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1 UNITED STATES OF AMERICA

2 NUCLEAR REGULATORY COMMISSION

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4 ADVISORY COMMITTEE ON NUCLEAR WASTE (ACNW)

5 138TH MEETING

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7 TUESDAY,

8 NOVEMBER 19, 2002

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10 ROCKVILLE, MARYLAND

11 + + + + +

12 The meeting convened in the Auditorium of the

13 Nuclear Regulatory Commission, 2 White Flint North,

14 11545 Rockville Pike, Rockville, Maryland, at 8:30

15 a.m., George M. Hornberger, Chairman, presiding.

16 MEMBERS PRESENT:

17 GEORGE M. HORNBERGER Chairman, ACNW

18 RAYMOND G. WYMER Vice Chairman, ACNW

19 B. JOHN GARRICK ACNW

20 TIMOTHY KOBETZ ACNW

21 MILTON LEVENSON ACNW

22 MICHAEL RYAN ACNW

23

24

25

ACNW STAFF PRESENT:

SHER BAHADUR	ACNW
HOWARD LARSON	Special Assistant, ACRS, ACNW
JOHN LARKINS	ACNW

GUESTS PRESENT:

DOUG AMMERMAN	Sandia National Laboratories
CHRIS BAJWA	Spent Fuel Project Office, NRC
E. WILLIAM BRACH	Spent Fuel Project Office, NRC
TOM DANNER	NAC International
LARRY FISCHER	Lawrence Livermore National Laboratories
ROBERT FRONCZAK	Association of American Railroads
BRIAN GUTHERMAN	Holtec International
ALAN HANSEN	Transnuclear
IAN HUNTER	Transnuclear/COGEMA
ROBERT LEWIS	Spent Fuel Project Office, NRC
PETER SHIH	Transnuclear
KRIS SINGH	Holtec International
ALAN SOLER	Holtec International
MICHAEL YAKSH	NAC International

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P-R-O-C-E-E-D-I-N-G-S

8:30 a.m.

CHAIRMAN HORNBERGER: The meeting will come to order. This is the first day of the 138th meeting of the Advisory Committee on Nuclear Waste. My name is George Hornberger, Chairman of the ACNW. The other committee members present are George Wymer -- Raymond Wymer, Vice Chairman, John Garrick, Milt Levenson and Michael Ryan. During today's meeting the Committee will hold a workshop on the transportation of spent fuel and high level waste.

Tim Kobetz is the designated federal official for today's initial session. This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. We have received no requests for time to make oral statements from members of the public regarding today's sessions. Should anyone wish to address the Committee, please make your wishes known to one of the Committee staff. It is requested that speakers use one of the microphones, identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

I would like now to turn the meeting over to Milt Levenson who will Chair the Transportation

1 Working Group sessions. Milt?

2 MEMBER LEVENSON: Thank you, George. Good
3 morning. This is a workshop for the Transportation
4 Working Group. I'm Milt Levenson, Chairman of the
5 Working Group. The Working Group is made up of all
6 five ACNW Committee members. The objective of today's
7 workshop is limited to examining the technical aspects
8 of spent fuel transportation package design, analysis
9 and testing methods to determine whether sufficient
10 evidence exists or additional evidence needs to be
11 obtained to substantiate that spent fuel can be
12 transported safely. In addition, spent fuel and high-
13 level waste transportation experience will be
14 examined, that's tomorrow session, to determine
15 whether the transportation packages have performed as
16 designed.

17 The ACNW will use this information to make
18 recommendations to the Commission as necessary on the
19 technical aspects of transportation of spent fuel. In
20 addition, it is our intent to publish the proceedings
21 of this workshop in an NRC NUREG. On the first day,
22 presentations will be made regarding research,
23 development, analysis and testing of such packages.
24 Presenters include various national labs, cask
25 vendors, industry groups and NRC staff that have been

1 directly involved in the evaluation of this type over
2 the past 30 years. We focus on the package because if
3 there is no significant package failure, there can be
4 no significant radiation consequences.
5 On the second day, presentations will be
6 made to the Working Group regarding spent fuel and
7 high-level waste transportation safety experience in
8 the U.S. and worldwide. For these discussions, the
9 presenters include various federal regulatory
10 agencies, industry representatives that have been
11 directly involved in the regulation and shipment of
12 spent fuel and high-level waste. Relevant experience,
13 which is obviously omitted from the presentations, and
14 for obvious reasons, is the experience of shipping
15 tens of thousands of nuclear weapons multiple times
16 around the country.
17 Presenters for today's workshop, because
18 it is a workshop, are encouraged to participate in the
19 discussions. If a presenter has a question or
20 comment, please stand your nameplate on end, and that
21 will notify me you have a comment to make. However,
22 I want to caution all participants that I intend to
23 stick strictly to the time schedule in order to not
24 short circuit the later speakers. Members of the
25 public will also have opportunity to make comments and

1 ask questions. It is requested that when speaking,
2 you first identify yourself, court reporter just
3 doesn't know everyone, and use one of the microphones
4 and speak with sufficient clarify and volume so you
5 can be readily heard.
6 I would like to point out for those of you
7 that hadn't already done so that there's a package of
8 view graphs in the back of the room that's all
9 inclusive for today's meeting. There will be a
10 similar package for tomorrow's meeting. We have
11 received no requests for time to make oral statements,
12 and one written comment from members of the public
13 regarding today's meeting. The written comment will
14 be entered into the transcript of today's meeting.
15 I would like to thank all of today's
16 participants for taking the time and making the effort
17 to participate in the workshop. We will now proceed
18 with the workshop, and I call upon Mr. Bill Brach,
19 Director of NRC's Spent Fuel Project Office for the
20 first presentation.
21 MR. BRACH: Good morning. As Dr. Levenson
22 mentioned, my name is Bill Brach. I'm Director of
23 NRC's Spent Fuel Project Office. If we could have the
24 next -- excuse me, back up to Slide Number 2. In your
25 handout, Slide Number 2 is titled, "Overview," and if

1 I can start with that one, Theresa.

2 First, again, good morning. I wanted to
3 thank the ACNW for the invitation in asking the NRC
4 staff to participate and as well as to lead off the
5 discussions for this important workshop. As Dr.
6 Levenson has described, you have a very full and I
7 believe interesting agenda with a broad spectrum of
8 government, government laboratory, industry
9 organization and industry presentations today and
10 tomorrow.

11 This morning in my presentation, I'll
12 briefly discuss our spent fuel transportation
13 activities, status and some of the past as well as the
14 planned transportation studies.

15 Slide 3, key messages, let me start off
16 first by saying, unequivocally, that the NRC staff
17 believes that shipments of spent fuel in the U.S. are
18 safe, and they're safe using the current regulations
19 and our current programs in place. I believe that's
20 an important point, let me just stress that one more
21 time: The staff believes that the shipments of spent
22 fuel in the U.S. are safe using our current programs
23 and our current regulations.

24 Now, this belief is based on NRC's
25 confidence in the shipping containers that we certify

1 and the ongoing research in the transportation safety.
2 And also let me add, as noted in Bullet Number 2 on
3 the overhead, that this confidence, if you will, is
4 based as well on the industry's strict compliance with
5 the safety regulations and the conditions of the
6 certificate and conditions of use that have resulted
7 in a strong transportation safety record.
8 The NRC ensures that shipping containers
9 are robust. We do this in many ways. First, by
10 regulating the design and construction of the shipping
11 containers. The NRC staff, in our review process,
12 review the designs, we independently confirm the
13 ability of the containers to meet the regulations and
14 the accident conditions through our modeling, analysis
15 and verification of the licensees with the applicant's
16 analysis and testing.
17 By NRC oversight and principally through
18 the licensee and the user's exercise in implementation
19 of their fundamental responsibility are assuring that
20 containers are built, that they're maintained and that
21 they're used properly and in strict conformance with
22 the certificate and with the regulations.
23 The NRC also follows an aggressive program
24 to investigate and to assess the continued safety of
25 spent fuel shipments. We do this through a number of

1 avenues, for example, including analyzing spent fuel
2 transportation experience in the records to better
3 understand safety issues and experiences, we evaluate
4 new transportation issues such as the potential for
5 increased spent fuel shipments, increased and changing
6 radioactive material contents of spent fuel packages,
7 as well as looking at population density and density
8 changes along the routes as well as other factors,
9 such as modeling and analytical capabilities to
10 estimate current and future levels of potential risks
11 to the public as a result of spent fuel
12 transportation.
13 NRC has found that the likelihood of a
14 release from an accident and the associated risks to
15 the public are extremely low. Even though, even so,
16 the NRC continues to maintain our vigilance with
17 regard to our primary mission responsibility to assure
18 public health and safety as an essential part of our
19 oversight of spent fuel transportation. Next slide,
20 please.
21 Clearly, an interest and focus with regard
22 to spent fuel transportation is derived from the
23 prospects of a national repository being built at
24 Yucca Mountain. I want to focus just briefly on NRC's
25 role with regard to transportation as it relates to

1 the National Geological Repository at Yucca Mountain.
2 NRC's role and responsibilities are guided by
3 legislation -- the Nuclear Waste Policy Act. NRC's
4 primary role in transportation of spent fuel to a
5 repository would be certification of packages used for
6 transport.
7 Section 180(a) of the Nuclear Waste Policy
8 Act prohibits the Secretary of Energy from
9 transporting spent nuclear fuel or high-level waste
10 except in packages that have been certified by the
11 Commission. The NRC has reviewed and certified a
12 number of spent fuel package designs which could be
13 used for the transport of spent fuel to a repository.
14 We have additional designs and design amendments under
15 review and as well we anticipate there will likely be
16 additional designs submitted in the not too distant
17 future.
18 There are additional provisions of the
19 Nuclear Waste Policy Act that also apply to
20 transportation. DOE, as noted in the overhead, is
21 required to follow NRC's advance notification
22 requirements. These requirements pertain to
23 notification and coordination with state governments
24 with regard to plans of spent fuel transportation.
25 The second item related to the DOE requirement to fund

