure to start working with, and I don't understand why it didn't just come out when the question was asked.

MR. WILLIAMS: I'm not sure exactly what you're talking, but you're basically right. Also, one thing I wanted to say is, this conceptual design was done to look at the feasibility of the concept, and the costs that were in there were looked at to get a conceptual feeling for what the costs are.

If we make a decision to go forward with an MPC concept, we, first of all, won't do it alone. We'll do it with input from stakeholders' meetings through national dialogue, through input from the utilities, and so forth, and we've also, I think Lake or Ron said that we would put this out for bid to vendors, and at that point, we will get a better feeling on what they think some innovative ways are to do an MPC, and what they would charge to build them, so we would get better costs on them.

But, following up on what Steve says, it's about four billion dollars to build MPCs, with our conceptual design costs.

DR. VERINK: Okay.

DR. NORTH: Warner North; Board.

Let me reiterate and maybe be a bit blunter about it. Lake Barrett talked about a national dialogue on this issue, and we heard the represented from Nevada, Judy Triechel, talk about the public's feeling of how effective that dialogue is at the present time.

I think, if I can paraphrase it, from the point of view of those members of the public, the dialogue isn't working very well, and it seems very unfair to have to pay your way to the meeting with grocery money. That's one of the reasons why this Board has its meetings half the time, twice a year in Nevada, so that we can try to minimize that grocery money expenditure.

There is a real need to get on with this process of having a dialogue so that we all can understand the problem better and have a better basis for a decision, and if DOE is not going to have an enormous fight on its hands, the public's got to understand better than it does now, and that's your problem, that's not the public's problem. The fact that they're willing to take their grocery money and their time and come to these meetings is, I think, rather generous on their behalf.

So, we really need to think about the institutional issues and the credibility of the analysis, and doing the analysis in an iterative fashion, where we can start with something that's back-of-the-envelope, or preliminary, and labeled as such, and understand why it's preliminary, what are the rather gross assumptions that went into those calculations, but let's see the numbers so that we don't force ourselves and our consultants to sit here doing back-of-the-envelope calculations, because there's no document that we can all look at.

Put documents out that we can review, and then let's have a meeting where everybody comes to the table more or less evenly informed, because we all have those documents, and we can look at the calculations. Then we have a basis for a real dialogue.

The alternative is, DOE says we have the problems in hand, there are technical solutions, trust us, we'll do it well, and the public stands up and says, well, based on past evidence, you haven't done it very well, so why in heaven's name should we trust you? You've got to solve that problem.

MS. TRIECHEL: Can I make one more comment, just real quickly? You also don't have to dumb it down, because there's a whole lot of folks that hang out at document rooms, that are on all kinds of mailing lists, that have UPS trucks pull up, and it's not Christmas, it's another report, and they know them and they understand them, and I get four, five, and six-page handwritten letters that, because I hang out at places like this, generally, I can answer, but a lot of times I have to go and get some technical answers for people, because they really do understand this stuff. So don't dumb it down. Just make it real available, and make access there for their comments.

MR. WILLIAMS: I'm a little bit surprised that someone says we don't put out documents. I've been working with the program for ten years, and we could fill the room with the documents that we've put out, as we showed by the document that was sitting on the table over there, and we're more than willing to give you all of our information.

And, as a matter of fact, the document that we had there that was three-feet long was something we haven't reviewed yet. You had this meeting at a time where TRW gave us the report. We made it available to the public during the same time as the DOE review, and, anyway, we've got lots of documents. If anybody wants a copy of that document, we would be more than happy to send it to you in summary, or the entire three-foot volume.

DR. NORTH: Let me try again; Warner North, Board.

I don't care to be buried in documents. I hate to tell you how many file cabinets and storage boxes I have from five years on this Board, of the documents. The trick is to find the important information and present that in a way that the people that are interested in the program, the stakeholders who are interested parties, don't have to dig it out of tons of paper. The program ought to be able to do that.

If what we're interested in is the cost of an MPC, with some assumptions about how much we're going to make, how far down the learning curve we've come, give us that, and tell us where you got it, and don't force us to dig through volumes of your previous reports to go find the number that's interesting. You can serve it up, and serve it up to us pretty well, and that ought to be a major priority for you, to get that out there.

MR. WILLIAMS: And I think we would if that was asked for in the letter, and we will if that's asked for in the next Board meeting. We can go through extensive detail on the cost. It wasn't in the request for this meeting, and we'll be happy to do that.