1 state and local governments in Indian tribes with
2 regard to response and preparedness activities is an
3 activity that perhaps some of the DOE presenters
4 later, I believe tomorrow, might be in a better
5 position to add or amplify DOE's current plans.
6 If I could move to the next slide. To
7 provide a perspective, this slide summarizes a picture
8 of the past, the current and the potential future
9 levels of spent fuel transportation. Significant past
10 operations have included, for example, return of
11 reactor fuel to utilities from the closed West Valley
12 Processing Plant back in the early 1980s, as well as
13 current levels that reflect primarily inter-power
14 plant shipments, shipments of some research reactor
15 fuel and other shipments.
16 And I would note for a number of you all
17 that may have seen these same statistics, while 1,300
18 shipments is the number we've represented over the
19 last 20 years, it's actually a little bit higher now.
20 As noted, there are roughly ten to 20 shipments per
21 year, and so in a rounding, it's approximately 1,300,
22 but the overall history for the last 20, 25 years for
23 NRC regulated shipments is in that range.
24 You'll also note on the overhead is a
25 proposed information for the private fuel storage

1 facility. That proposed facility would be located
2 roughly 100 miles west of Salt Lake City while Yucca
3 Mountain is somewhat analogous -- it's about 100
4 miles, approximately, northwest of Las Vegas. Neither
5 of the facilities have yet obtained NRC license for
6 authorization. A PFS, private fuel storage, has
7 applied, and the matter is currently before the staff,
8 before the -- excuse me, it's being considered in
9 hearings before the Atomic Safety Licensing Board.
10 The private fuel storage facility is planning to use
11 the Holtec High Star, High Star and dual-purpose cask
12 system at their facility, and I believe Dr. Chris
13 Singh from Holtec is on the agenda later and will be
14 discussing in much more detail the Holtec dual-purpose
15 dry cask storage system.
16 The Yucca Mountain facility is roughly
17 twice the size in the way of capacity of the private
18 fuel storage facility. The Nuclear Waste Policy Act
19 limits the 70,000 tons of high-level waste at Yucca
20 Mountain to approximately 73,000 metric tons of
21 commercial sector spent fuel. You'll note on the
22 overhead as well the statistics with regard to the
23 planned number of shipments. A private fuel storage
24 facility plan to operate for a 20-year period would
25 have approximately 50 shipments per year, as noted

1 with forecasts for shipment. The Yucca Mountain
2 facility, the preliminary information we have at this
3 point from the Department of Energy is that
4 approximately 175 shipments on an annualized basis,
5 130 by rail and approximately 45 by truck. This
6 overhead gives a general summary, if you will, a
7 comparison of the planned shipment profile for these
8 two sites in the coming years.
9 The NRC routinely conducts studies to
10 review the adequacy of the regulations. For
11 transportation regulations, we have completed three
12 major studies to date since the 1970s, with the most
13 recent having been completed in 2000. In addition,
14 our current major activity or effort underway is the
15 package performance study, which I'll discuss briefly
16 in just a minute.
17 After completing the final environment
18 impact statement on the transportation of radioactive
19 material by air and other modes, commonly referred to
20 as NUREG-0170, the Commission, NRC Commission,
21 concluded in 1981 that its transportation regulations
22 are adequate to protect the public against
23 unreasonable risk in the transport of radioactive
24 materials, including spent nuclear fuel. I will note
25 that I believe spent fuel was one of about 25

1 radioactive materials addressed in NUREG-0170.

2 The Commission also concluded at that

3 time, however, that prudence dictates that regulatory

4 policy concerning radioactive materials be subject to

5 close and continuing review. In the ensuing years,

6 the NRC has conducted additional transportation risk

7 assessments in other studies that confirm our earlier

8 finding on spent fuel transportation safety.

9 In the mid to late 1980s, to better assess

10 response to spent fuel and spent fuel casks to severe

11 accident conditions, NRC sponsored an examination of

12 collision and fire accident conditions. Lawrence

13 Livermore National Laboratory conducted this effort.

14 It's frequently referred as the Modal study. Larry

15 Fischer from Lawrence Livermore National Lab is also

16 on the agenda and will be discussing aspects of the

17 Modal study in a little bit more detail.

18 From the Modal study, the NRC staff has

19 concluded that the Modal study -- excuse me, has

20 concluded from the Modal study that NUREG-0170 clearly

21 bounded spent fuel shipment accident risks, and by the

22 Modal study we concluded that they were bounded by a

23 factor of approximately three. Next slide, please.

24 Continuing with the transportation

25 studies, in March of 2000, NRC published a report

1 entitled, "Reexamination of Spent Fuel Shipment Risk
2 Estimates." It's commonly referred to as NUREG/CR-
3 6672. This study focused on a risks of a modern spent
4 fuel transportation campaign from reactor sites to a
5 possible interim storage facility, such as the private
6 fuel storage facility I just mentioned, or to a
7 permanent geological repository, for example, the
8 Yucca Mountain facility.
9 NUREG-6672 was initiated in 1996. The NRC
10 had recognized that, one, there was going to be a
11 significant increase in the number of spent fuel
12 transportation activities over the coming decades, and
13 I believe that was represented in an earlier slide.
14 If you recall, our current operating history, if you
15 will, with regard to spent fuel transportation is in
16 the neighborhood of ten to 20 shipments per year, and
17 it's represented by the information for both private
18 fuel storage and potentially for the Yucca Mountain
19 facility as well. Those numbers increase rather
20 significantly.
21 The transportation activities as well will
22 be made to facilities along routes and in casks that
23 have not been previously examined in past studies.
24 And the risks associated with these transports can be
25 better estimated using new data and improved methods

1 of analyses. I would mention as well that in NUREG-
2 6672 we were looking at designs of contemporary --
3 spent fuel packages, excuse me, of designs that are
4 larger in size and have larger radioactive material
5 contents than some of the packages that had been
6 examined in previous studies. The results of the
7 study, the NUREG-6672, also did conclude that the
8 accident risks were much less than those that had been
9 estimated in NUREG-0170, the 1977 EIS.
10 In 1999, the NRC initiated the spent fuel
11 transportation package performance study. This study
12 is expected to take on the order of five to six years
13 to complete. The study is being developed by staff to
14 confirm their alliance of analytical techniques, to
15 predict cask performance, and as well as a study in
16 significant ways attempting to consider public
17 concerns and input. The study is being developed to
18 demonstrate the robustness of the NRC-certified
19 transportation casks.
20 The study is using what we've referred to
21 as a public-enhanced, public participatory process and
22 approach to solicit and obtain public input and
23 comments on our tests and on our plans and our
24 considerations that we're looking at in developing the
25 study approach and concept. Our current plans for the

1 package performance study include full-scale physical
2 testing to confirm cask performance and safety during
3 transportation accident conditions.
4 There also are some additional
5 transportation studies that I'd like to bring to your
6 attention. Many of you, I'm sure, recall the train
7 derailment in Baltimore in July of last year, in July
8 of 2001. We, NRC, are continuing to review this
9 accident closely with the Department of Transportation
10 and the National Transportation Safety Review Board to
11 assess what might have happened if a spent fuel cask
12 had been on the train. NRC's preliminary analyses are
13 very positive and suggest that the transportation cask
14 would not have failed had they been in the Baltimore
15 Tunnel railroad fire. You'll hear more later today
16 from Chris Bajway, also of the Spent Fuel Project
17 Office, on the study and preliminary information we've
18 developed in our review of that fire and the
19 consideration had it included a spent fuel
20 transportation package.
21 There are other activities as well
22 underway. Recently, NRC and other federal agencies
23 have been providing or have provided joint funding to
24 a project that the National Academy of Sciences, the
25 Board of Radioactive Waste Management, is embarking on

1 to form a group, an expert panel, that will be
2 reviewing the societal and health risks of
3 transportation. I believe that study should be
4 initiated in early -- calendar year 2003.
5 Also, there have been other studies, tests
6 and demonstrations. Many, I'm sure, are familiar with
7 the Sandia and the British crash tests and the videos,
8 and you may have seen these in the media or in other
9 arenas. I would note that these tests were not
10 sponsored by the NRC. They did not have, if you will,
11 an NRC regulatory purpose for the testing, and they,
12 therefore, are not a part of the basis for our
13 regulatory program. But having said that, I'm not
14 trying to distance myself from those tests or
15 ourselves from those tests, we clearly do believe that
16 those videos, those tests have demonstrated that the
17 casks are very robust in the specific accident
18 conditions in which they were tested. And as well
19 they give added confidence that the regulatory tests
20 are indeed very severe in establishing test conditions
21 and criteria.
22 Additionally, one important conclusion
23 that you can see from these other studies and tests is
24 that they have demonstrated that the casks upon impact
25 the impact surfaces actually absorb much of the energy

1 of the impact. And those that are familiar with our
2 transportation regulations are aware that our testing
3 criteria require that our drop tests, for example, be
4 onto an unyielding surface so that all of the energies
5 of impact are transmitted back into the transport
6 package.
7 I've touched in this brief overview a
8 number of the research or study programs and
9 activities that have occurred over the past few years,
10 past 20 years, as well as some that are ongoing right
11 now to address spent fuel transportation. The U.S.
12 domestic standards and requirements, our regulations,
13 were developed using an expert consensus approach,
14 both domestically and through participating with
15 fellow international transportation regulators at the
16 International Atomic Energy Agency. These
17 regulations, we believe, have resulted in an exemplary
18 level of safety and have demonstrated a long favorable
19 history of use, both here in the U.S. as well as
20 internationally.
21 While risk insights or risk studies have
22 not traditionally been used to establish these
23 regulations, the research studies and programs I've
24 discussed have mostly been of a confirmatory nature,
25 and they have supported the conclusions regarding the

1 adequacy of our regulatory standards.

2 As technologies have changed and analysis
3 capabilities have improved, we've continued to review
4 our research and findings and conclusions consistent,
5 if you will, with the Commission's earlier direction
6 to us from back in 1981. If you recall, I had
7 mentioned the Commission's conclusion following the
8 EIS is that the Commission had dictated that
9 regulatory policy concerning radioactive materials be
10 subject to close and continuing review, and I believe
11 our studies that we've been carrying out from that
12 perspective have been our efforts to comport with the
13 Commission's earlier guidance.

14 I would note as well, though, that to date
15 none of the NRC transportation risk studies, if you
16 will, or studies, have included physical testing.
17 They've been primarily based on computer modeling and
18 analysis, and so one aspect we clearly are looking
19 forward to our package performance study, which, as I
20 mentioned briefly, does include aspects of physical
21 testing.

22 The basic methodology that was developed
23 for NUREG-0170 and its supporting works, including,
24 for example, the development of the radtran code and
25 release assumptions, have, if you will, reasonably

1 withstood the test of time and analysis and have
2 recently as well been used in major environmental
3 impact statements.
4 Let me conclude by saying the staff
5 welcomes and appreciates the Committee's timely and
6 valuable workshop initiated today to further the
7 discussion of spent fuel transportation with our
8 various stakeholders, and we found past and similar
9 meetings to have been very valuable. Thank you.
10 MEMBER LEVENSON: First, let me thank you
11 for setting a good example for subsequent speakers by
12 sticking strictly to your time. Thank you.
13 Any of the ACNW members have questions or
14 comments? Mike? Bob?
15 MEMBER GARRICK: Probably most of the
16 questions I have will come later, but one of the
17 things you said, Bill, that I'm wrestling with is the
18 position of the NRC relative to the Sandia test, and
19 you qualified it by saying that you're not trying to
20 put any distance between the NRC and the tests, but
21 they're not a part of the NRC program.
22 I guess I'm questioning just how far that
23 interpretation goes. Generating the steam tables was
24 not a part of the NRC program either, but you use them
25 all the time in your thermalhydraulic work. It just

1 seems to me that that doesn't make much sense. In
2 inevitably has to be a part of -- the results of those
3 tests inevitably have to be a part of the analyses and
4 the investigations that you make about transportation
5 safety. Could you comment on that a little bit?
6 MR. BRACH: Be glad to, yes. The point I
7 was trying to make is that the conduct of those tests
8 were not tests that, if you will, were part of the
9 regulatory basis on which we, the NRC, are relying
10 with regard to our existing regulations and our
11 guidance, that the tests were -- again, I'm not trying
12 to distance from those tests, I'm trying to explain
13 that the conduct of those tests, the outcome of those
14 tests, the information, the data that was developed as
15 a result of those tests were not a fundamental part
16 nor were they critical to the development or the
17 confirmation of our existing regulatory standards and
18 bases.
19 MEMBER GARRICK: I have several other
20 questions but I'm going to postpone them later, but
21 there is one I'd like to ask you. I realize that the
22 NRC is focused on the cask and the packages, but do
23 you plan any route-specific analysis just to get some
24 sort of a handle on however small the risk is that it
25 might be affected by the choice of transportation

1 route?

2 MR. BRACH: There are a couple of aspects.

3 One, the specific selection of routes that would be,

4 for example, used to the private fuel storage facility

5 or potentially to Yucca Mountain as well is not an

6 NRC, if you will, decision, action or direction.

7 Those are guided by other regulatory standards from,

8 for example, Department of Transportation, and those

9 will be selected by, in the case of Yucca Mountain, by

10 Department of Energy in consultation with the states

11 along those routes.

12 Very specifically, though, with regard to

13 the studies and activities, I'll reference, for

14 example, NUREG-6672, we did in that study pick a few

15 of what I'll call generic but what we believe to be,

16 and of course that also requires the test of time to

17 analyze, to be representative routes that would be

18 used. We selected some routes that are cross country

19 and various parts of the U.S. In selecting those

20 routes, we were looking at length as well as looking

21 at what might be, to the extent we can identify, some

22 of the most challenging or limiting types of

23 conditions of transport with regard to under accident

24 conditions what might be the locality from the

25 standpoint of what might be potential impacts and

1 other considerations. So we're looking at that not in
2 a -- looking at site -- or excuse me, route specific,
3 but we're trying to bound that, if you will, through
4 our generic analysis of looking at various
5 hypothesized routes that could be identified and then
6 analyzed.
7 MEMBER GARRICK: Thank you.
8 VICE-CHAIRMAN WYMER: I have one question.
9 MR. BRACH: Sure.
10 VICE-CHAIRMAN WYMER: They're kidding
11 about my name wrong on the name tag here.
12 In connection with the new package
13 performance study to be completed in about 2005, you
14 made a point of saying that there will be enhanced
15 public participation. Now, you've had what appeared
16 to me to be substantial public participation in the
17 past. What does enhanced public participation mean?
18 MR. BRACH: Let me explain what our
19 participation has been, and then maybe in the eyes of
20 the beholder whether that's enhanced or not. As you
21 mentioned, Dr. Wymer, over the past few years we've
22 had a series of public outreach meetings with regard
23 to the package performance study. We started the
24 process off with a series of meetings here in the
25 Washington area as well as out in the Las Vegas,

1 Nevada area, the Rockville area. The first round of
2 public meetings started with our asking the public,
3 the stakeholders, for input with regard to if we were
4 to be carrying out a fiscal testing program for spent
5 fuel package, what type of testing, what type of
6 conditions, what issues should we be including in the
7 study? And we were really out, if you will, in a
8 listening mode explaining our ideas and plans for
9 conducting a study but in a very general and broad
10 concept but asking for the stakeholders, both state
11 and local governments, industry, industry groups and
12 concerned citizen groups, individual citizens what
13 types of issues do they see.
14 From that series of meetings, we developed
15 what we called an issues paper, and that issues paper
16 was an attempt on our part to summarize the various
17 suggestions, comments, issues that had been identified
18 to us. We followed them with a second series, round
19 if you will, of public meetings, again, here in
20 Washington area, Rockville area, and also out West in
21 the Las Vegas area to, again, go through the process
22 again of this is what we've heard. One, did we hear
23 you correctly? Have we characterized and summarized
24 the issues, and also we tried to as well put an NRC
25 staff understanding of the issues but also a

1 perspective as to what some of the tests of various
2 conditions and activities may yield or some of the
3 complexities of that testing activity.
4 And from that process, we then stepped
5 back and our next step is the development of what I'll
6 refer to as the test protocol. And I also should
7 mention we had as well an opportunity -- we
8 established a web page where it could be reasonably
9 interactive, interactions to NRC and folks submitting
10 comments in both of those rounds with regard to
11 suggestions, as well as options for providing written
12 comments.
13 The step we're in right now with regard to
14 the package performance study, again, from the public
15 perspective and public involvement and input
16 perspective, is that based on the comments we received
17 on the issues paper, we are formulating what we'll
18 call a draft test protocol for the type of testing and
19 analysis that could be carried in the package
20 performance study. We're planning that as we finish
21 that draft, what I'll call again the test protocol,
22 we'll go out for yet another round of public
23 involvement to discuss with the public, the
24 stakeholders, the test plan and to ask for views and
25 comments on that test plan before we move to an

1 embarkment, if you will, of actual carrying out of the
2 tests and activities.
3 And we're also, as far as the carry out of
4 the study and activities, we're planning that there be
5 fairly full public participation, awareness and
6 knowledge of the conduct of the tests, the tests
7 results that we've gathered, ironing out what those
8 results are, what our analysis of those tests results
9 show and the recommendations they lead to.
10 So that is -- when I'm using the phrase,
11 "enhanced public participatory process," I'm trying to
12 describe that process that, on our part, is trying to
13 significantly give the public an opportunity to give
14 us input, tell us whether they think we heard them
15 correctly or not or whether they are of the opinion
16 that the tests we're carrying out would meet
17 objectives as they see it or as we represent them.
18 VICE-CHAIRMAN WYMER: Thank you.
19 CHAIRMAN HORNBERGER: Do you anticipate
20 any changes in the regulations resulting from the
21 package performance test?
22 MR. BRACH: Well, I clearly want to be
23 open, that from any study or test we need to be
24 cognizant that the information that we learn we need
25 to apply that information, whether it be to our

1 regulations, whether it be to our licensing process,
2 our inspection process or our review criteria. So
3 from that perspective, we clearly are open as to what
4 the test results may demonstrate.
5 We, from the standpoint of our
6 understanding of the package designs and understanding
7 of the tests and our modeling of what we'd anticipate
8 in the way of test conditions to be represented
9 through physical testing, we clearly are looking at
10 this and anticipating it to be confirmatory in nature,
11 confirming our predictions and expectations. But, Dr.
12 Hornberger, clearly, we have to have our eyes, if you
13 will, wide open with regard to what the test results
14 tell us and what the implications of those results
15 might be with regard to regulations or our other
16 practices.
17 MEMBER LEVENSON: I just have one comment
18 that's a little bit of a follow up on John's, and that
19 is I was glad to see you referred to the other tests,
20 because there have been some misunderstandings in the
21 past when people have asked the question like, "Have
22 you ever tested full scale?" The question they were
23 asking was a generic "you," and the response was, "No,
24 we have not tested," and the "we" was a very parochial
25 "we." And I think in discussing technical issues, we

1 need to include all of the available literature and
2 information.
3 Do any of the other presenters -- first,
4 are there any questions from ACNW staff? Any
5 questions or comments from the other participants in
6 today's session? Still have a couple of minutes,
7 anyone in the public care to raise a question or make
8 a comment? Okay. If not, thank you, Bill.
9 Our next presentation is by Doug Ammerman
10 of Sandia who will summarize the laboratory research,
11 as understood to be with a capital L. This is the
12 research at Sandia National Laboratory, it may or may
13 not be actual laboratory type research. Doug?
14 MR. AMMERMAN: Sandia National
15 Laboratories is a DOE facility that has been involved
16 in areas of national interest since its inception in
17 1948. Our primary mission has been -- oh, sounds much
18 better. Let me start over.
19 Sandia National Laboratories is a DOE
20 facility that has been involved in areas of national
21 interest since its inception in 1948. Primarily that
22 interest has been nuclear weapons, but the expertise
23 that's been developed as part of our nuclear weapons
24 experience has led us into other areas of system level
25 testing. Next slide, please.