DR. NORTH: I'm trying to be very unambiguous about my request for the next meeting. Give us the numbers and tell us where they came from, and, please, not more pretty pictures of the technologies involved, or the progress in putting the tunnel into Yucca Mountain. That's wonderful, I enjoy them, but I really want to see the numbers, and I want to know where they came from, and I suspect the folks in

Nevada, and other interested parties would echo this concern.

DR. VERINK: At this stage, I think it would be appropriate for me to give special thanks to the speakers and participants in this meeting.

MR. SHELOR: Dwight Shelor again.

I just wanted to say that your message is loud and clear, but I'd also like to take this opportunity to tell everyone one of the steps that we're taking, which I hope is in the right direction.

In December 8 and 9th, we plan to have a panel meeting with invited participants from some stakeholders in Washington, D.C., and at that meeting, we will discuss the results and describe the alternatives that we have evaluated in the top-level system architecture study.

We, at that point, will not have drawn any conclusions, but the study is to provide information so that we can interact with stakeholders and obtain their views on what attributes should be used to evaluate a system architecture, with the goal of accepting wastes and eventually disposing of them.

I think that that meeting is an open meeting. Everybody is welcome to come and observe the participants in this process, and we will be prepared to present the results of our studies and the results of this panel meeting in our January discussion.

DR. VERINK: Okay, thank you. Let me conclude by--

MR. CALLEN: One more comment for you. I'm Ron Callen from the Michigan Public Service Commission.

I guess I have two comments now that I've listened to the discussion. I certainly support the position taken by Dr. North. I would say that, too often, I'm afraid we've looked upon the public as an impediment to be overcome, and I would suggest that, on the contrary, that they're the final judge, and they should be convinced.

The other comment I wanted to make goes to the question of system analysis, and I don't know your system analysis, so let me make the comment, and you're welcome to respond or not.

The system, too often, may be the system that DOE looks at, the system that DOE can influence, the system out of which DOE's funds and the nuclear waste funds will be impacted, but let me give you an example of the larger national system that I think often has to be looked at.

The question of handling spent fuel with a cask or not, and the delays thereto from the DOE program, et cetera, have significant influence over the cost of the operation and closure of nuclear powerplants, and I think that's, unfortunately, a cost that's very large and has to be looked at in the total system analysis.

For example, I mentioned yesterday that there's a significant influence over the cost of decommissioning nuclear powerplants, depending on how quickly or how slowly the fuel is taken away, and if we want a national answer, that kind of impact has to be in there.

MR. WILLIAMS: I would like to respond that, yes, it is in there in detail. As I mentioned before, we've looked at cost of $4 million a pool year, we've looked at dry storage costs, we've looked at costs of transferring fuel at reactors, and we've done a very thorough analysis at the reactor portion of the cost of the system.

MR. CALLEN: Do you include the cost of the slowdown and non-optimal decommissioning of the plants themselves?

MR. WILLIAMS: No. That's one thing we haven't gotten into yet, because trying to guess which pool reactor should shut down early, or which ones can slow down, that's something, I think, that we'd need to interact with the utilities to get a better handle on, on what that situation would be like.

MR. CALLEN: I'm not sure I understand. I'm not suggesting that plants shut down early, but baseline would be to presume that plant operates to end of life, normal end of life.

MR. WILLIAMS: Right. That's been our baseline.

MR. CALLEN: And that you would analyze for influence over decommissioning costs, depending upon how soon or how late the utility can decommission?

MR. WILLIAMS: Yes, that's right.

DR. NORTH: Warner North.

If it's not evident, why don't you put on your list to have the interaction with the utilities that you just described. You need to engage them in dialogue, and work out some scenarios for how fast this issue of closing down the pool, because without the plant, it's so expensive to maintain, what that does to your overall calculations. I gather it was not in the case that you looked at with the, I'll call it the bubble chart.

MR. WILLIAMS: Yeah, you're right. We have not tried to--I mean, this is sort of a new thing. In the past, we've looked at new reactor orders, we've looked at extended lifetime. The first one that was going to extend its life was Yankee Row, and now it's shut down early, and we have not yet started to factor in early shut-downs, and it's something that could be very helpful.

DR. NORTH: Perhaps you can give us some preliminary results in January.