1 Our presentation will go over past
2 significant test programs at Sandia National
3 Laboratories, starting with the 1970s Crash Test
4 Program that Mr. Bach alluded to, talking about some
5 certification testing that we did for DOE on the
6 defense high-level waste and also on the certification
7 testing that we did for DOE on the TRUPACT-II. It's
8 not a spent fuel package. That particular package is
9 for transporting true waste, plutonium-laced garbage,
10 essentially, and those are done in full-scale tests.
11 Then I'll talk about analysis methodology, how we
12 determined the response of packages using analytical
13 techniques, both through structural modeling and
14 thermal modeling. Finally, I'll go to linking
15 analysis that we've done to testing, both code
16 verification and validation and then examples, side-
17 by-side comparisons of analysis results with test
18 results. And, finally, in my conclusions slide, where
19 are the gaps, what do we need to know more than what
20 we currently know?
21 Sandia has since its beginning -- next
22 slide, please. Sandia has since its beginning been
23 involved in systems level testing. Like I said
24 earlier, initially those systems were nuclear weapons,
25 but systems level testing expertise applies to a lot

1 of different fields, and it's been used in the area of
2 transportation package testing for about 30 years. Of
3 course, different programs have different goals and
4 different purposes. These goals and purposes define
5 the way the tests were carried out. Some of the tests
6 were, if you will, engineering tests, trying to
7 improve our state of knowledge; other tests
8 certification tests, trying to say do these packages
9 meet the requirements put out by the NRC? Some of the
10 tests are demonstration tests, just trying to
11 demonstrate that this package will survive in an
12 environment that's not necessarily the regulatory
13 environment but a severe environment. Next slide,
14 please.
15 The 1970s Crash Test Program was perhaps
16 one of the most visible testing activities carried out
17 on spent nuclear fuel packages. The purpose of this
18 Program was to assess and demonstrate the validity of
19 analytical tools and scale model techniques for
20 predicting the response of packages to accident
21 environments by comparing the predicted results with
22 full-scale actual test results, also to gain
23 quantitative knowledge regarding extreme accident
24 conditions by measuring response of full-scale
25 packages under actual crash conditions.

1 Part of the issue with the regulatory
2 position is that it's a hypothetical accident
3 condition, doesn't necessarily correlate very easily
4 in the mind's eye to real test conditions. One of the
5 purposes of this Program was to show that indeed the
6 hypothetical accident conditions of the NRC
7 regulations do provide adequate safety in actual
8 accident conditions. In this Program, there were
9 mathematical models developed, including some very
10 crude computer scale model testing and finally the
11 combination was full-scale tests. Next slide, please.
12 This test program included some
13 instrumentation on the scale and full-scale hardware
14 to measure accelerations of package and transport
15 systems, including the conveyance that was being used
16 and in the case of one of the tests the -- or actually
17 a couple of tests we also put instrumentation on the
18 targets; strain gauges to measure strains on various
19 cask and transport system components.
20 One of the not necessarily requirements
21 but applied requirements, if you will, it's not part
22 of the NRC regulations but it's been implied by the
23 certification processes, that we like to limit the
24 amount of plastic deformation to packages. Strain
25 gauges are a way of measuring that plastic

1 deformation. In addition, there was high-speed
2 photography to record cask and transport system
3 response, and you'll see some of the results of that
4 in the next few slides. Next slide, please.
5 One of the tests, and this is the one that
6 I personally view as the most spectacular test, was to
7 simulate a grade crossing accident. A truck
8 transporting a spent fuel cask was stopped on crossing
9 a railroad track and slammed into by a locomotive. It
10 was an actual truck in transport trailer that was used
11 at that time for transporting it. One of the
12 criticisms of this particular test has been that the
13 center line of the cask was higher than the frame
14 rails or not equal to the frame rails of the
15 locomotive, and the cask then rode up over the train.
16 Why don't you click on the picture there and you
17 should be able to see the actual test taking place.
18 And you see the cask gets thrown up into the air.
19 Well, that's only partly the result of the
20 configuration of the test. Recently, the American
21 Association of Railroad Test Facility at Pueblo,
22 Colorado has done some tests with passenger trains
23 colliding with each other, and the same kind of
24 behavior is seen. The locomotive essentially plows
25 underneath what it strikes.

1 Like I said, this is a very spectacular
2 test, and it demonstrated in that 80 mile per hour
3 impact that the regulatory impact, which is a 30 mile
4 per hour does provide a large deal of safety for these
5 packages when you consider that the railroad target
6 goes into a rigid target. In this particular impact,
7 it was by something that people consider pretty rigid.
8 I mean if you want to go and hit something, a train is
9 a pretty bad thing to hit or to have hit you. There's
10 not very many structures out there in the
11 transportation world that are viewed to be more stiff
12 than the front end of a train, but you can see from
13 that picture that that train absorbed a lot of the
14 energy of that impact. There was lots of deformation
15 to the train.
16 The results of that test are documented in
17 SAND79-2291. Anybody who wants to get a copy of that
18 can obtain that report and read about in detail what's
19 happened in that particular test. There were 18 high-
20 speed cameras, and you saw the footage from a couple
21 of them there, seven strain gauges on the cask body,
22 four piezoresistive accelerometers on the cask, one
23 accelerometer on the locomotive, and the data was
24 acquired via a telemetry system to a remote recording
25 site. So that's why you don't see any cables coming

1 off of that cask, as is typical in the way that we do
2 transportation package testing. You see an umbilical
3 line of cables that are used to get the data off of
4 the testing to a recording system. Next slide,
5 please.
6 Actually, there were two tests in this
7 particular configuration, involved a truck carrying a
8 transport cask. Would you click on the slide, please,
9 to play that movie? The first test was at 60 miles
10 per hour.
11 (Movie played.)
12 MOVIE MODERATOR: In the first test, a
13 truck carrying a 22-ton spent fuel cask impacted a
14 690-ton concrete block at 60 miles per hour. Here's
15 the impact in slow motion.
16 (Movie stopped.)
17 MR. AMMERMAN: For the second test, we had
18 to get a new driver.
19 (Laughter.)
20 The two tests were at 60 miles -- next
21 slide, please -- were at 60 miles per hour and 84
22 miles per hour. The results of those tests are
23 documented in SAND77-0270. Again, that's available to
24 anybody who wants to get a copy of it. This test was
25 monitored with about 14 high-speed cameras, photorays

1 between 400 frames per second and 3,000 frames per
2 second, five accelerometers on the cask body, strain
3 gauges on the cask head and pressure transducers
4 placed inside the cask cavity. The results of both of
5 those tests, the first test, the 60-mile per hour
6 test, had such little deformation to the cask that we
7 said, "You know what? That was no big deal, let's go
8 out and do it a faster test," and so we did the second
9 test, which was 84 miles per hour. Even that test had
10 very little deformation to the cask, and the package
11 remained essentially tight. Next slide, please.
12 The next test type was a rail transport
13 cask. In this particular instance, we just used the
14 rail car that was used to transport that cask and not
15 the whole train for the impact. Typically, you would
16 have the mitigating structure of cars in front of the
17 car being tested to absorb energy as well, but in this
18 particular test, if you click on the slide, please,
19 the car was slammed into that same --
20 (Movie played.)
21 MOVIE MODERATOR: The 74-ton shipping
22 cask, carried by a cask rail car, crashed into the
23 concrete block at 81 miles per hour.
24 (Movie stopped.)
25 MR. AMMERMAN: You can see that the

1 deformation of the rail car was extensive. The cask
2 did not actually come completely out of its carriage,
3 and, again, there was no significant leakage on that
4 cask. Next slide, please. Documentation of that test
5 is available on SAND78-0458. This was monitored with
6 numerous high-speed cameras, up to 3,000 frames per
7 second framing rates, placed above, on the sides and
8 at various angles. Active accelerometers were placed
9 on the rail car frame, the rail car cage cover, which
10 you can see gets extremely damaged in the test, on the
11 cask and also on the target.
12 One of the things that we tried to learn
13 from that is that concrete target that you see there
14 that that rail car impacts into, and the truck in the
15 previous slide, is not a rigid target. It's a massive
16 block of concrete, but there is energy absorbed by
17 that concrete. It does not have a steel face on it as
18 is required or is typically required for the
19 certification tests. Strain gauges were installed on
20 the rail car frame, cask body and to the rods inside
21 the cask. Next slide, please. Thank you.
22 In addition to these impact-type tests,
23 that test program also involved a thermal test. The
24 same rail car that we just saw impacted into the
25 concrete barrier was placed into a full-engulfing fire

1 and burned for a period of 90 minutes.

2 (Movie played.)

3 MOVIE MODERATOR: After 90 minutes, three

4 times the duration of current qualification test

5 criteria, surface temperatures exceeded 1,400 degrees

6 fahrenheit, but inside the cask where the spent fuel

7 rods would be contained temperatures were below 300

8 degrees, not enough to melt the spent fuel rods.

9 (Movie stopped.)

10 MR. AMMERMAN: Next slide, please. That

11 particular cask in the fire was instrumented with

12 numerous thermocouples. As you can tell from the

13 narration on the film clip, some on the inside, some

14 on the outside to measure the thermoresponse of the

15 cask. Next slide, please.

16 What have we learned from this Crash Test

17 Program? The results indicated that current, at the

18 time late '70s, analytical and scale modeling

19 techniques could predict vehicular and cask damage in

20 extremely severe accident environments with reasonably

21 good accuracy. In addition to this full-scale sound

22 clips there are clips of the scale model tests of some

23 of those casks, and the difference in response or the

24 similarity in response is amazing, except for if you

25 have something that will reference the scale. And I

1 notice the fact that the scale models look a little
2 bit toy-ish, if you will, not in the same degree of
3 complexity as the full-scale ones. It's very
4 difficult to tell that one of those is a scale model
5 test and one of them is a full-scale test, the
6 response is so similar.
7 The data collected on responsive transport
8 systems and accident environments was valuable. It
9 demonstrated the fact that these casks are extremely
10 rugged and capable of surviving very severe accidents
11 with much higher velocities than the regulatory 30-
12 mile per hour impact velocity. Next slide, please.
13 Is there any additional information that
14 can be gleaned from these tests? The analysis
15 computer software that we have today is much more
16 robust or much more capable than it was in the 1970s.
17 We all used 2-D final analysis and lump parameter
18 models, such as spring mass models at that time to
19 represent the casks. Today, we have detailed 3-D
20 final element models that can model many of the
21 components of the packages as well as the global
22 response.
23 Some of the data from these tests could be
24 used to benchmark the present-day codes. For example,
25 the locomotive cask grade crossing test is a good

1 candidate for that. One of the difficulties of that,
2 though, is that in order to do these detailed final
3 element models that we have today, we need to have
4 detailed information about the packages that were
5 tested or are being tested and the target or in this
6 case the locomotive, the geometry of them. Since
7 those tests were done so long ago, we can't go back
8 and say what are the material properties of the
9 different materials that are involved in that impact?
10 What is the exact geometry of the cask? We can use
11 the drawings of the cask, which maybe are still on
12 file here at the NRC someplace, since those were
13 certified casks at the time. Well, they weren't
14 certified at the time of the test but they had been
15 certified previously to that to get a general
16 description of what the geometry was but tolerances,
17 gaps that are produced in the packages as a function
18 of use, or just fit-up and things like that, we don't
19 know that information.
20 Some of that information is important in
21 determining what the response is in events such as
22 these that you see here. And even more so, more
23 problematic, is what is the properties of the
24 locomotive. The QA on locomotive design I'm sure is
25 not as stringent as the QA on cask design, and the

information on that particular locomotive may be very difficult to get as to even what the geometry of it was, the exact geometry.

Also, since the 1970s, there have been tremendous improvements in data collection, instrumentation and sensors. We're able to obtain much more information in tests that are done today than was possible in the 1970s. Next slide, please.

Another test program, extensive test program conductive at Sandia in 1986 was the DHLW Cask Tests. The purpose of this test program primarily was to do certification impact and puncture test sequence, to provide test data on accelerations and strains to compare with analysis results. It's kind of the same kind of thing that we're looking at today, can we compare tests and analyses? To define the damage state of the cask as input into the hypothetical fire analysis, there was not a fire test because it was a half-scale model. Half-scale fires don't work really well, and so this particular package was intended to be certified in a fire environment only by analyses, and so we needed data on what the deformed shape of the package was to start that analysis with. The test sequence included five 30-foot drops and two puncture spike tests. Next slide, please.

1 For these tests, there was rather a lot of
2 instrumentation. Accelerometers on the cask varied
3 from six to 15, depending on cask orientation. Strain
4 gauges varied from four to 24. Strain gauge bolts,
5 some of the closure bolts were replaced with bolts
6 that had strain gauges mounted on the inside of them
7 so that that bolt acted like a load cell, could
8 measure during the test what the load on that
9 particular bolt was, and it varied from zero to eight
10 of those. The side impact test didn't have any strain
11 gauge bolts and then the end impact and corner impact
12 tests had up to eight.
13 In addition, there were LVDTs, linear
14 variable differential transducers, to measure the
15 displacement between the cask lid and the cask body to
16 give -- to see if the analysis that predicted that
17 there would be no deformation of closure was indeed
18 correct. And also since you can't really measure leak
19 rates in scale model testing and there's not a
20 straightforward correlation between leak rates and a
21 scale model test to leak rates in a full-scale
22 package, this information would provide us information
23 to say indeed was the response of the closure such
24 that the package should remain leak tight in the full
25 scale, because you can scale the strains in the

1 deformations. Next slide, please.

2 Here you see one of the tests. This test

3 was done at minus 31 degrees centigrade. The target

4 was minus 29 but we had -- because the package was

5 warming up while it was hanging up there in the air,

6 it got a little bit colder and we actually ran the

7 test at a minus 31. And you can see the damage to the

8 cask. It curls up the impact limiter there at the

9 end. This package is a little bit different than a

10 spent fuel cask. This is a -- DHLW stands for Defense

11 High-Level Waste. The purpose of this package was to

12 transport vitrified high-level waste logs, essentially

13 a stainless steel canister filled with glass that

14 contains high level waste. It had kind of a unique

15 design, and that doesn't have an impact limiter around

16 the end. For the end drops it had a ring impact

17 limiter, and not in this test but for the sides tests

18 there was a typical, if you will. honeycomb impact

19 limiter to absorb the impact energy. Those impact

20 limiters are done in this test.

21 The results of that test sequence

22 indicated the package was leak-tight after each test,

23 closure deformations were very small. The various

24 tests where the closure deformation was measured was

25 0.004 inches, and that was a dynamic measurement, so

that wasn't at the end of the test, that was at peak during the test. At the end of the test, all the closure measurements were back to essentially a zero strain or zero deformation. The peak strain measured was 0.0033. Recall that yield strain levels for stainless steel are about 0.0015, so this is barely above yield, although that strain measurement wasn't done during the impact limiter region, it was up in the closure or up in the container boundary of the cask. Strains in the impact limiter are considerably higher than that. Peak acceleration measured was 2,200 Gs on a half-scale, which would be 1,000 Gs on full-scale. This package is a very stiff package, and so the acceleration levels are much higher than are typically seen in spent fuel casks. And the analysis results were generally conservative. Next slide, please.

What can we learn from these tests or is more information available from these tests that we can use to enhance our current level of knowledge? This test series was very thorough, and it can be used as a demonstration of the types of instrumentation information that can be obtained from a drop test. Recall that there was strain gauge data, accelerometer data, load cell data and deformation data that were

1 acquired dynamically during the test. Any future
2 testing, such as what Bill suggested that we're going
3 to be doing in PPS, should probably include all those
4 types of instrumentation.
5 The tests were performed in 1986 and it
6 would be difficult to resurrect any of the digital
7 data that was obtained from the test. So to compare
8 test results to new analysis results wouldn't have the
9 fidelity that you could get if you were doing a test
10 today. But the test results could be compared to
11 modern analysis results, as I say, but with slightly
12 lower fidelity than current test results.
13 CHAIRMAN HORNBERGER: Why would it be
14 difficult to resurrect the data, you didn't archive
15 it?
16 MR. AMMERMAN: Yes. It's archived on 9-
17 track tape. Now, my computer doesn't have a 9-track
18 on it, and there are very few of them that do. I'm
19 not saying it would be impossible. I think that
20 Sandia still has 9-track tape readers. I don't know
21 if there's any modern operating system that can talk
22 to those machines or not, which is why I say it would
23 be difficult. I think it's possible.
24 Another test sequence that was performed
25 at Sandia was a full-scale test in the TRUPACT-II.

1 These tests were carried out in 1989 and actually some
2 earlier ones earlier than that in 1988, the initial
3 ones, and some of the tests maybe actually spilled
4 over into 1990 even. The purpose of those test was
5 certification test sequence -- drop, puncture and
6 fire. This package was certified by full-scale
7 testing, so there was very little analysis that went
8 along with the certification process. Multiple tests
9 of each type were performed because the regulations
10 require that packages be tested in the most damaging
11 orientation. However, what's most damaging to one
12 component of the package may not be the most damaging
13 orientation for some other component of the package,
14 so there were quite a few tests done in this sequence
15 of tests.
16 Because it was not a need to compare test
17 results to analysis results, there was very little
18 dynamic instrumentation taken on this test sequence.
19 However, post-test leak checks were performed after
20 test and the package remained leak-tight, and there
21 was also photometric coverage. Next slide, please.
22 Here you can see a couple of the tests --
23 let me click on this movie. This was a 30-foot CG
24 over corner impact test. This is kind of just like
25 testing, you sit around all day waiting for something

1 to happen. And the impact on the closure and to the
2 package. Some of these tests were also conducted, and
3 here you see the fire test. The large object on the
4 left-hand side of that fire is something that was
5 done. We were trying to -- we had a big fire going
6 and we said, well, let's do some characterization of
7 the fire environment too, and I'll talk a little bit
8 more about why characterization of the fire
9 environment is important as well.
10 As I say, some of the tests for the
11 TRUPACT-II were done at elevated temperature. That
12 particular package has polyurethane foam as an impact-
13 absorbing material. It has significant temperature-
14 dependent material properties. Some of the tests to
15 that package were done with the package hot, some of
16 it done with it cold. Next slide, please.
17 The results of the TRUPACT-II testing were
18 that the package remained leak-tight following all
19 tests, but the relatively fluctual package experience
20 was visible deformations, which I think is one thing
21 that's important if we're going to do a benchmarking
22 type of study, we want to have something that people
23 can see. If I test a spent fuel cask to the
24 regulatory environment, the cask body itself is going
25 to have no deformation, which is the way we design

1 packages. That's the intent, all the deformation is
2 in the impact limiter. I'm not sure if that's
3 sufficient to convince the public that we know how to
4 analyze a package for environments that are more
5 severe than the regulatory test environment and to be
6 able to predict by analysis when the package is going
7 to start to leak or to fail. Next slide, please.
8 Is there any additional information that
9 can be gleaned from these tests? The lack of
10 instrumentation during the test sequence makes it
11 difficult to compare test results to analyses. You
12 can compare deformed shape, but that stuff is not
13 archived really well. We can't go up and say, well,
14 we have more detailed analyses now than what you did
15 when you did the test. Let's go out and measure what
16 the package is and say how well that analysis compared
17 to the tests. Measurements that weren't taken at the
18 time of the test are probably not available at this
19 time.
20 The extent of the test sequence, and you
21 didn't really see from my presentation, but there were
22 I think a total of 14 drop tests performed on the
23 TRUPACT-II using two different test units. It
24 demonstrates the expense of relying on testing for
25 certification, which is one of the main reasons why