MR. WELLS: Dwight says yes.

DR. VERINK: I guess it's time to do some summing up here, as I started to do. I wanted to be sure we thanked the speakers and the participants today, and the audience for their interest and help, and it's clear that the matter of storage technology issues and challenges is certainly a dynamic one, and there are a number of activities that are underway, and there are efforts at accelerating tests and performance assessment, and so on, but there are also many unanswered questions; MPC versus MPU, fabrication, materials, criticality, fillers, buffering, corrosion, shielding, waste handling, emplacement modes, expected life, the effect of acceleration of tests, and so on.

We've had, I think, a very nice overview of the present status, and it certainly is an evidence of momentum, and that the momentum is quite evidently building, and should serve as a very good basis for tracking future progress.

I wonder if, Warner, do you have any final comments you'd like to make?

DR. NORTH: I'll just reiterate. Thanks to the speakers and the members of the audience who have participated vigorously. I feel very pleased that we've had a productive exchange of views, what I hope would be an initiation of dialogue on this issue, and I look forward to having a lot more of it.

DR. VERINK: Dennis, perhaps you'd have some final remarks.

DR. PRICE: Well, you've already thanked the participants, both of you, and that was the first thing I had on my list as a summary. I appreciate our being able to get together on this particular topic, because it is one that integrates much of the program, and I think the Board has been very outspoken in trying to encourage that the program be looked at from the generation of the fuel through the repository, and we do have something beside the mountain.

There's a number of concepts, if we're going to ever get through the concept stage. There's the concept of the mountain, which certainly is important. There's the concept of the waste package, there's the concept of the transportation program, there's the concept of the interim storage, and I think what we've addressed today has cut across a lot of that, and I believe it's been very profitable to do that.

I appreciated especially the public's participation and some of the comments which they have brought to this meeting. I thought the special speakers, Dr. Starr starred all right, and provided for us lots to think about, and his comments about the flexibility that perhaps we need to have for a program like this I thought very, very important.

Lake Barrett's early comments at the first, yesterday morning, caused a lot of interest, and also some concern. He characterized this overall problem as about 10 per cent technical and 90 per cent institutional. That seemed a little bit weighty to me on the institutional side. We've gone for a long time being concerned that we would be concerned about the institutional. To put that weighting factor on it of 90 per cent of the program seems to be a little bit heavy.

One thing that concerns about that is that if it's 90 per cent institutional, and this institutional thing gets very vague because it reaches clear to anybody anywhere, as part of the institutional, how do you resolve that, and how do you get consensus and know you've got consensus when you get it? And I think the issue of consensus is one that, if we're talking about a majority consensus against the vagary of institutionality and what is it, at least we would recognize that's a long track. That's going to take awhile, so we're introducing time in it.

When we got to the stage of speaking about the tradeoffs, I was glad to see some tradeoffs across the different options, because we've tried to encourage that, and we've tried to encourage actually looking at the MPC, if you'll remember. The Board has encouraged this, and a little more than a year ago--maybe it's two years ago; time goes by, because I'm getting old--the International High-Level Radioactive Waste Management Conference was the site where I brought a plenary address in which we encouraged looking at the single, the dual, the universal, the canister with overpacks, and so we've got to be glad to see that these things have received some attention.

The thing I scratch my head a little bit about is the multi-purpose canister kind of rose to the surface, and then it continued beyond the surface up into the air and had a lot of buoyancy, and I was wondering, what is driving this? Of course, I think it's obvious, some of the things that drive this, but is it on the basis of the tradeoffs? We did see tradeoffs, but as Warner has already said, we didn't see a lot of backup as to what the data was behind it. What are the assumptions?

We heard some criticism about assumptions coming from the floor, but what are the assumptions and how were the tradeoffs actually made? Is the MPC something that is coming from DOE out of the basis of the substantive results of the tradeoff, or are other things really driving, coming to this?

And, also, Ron Milner's tradeoffs, which he has indicated to us that further details are forthcoming, because he said, "We looked at this and looked at that," and what is a look? Is it a glance, or is it really a good study? And we touched quite often during this thing on systems analysis and the need for systems analysis, and I think we have the promise made to us that systems analysis is going to receive attention and continue to receive attention.

DR. VERINK: I'll thank you all for your participation. I guess the session is adjourned.

(Whereupon, at 12:25 p.m., the meeting was adjourned.)