1 these kind of people over here, the package vendors,
2 typically use a combination of testing and analysis to
3 do their certification.
4 So let's talk a little bit about analysis.
5 Cask vendors rely on analysis to some extent to
6 demonstrate package response to the hypothetical
7 accident tests, and that extent for some packages is
8 more than it is for others. Even the TRUPACT-II which
9 was certified primarily by tests there were analyses
10 done as well to demonstrate compliance with some of
11 the requirements of the 10 CFR 71. Other packages are
12 certified without any testing. A good example of that
13 is the bus cask, which is a DOE package. The package
14 was never tested, it was completely certified by
15 analyses.
16 Conservatisms introduced into analysis
17 methods or assumptions within those analysis methods
18 for design certification are not always applicable for
19 test predictions. When I'm doing design I'm going to
20 use minimal material properties, for example. The
21 real testing isn't going to have minimal material
22 properties, it's going to have something close to
23 nominal material properties. The behavior of the
24 package is going to be different if it has -- if it's
25 built with material with minimum material properties

1 than if it's built with material with nominal material
2 properties. If I'm going to do a test prediction, I
3 need to know exactly what the material is that's
4 actually in the test unit. I can't go to the ASME
5 code and say this particular steel has a yield
6 strength of, for example, 30 KSI. It's not adequate
7 for doing a pre-test prediction of the behavior of the
8 package. I need to know what the stress/strain curve
9 is of that particular material. And so any detailed
10 program, such as PPS, that we're proposing is going to
11 require actual coupon testing of the real material as
12 being used in the package, as it's being fabricated
13 most likely, and recording of the complete
14 stress/strain curve, not just -- I'm sure that when
15 people design packages, when they have them built, one
16 of them who covers the fabricator is you pull coupons
17 and you do tests. But what's recorded from those
18 tests? Yield strength, ultimate strength, perhaps
19 elongation, maybe, and less likely this, percent
20 reduction in area, and chemistry of the sample.
21 MEMBER LEVENSON: Let me interrupt for a
22 second. I understand what you're saying if what you
23 were doing had only pure scientific interest but it's
24 been stated that the purpose of the test is to
25 demonstrate to the public that nothing happens to the

1 cask, and I don't understand why you need all of that
2 detailed information for that purpose.
3 MR. AMMERMAN: Our risk analyses that we
4 have done, for example, 6672 that Bill talked about
5 earlier, use computer analyses that demonstrate the
6 response to the package to environments that have
7 never been tested. In order for somebody to have
8 confidence in those computer analyses, it's my belief
9 at least that we have to go out and do a pre-test
10 prediction of the response of the package to an actual
11 test. In order to do a pre-test prediction, even to
12 the regulatory test where there's very little plastic
13 deformation, I still need to know mature properties,
14 I need to know when yield, for example, comes about.
15 I can't use minimal analysis because then
16 if I don't use the real material properties, my
17 analysis predicts a different result that's shown in
18 the test. The public says, "Look, you cannot predict
19 the test results. How do we know that the analysis
20 that you did for your risk assessment is correct?
21 What confidence do we have in the analysis that's done
22 to demonstrate that the risks are small, that people
23 like DOE rely on when they do an EIS to say that
24 there's no impact of transporting or not -- a
25 significant impact of transporting 63,000 metric tons

1 of fuel to Yucca Mountain?"

2 MEMBER LEVENSON: But that would make

3 sense only if your analysis had zero conservatism in

4 it, because if it does not have zero conservatism, the

5 test is only going to confirm that it is conservative.

6 It's not going to demonstrate how conservative. So

7 what you're saying makes sense only if you tell me

8 that your analysis is designed to have zero

9 conservatism. I'm not sure that's very acceptable for

10 regulatory use.

11 MR. AMMERMAN: And that's the reason why

12 that second bullet on this slide, for regulatory use

13 it's not acceptable. I want to have analyses that has

14 conservatism for regulatory use. The certification

15 process is going to require conservative analysis, but

16 if I'm doing test predictions and I want to get the

17 right answer as opposed to a conservative answer,

18 you're right, I'm going to do an analysis with no

19 conservatism.

20 MEMBER LEVENSON: Are you telling me that

21 these tests are not going to be usable for regulatory

22 use?

23 MR. AMMERMAN: No, they'll be usable for

24 regulatory use but that's not their -- no, let me

25 rephrase that. They're not going to be usable for

1 certification. They're not certification tests.
2 They're going to be used to demonstrate that the
3 process used in certification provides safety. The
4 responsibility for demonstrating that packages meet
5 the certification requirements lies with the package
6 vendors. They do analyses to demonstrate compliance
7 with certification. The analyses that Sandia is going
8 to do as part of the package performance study is not
9 for certification.
10 MEMBER LEVENSON: Excuse me one second.
11 Two of our members are leaving, not because of your
12 talk but because they have to go talk to a
13 commissioner. That has a little bit of a priority.
14 I'm sorry, go ahead.
15 MR. AMMERMAN: Well, we'll excuse them, I
16 guess, then. As I was saying, the responsibility for
17 demonstrating regulatory compliance is up to the
18 vendors, and NRC reviews that analyses and makes sure
19 that they do a good job of that and that their
20 analysis is correct and that their package does indeed
21 meet those certification requirements. The
22 responsibility of the package performance study of an
23 organization like Sandia National Laboratories in this
24 particular instance is to demonstrate reality, not
25 conservatism. Next slide, please.

1 To do the structural model, we use the --
2 Sandia uses transient dynamic finite element codes
3 with explicit integration of the equations of motion.
4 Such codes are called shock dynamic codes. First code
5 of this type was HONDO, which was developed at Sandia.
6 Lawrence Livermore developed a follow-on code with
7 more capability called DYNA. That particular code has
8 been commercialized and is available to anybody in the
9 commercial sector who wants it. PRONTO is another
10 code developed at Sandia. It's the code that was used
11 to do the analysis that are in 6672. That particular
12 code is export controlled and therefore has very tight
13 distribution requirements on it, it's not available
14 commercially. ABAQUS/Explicit was written, actually,
15 by the same people who wrote PRONTO. They left Sandia
16 and went to work for HKS and developed
17 ABAQUS/Explicit, which is commercially available. And
18 currently, or just recently, Sandia has developed a
19 code called PRESTO, which is the newest code in this
20 family. PRESTO, unlike the previous codes, was
21 written from the start for parallel analysis using
22 parallel computers and so it's a little bit -- at
23 least I'm told that it's going to be more robust in
24 that environment. Next slide, please.
25 For thermal modeling analysis, Sandia uses

1 both computation fluid dynamics codes and fine element
2 codes to solve the fire dynamics and the heat transfer
3 problems. CAFE, which stands for cast analysis in
4 fire environments, was a code developed at Sandia
5 designed to model large fires engulfing a package.
6 And it's coupled to P/Thermal so that the CAFE part of
7 the code models the fire environment. P/Thermal
8 models the heat transfer within the cask. P/Thermal
9 is a fine element code which is commercially
10 available.
11 SODDIT, Sandia One-Dimensional Direct and
12 Inverse Heat Transfer is what SODDIT stands for, is a
13 code that's used when we're doing fire tests. We
14 cannot measure what the incipient heat onto the
15 package is, how many kilowatts per square meter, for
16 example, is being imparted to the package. There's
17 not a gauge that measures that type of information.
18 So what you do is you measure surface temperatures on
19 the package and you use a code like SODDIT to
20 calculate what the heat transfer rate is to the
21 surface of the package. Because it's a one-
22 dimensional code, it's essentially assuming that the
23 test unit is a spherical -- has a spherical geometry.
24 It has some limitations, therefore, when applied to a
25 cylindrical geometry, such as a cask, especially up in

1 the closure region.

2 Vulcan is a computational fluid dynamics
3 code developed at Sandia to solve a broad range of
4 fire problems, unlike CAFE, which is designed to solve
5 a much broader class of fire problems, for example
6 offset fire is a good example. A tunnel fire would be
7 another good example.

8 COYOTE is a fine element code developed at
9 Sandia for solving heat transfer problems. It's a
10 very robust code for solving a large class of
11 problems. But it's kind of a legacy code, if you
12 will. It's being phased out in favor of the next code
13 on the list, CALORE, which is the newest Sandia fine
14 element heat transfer code. The advantage of CALORE,
15 or one of the advantages of CALORE, is it's been
16 developed in the same architecture as the impact code,
17 PRESTO. Those two codes talk to each other completely
18 so you build a model in PRESTO, subject it to impact,
19 you can take that deformed shape now that you've
20 gotten from the impact calculations and use CALORE to
21 apply a fire environment to it.

22 How do we know that these analysis codes
23 are giving us the correct results? One of the methods
24 is code verification validation. Verification
25 validation provide high confidence, at least in the

1 scientific community, to the computational accuracy of
2 simulations, demonstrating the predictive capability
3 of the codes and their underlying models.
4 Verification is the process of determining that the
5 code is correctly implementing the mathematical models
6 that are used to describe the physical process.
7 That's saying does the code solve two plus two and get
8 four?
9 The validation is the process of
10 determining do I have the right code correctly. The
11 validation process tells me that two plus two is what
12 I want to solve, not two times two. The combination
13 of verification and validation tells me, and I need to
14 do this over a broad range because in that example I
15 gave you two plus two and two times two both give me
16 the right answer. The code solving two plus two that
17 gets four, that's the right answer for two times two.
18 I need to do that over a broad range, because one
19 times three is not the same as one plus three. That's
20 the process of validation. Validation makes use of
21 physical data, for example comparing tests to
22 analyses, and also does code-to-code comparisons --
23 does my code get the same answer as somebody else's
24 code? Next slide, please.
25 Here's an example of the -- I told you

1 that the analysis and the test results agreed fairly
2 well for DHLW. Here's an example from a corner impact
3 test. On the left you see the test result, on the
4 right you see the analysis result. And they agree, as
5 you can see, quite closely. You probably can't read
6 what the strain level is on that on here, but the peak
7 strain I think there is about maybe 70 percent. Large
8 deformations in the impact limiter. This is that ring
9 impact limiter that I was telling you about. High
10 level of strains in the impact limiter, very low
11 strains measured from strain gauges up in the
12 containment boundary. Next slide, please.
13 A little more detailed analysis of a --
14 essentially, this was a -- SETU stands for structural
15 evaluation testing. It was nominally a third-scale
16 rail cask designed to be minimally acceptable, to just
17 meet the requirements of the ASME code, have stress
18 levels at the allowable limit from the regulatory
19 impact test. It was then tested at speeds up to 60
20 miles per hour. This particular test was seven
21 degrees off a vertical impact, and that test result is
22 compared to the analysis on the right. You can see
23 that the analysis does a very good job of predicting
24 the deformed shape of the test. It also -- that test
25 had many accelerometers, strain gauges, strain gauge

1 bolts and LVDTs on it. And the analysis also
2 predicted the response of those gauges quite well.
3 Next slide, please.
4 In addition to modeling impact events, we
5 also model thermal events. This is an example of the
6 CAFE fire analysis code. On the left, you see a test
7 fire that was used to benchmark this particular code
8 with, and on the right, you see the code results,
9 again, agreeing very closely.
10 Finally, where are the gaps? What don't
11 we know? Certification tests, for example, DHLW and
12 TRUPACT-II, do not involve significant plastic
13 deformation in the closure region. That's by design.
14 We wouldn't want to have a package going out there
15 that had plastic deformation in its closure region
16 transporting fuel, if it had that, in the regulatory
17 environment. Our risk assessments, though, predict
18 when we're going to get package deformation in the
19 closure region. Do we want to have benchmarks that
20 show that we can predict that response accurately?
21 The SETU tests were not full-scale tests
22 and did not involve the complete cask system. It was
23 close. I mean it had a closure, a bolted closure, it
24 had a lead steel wall, but it didn't have some of the
25 other components that packages have. It didn't have

1 test parts, it didn't have drain valves, it didn't
2 have neutron shielding. Its impact limit was designed
3 only for end impacts or nearly end impacts, it didn't
4 have a complete impact lender system. That was done
5 so that we could do a good job of comparing test and
6 analysis results. It was done so it was easy or
7 relatively easy to do the analysis. It's not as
8 complex of a system as a real cask.
9 The Crash Test Program in the '70s had
10 little instrumentation to compare analysis results and
11 also it used cask designs that were obsolete at the
12 time that they were tested almost 30 years ago. So
13 that's not an accurate portrayal of what kind of
14 packages are being used today to transport spent fuel.
15 There's no data available on surface heat
16 flux incipient onto a rail cask-like object in a fully
17 engulfing open pool fire. Tests have been done with
18 that slide that I showed previously, that calorimeter.
19 That was almost the size of the truck cask. So for
20 smaller objects we have that on what kind of -- what
21 the fire environment looks like. A rail cask has a
22 lot of mass, it has a high thermal capacity. That
23 thermal mass affects the fire dynamics. We don't have
24 any data on how well we can model that interaction
25 between a massive, large cask and a engulfing fire.

1 There's also no data available on the
2 response of spent fuel to severe transportation
3 environments. We have some tests that indicate what
4 the response of packages are, and actually that Crash
5 Test Program had spent fuel in it, but we don't even
6 know what the environments that spent fuel saw in
7 those tests was, so we have very little data on how
8 does spent fuel behave in accident environments,
9 especially how does it fail in accident environments.
10 In a certification process, NRC typically
11 assumes that in the hypothetical accident conditions
12 100 percent of the fuel has failed, which is why
13 typically packages are designed to be leak-tight
14 following the certification process so that they can
15 demonstrate that they have no release of an A2 per
16 week.
17 There's also no demonstrated comparison
18 between the analysis used in risk assessments, for
19 example, 6672, and full-scale, high-speed impact and
20 fire tests. Package performance study is aimed at
21 addressing that, especially that last bullet. We need
22 to have comparisons for impacts that are a threat to
23 the package. We know what the response of the package
24 is to the regulatory environment. We want to see what
25 the response to the package is to environments that

are more severe than that. Thank you.

MEMBER LEVENSON: Thank you. Ray?

VICE-CHAIRMAN WYMER: Yes, I have one question. It has a couple of parts but it's basically one question. You say there that there was no data on surface heat flux incipient on the rail cask-like object in an open pool fire, but in fact you said earlier that you had a 1,400 degree fire and it got to 300 degrees inside the waste package. Isn't that data?

MR. AMMERMAN: We have data on temperatures in that particular test, but we have -- like I said, to relate temperatures to heat flux is not an easy thing. That particular test package was tested with its rail car included, which severely affected the heat flux onto the package. And in a real accident, that's probably the configuration that you would have. For most fires, the cask would remain on its conveyance. What happens is that the conveyance provides thermal shielding, protects part of the package from the fire environment. In that particular case, there was a cage all the way around the package, so that provided a great deal of protection to the cask.

It's not conservative and that's the

1 reason that the NRC doesn't do that in certification
2 process to assume that the package is going to always
3 be on its conveyance. So the plan is for the package
4 performance study to test the package without its
5 conveyance, so the impact has to be only of the
6 package, not of a package plus tractor trailer or
7 package plus rail car. The fire test also will be a
8 bare package sitting in the fire environment as if
9 somehow the tie-downs had failed and the package had
10 come off of its conveyance mode.
11 So, yes, there is some data available, but
12 it's very difficult from that small amount of
13 available data to infer what heat flux is.
14 VICE-CHAIRMAN WYMER: Now, what you said
15 was true and accurate, but it was misleading, I
16 thought, because the suggestion earlier was that you
17 had actually exposed the package to a 1,400 degree
18 centigrade and in fact you hadn't.
19 MR. AMMERMAN: We had exposed a package
20 plus conveyance to a --
21 VICE-CHAIRMAN WYMER: No.
22 MR. AMMERMAN: -- an engulfing fire, not
23 necessarily a 1,475 degree fire. Real fires tend to
24 be actually a little bit hotter than that, and so the
25 fire environment that that package saw may or may not

1 be more severe than the regulatory environment. Same
2 with the crash environments.
3 VICE-CHAIRMAN WYMER: But it wasn't 1,400
4 degrees.
5 MR. AMMERMAN: Well, I'm guessing it was
6 -- the surface of the package got to 1,400 degrees, so
7 obviously it saw an environment. Now, did it get to
8 -- was it at 1,400 degrees for 30 minutes like the
9 regulatory fire -- actually, 1,45? Probably, yes,
10 because that was a very long duration fire, it was a
11 90-minute fire. And so the protection offered by the
12 conveyance probably didn't -- and this is one of the
13 difficulties with using that test as a benchmark, I
14 say it probably didn't because we don't know --
15 protect the package to the extent that it didn't see
16 even an environment as severe as the certification
17 environment.
18 The same is true with the impact tests, in
19 the crash tests of the truck casks, for example. The
20 tractor absorbed some energy, the front part of the
21 trailer absorbed some of that impact energy. By the
22 time the cask actually hit the impacting surface,
23 which wasn't the rigid surface, it wasn't going at its
24 initial velocity of 60 miles per hour for the first
25 test or 84 miles per hour for the second test; it

1 slowed down. Those environments may or may not have
2 been ex-regulatory.
3 VICE-CHAIRMAN WYMER: Was the 300 degrees
4 internal temperature the peak temperature? Is that
5 what it rose to or was that the temperature at the
6 time you started squirting water on the fire or what?
7 MR. AMMERMAN: Well, I don't believe that
8 that fire was extinguished and the cast was
9 artificially cooled. I think that that 300 degrees
10 was the temperature of the internals at 90 minutes.
11 VICE-CHAIRMAN WYMER: Oh, not necessarily
12 peak.
13 MR. AMMERMAN: Not necessarily peak.
14 VICE-CHAIRMAN WYMER: Because it would
15 have coasted up from there.
16 MR. AMMERMAN: Right. Because of the
17 thermal leg, it would have gone up beyond that.
18 VICE-CHAIRMAN WYMER: You don't know how
19 far.
20 MR. AMMERMAN: I would be willing to wager
21 that it's documented in that Centigrade part that I
22 talked about but I don't know.
23 VICE-CHAIRMAN WYMER: Okay. Thank you.
24 MEMBER LEVENSON: John?
25 MEMBER GARRICK: One of the things the

1 Committee's been struggling with looking at the
2 transportation problem and the tests in particular is
3 this issue of the information that you're getting
4 being for the benefit of demonstrating safety versus
5 being for the benefit of the science that you're
6 trying to deal with. And our obsession, of course, is
7 with the safety and demonstrating the safety. One of
8 the things that concerns me here is that you're
9 delineating a lot of things that you didn't do, and
10 part of this is a lead up to the package performance
11 study that is coming out and that you're not going to
12 make the same mistakes this time around, you're going
13 to do all those things. But I suspect in ten, 20
14 years from now, we'll be looking back on the package
15 performance results with the same kind of concerns
16 because of the advances that are made and so forth.
17 So the question I have here is trying to
18 get a handle on how this information is used. I was
19 at the 1970s test, they were very impressive as a
20 demonstration of transportation safety of the cask,
21 and as I look at those tests and compare it with other
22 engineering issues that exist and the gaps between
23 demonstration tests an the designs, I suspect we build
24 a lot more things with much less testing and much less
25 data than we're building these casks, and yet we seem

1 to downplay the fact that in spite of the fact that we
2 had accelerometers and strain gauges and high-speed
3 photography and target instrumentation on the 1970s
4 tests, we're not able to convince ourselves, at least
5 from an analysis standpoint, that they were very
6 useful. And I just have a great deal of difficulty
7 with that.
8 And I guess I'd like to ask a specific
9 question. Can you tell me how these tests have been
10 used in the models that people have been using, say
11 the three risk studies that have been performed?
12 MR. AMMERMAN: I would say that they've
13 been used very little.
14 MEMBER GARRICK: And I think that's
15 amazing.
16 MR. AMMERMAN: Yes.
17 MEMBER GARRICK: I think that's absolutely
18 amazing, and it doesn't give me a heck of a lot of
19 confidence that the package performance study is going
20 to reap a great deal of benefit when you have a
21 history of those very impressive tests and quite a bit
22 of instrumentation, certainly at the time. And then
23 you look at the risk assessments that have been
24 performed, which are pretty crude and are not very
25 well anchored to those tests in terms of having a

1 scientific basis, and you really wonder where this
2 thing is going. You start out by saying that we have
3 enough evidence in front of us now to be high
4 confident that the casks that we use today are safe,
5 and then we immediately -- and this is not very
6 reassuring to the public, I'm sure -- then we
7 immediately give a list of gaps and things that don't
8 exist.
9 These gaps, in my opinion, are probably
10 mostly relative to the science and very little
11 relevance to the safety. And I just wonder if there
12 isn't a way we could do a better job of presenting
13 that picture; that is to say showing the separation
14 between what is for the good of science and what is
15 necessary to give the public high confidence in the
16 safety of the cask.
17 It's like some of the analysis I saw in
18 the package performance study justification of not
19 taking any credit for energy absorption in anything
20 except the cask itself. Well, I suspect if you did a
21 very meaningful analysis of energy absorption
22 partitioning based on the 1970s tests, you would come
23 up with some rather dramatic pieces of information
24 about how the energy absorption is allocated in these
25 kinds of events. And I don't know whether that's been

1 done or not but it seems to me it's something that
2 could be done and would be extremely useful.
3 So I have a whole lot of questions about
4 this business and the lack of a history of continuity
5 between the tests and the analyses and particularly
6 the risk analyses. The risk analyses that I saw, for
7 example, had very little information in them to
8 portray the uncertainties that are involved and to
9 really give an accountability of what we should be
10 worrying about. Because the risk is in the
11 uncertainties, and yet those assessments do not
12 present the results with any kind of uncertainties
13 associated with the critical parameters except in the
14 sampling process that was performed in the course of
15 doing the analysis.
16 So I think there's a great deal that needs
17 to be don here to put this whole act together in terms
18 of getting the right message out to the public, on the
19 one hand, and then on the other hand, allowing the
20 science to move forward as necessary. But I'm not
21 very impressed with the way the test data that's been
22 generated so far has been kind of buried and not
23 manifesting itself in the course of the kinds of
24 analyses that are what we're interested in doing
25 today, particularly if we mean what we say relative to

1 being risk informed. And I just wondered if you had
2 any comment about that litany of concerns, because I'm
3 frankly not very impressed.
4 MR. AMMERMAN: To start out with, we have
5 struggled both at Sandia and at NRC, I think, with the
6 dual purposes of the package performance study. Is it
7 a scientific study intended to address the
8 shortcomings or gaps, let's say, in our understanding
9 of the science or is it, on the other hand, a
10 demonstration program to demonstrate safety? And to
11 what degree can we marry these two purposes together
12 and come up with a program that addresses both issues?
13 It's been a very difficult struggle, because sometimes
14 what this side wants is counter to what this side
15 wants. I'm not certain that we have in our currently
16 proposed program achieved the correct balance.
17 That's one of the reasons why we're having
18 this next round of public meetings to talk about the
19 test protocols. We'll go out and say, "These are the
20 tests that we're planning on performing." Did these
21 tests address the concerns that the community as a
22 whole has, and if not, what should we do instead or in
23 addition to this series of tests that we currently
24 have planned? The results of that series of public
25 meetings, I think, will tend to either tell us that

1 your concerns are legitimate and that we need to do
2 something different than what we're going to do or
3 that we have reached adequate compromise between the
4 two, the dual purposes of the program.
5 Obviously, there are going to be members
6 of the public that are more swayed by the safety
7 demonstration issue than the science issue, and maybe
8 that's going to push the compromise more toward this
9 side of the fence, if you will, than toward this side
10 of the fence. And, obviously, since Sandia is the
11 organization who wrote the test protocols and has
12 primarily a scientific interest, I wouldn't be
13 surprised that the current plan is a little bit
14 leaning this way toward the scientific analysis or
15 answering the scientific questions.
16 One of the things that I think is
17 imperative and why -- is that if we can convince the
18 scientific community as a whole that this program was
19 conducted in a rigorous manner and therefore the
20 results of it are correct, if you can say that the
21 results of this are correct and apply them now to a
22 risk study, that gives great credence to the fact that
23 that risk study is also correct and removes one of the
24 stages of doubt, if you will, on the risk study.
25 MEMBER GARRICK: Well, there's a lot of

1 very important things that I think can be done. For
2 example, in the reactor safety field, we made some
3 major breakthroughs and better understanding of the
4 safety reactors when we started looking at things like
5 the likelihood of containment failure as a function of
6 the capacity of the containment. And we made some
7 very important discoveries that gave high assurance
8 that these containments, at least some of them, were
9 extremely good and overdesigned and conservative. We
10 want to regulate conservatively, but we want to know
11 what we're regulating from, what constitutes the
12 baseline for conservatism. And in the case of the
13 containments, especially on the large, dry
14 containments, the analysis and the testing
15 demonstrated pretty convincingly that the capacities
16 of the containments were anywhere from one and a half
17 to four times their design basis, and that was an
18 extremely reassuring piece of information that came
19 out of a combination of tests and analysis and risk
20 analysis.
21 So, for example, if we had something on
22 these casks that was something like a parameter that
23 was the likelihood of release as a function of impact
24 force or energy absorption, I think that would be a
25 very insightful piece of information as to what the

1 containment capability of these casks are. And from
2 a safety and risk standpoint, I think these are the
3 kinds of things we'd like to see much more focus on.
4 MR. AMMERMAN: And I think that was one of
5 the big differences between 6672 and the prior risk
6 studies. Both 0170 and, to maybe a slighter lesser
7 extent, the Modal study, assumed that the packages
8 failed as soon as they got into an ex-regulatory
9 regime.
10 MEMBER GARRICK: Right.
11 MR. AMMERMAN: That they had zero design
12 margin. Sixty-six seventy-two did not make that
13 assumption.
14 MEMBER GARRICK: Right.
15 MR. AMMERMAN: It said we will determine
16 or we will attempt to determine what the design margin
17 is of a generic cask. One of the other issues with
18 the risk studies, all of them have been done using
19 generic casks. Is that the correct answer? Maybe
20 not. Maybe what we should do is look at some specific
21 casks. One of the reasons why the -- that generic
22 cask assumption is one of the reasons why the impact
23 limiter was assumed to have zero design margin in
24 6672. Sixty-six seventy-two said the impact limiter
25 absorbed the energy of a 30-foot drop and no more.

1 And so for higher velocity impacts, the
2 analysis said we'll just add the energy that the
3 impact limiter absorbed to the equivalent velocity and
4 get a higher equivalent velocity. And at a 60 mile
5 per hour impact speed, that makes that 60 mile per
6 hour instead to be a 67 mile per hour, which is a
7 relatively small delta. And, of course, at 90 --
8 that's just not true. The impact limiters have
9 tremendous design margin in them. They can absorb
10 much more energy than just the 30-foot drop.
11 If we were to do an analysis of a real
12 package, and this is one of the things that PPS is
13 going to do, it's going to use a real cask, not a
14 generic cask, not a test model, it's going to use real
15 production cask, and one of the things that the
16 analyses that we've done to write the protocol report,
17 as indicated for the rail cask where the test is going
18 to involve the impact limiter is that the impact
19 limiter has a tremendous margin of design margin in
20 it, and it absorbs much more energy than just a 30-
21 foot drop.
22 MEMBER GARRICK: My only point is that I
23 would like to see a much stronger relationship between
24 the tests and the analyses, and the nature of the
25 analyses I'd like to see that stronger relationship is

1 with risk and safety, not necessarily just a finite
2 element code or structural or thermal, because all of
3 the codes that you present up there are either
4 structural or thermal. There's nothing up there about
5 leak rate or there's nothing up there about risk, and
6 in many respects to the public, there's nothing up
7 there that really makes the final connection to what
8 they're most interested in, namely whether one of
9 these things is going to break open and release a lot
10 of material. That's my point.
11 VICE-CHAIRMAN WYMER: I have one sort of
12 half facetious follow-up on temperature. Your drop
13 test was at minus 30 degrees. Did you deliberately
14 choose the coldest day in the winter in order to get
15 the properties of the materials that you wanted or
16 you're just sort of masochistic?
17 MR. AMMERMAN: Actually, you know, it kind
18 of works out this way, it seems like, that people come
19 to us and want us to do a cold test in the summertime,
20 and they come to us and they want us to do a hot test
21 in the wintertime, I don't know. And so what we do is
22 we put the test in an environmental chamber, we cool
23 it down to the desired test temperature. The air
24 temperature that day was not that cold. As a matter
25 of fact, I don't see any ice around the target area,

1 so I'm guessing that that test was done -- actually,
2 as I recall, it was done in April, so the air
3 temperature was probably at that site someplace in the
4 70s when that test was conducted, 60s or 70s.
5 VICE-CHAIRMAN WYMER: So you cooled the
6 cask, then you cooled the plate and then you quickly
7 ran them out there and dropped them?
8 MR. AMMERMAN: The plate is at ambient
9 temperature, we just cool the cask.
10 VICE-CHAIRMAN WYMER: I thought you said
11 it was at minus 29.
12 MR. AMMERMAN: The cask was at minus 31,
13 actually.
14 VICE-CHAIRMAN WYMER: And I thought you
15 said the plate was at minus 29.
16 MR. AMMERMAN: No. The plate was at
17 ambient temperature.
18 VICE-CHAIRMAN WYMER: What was the minus
19 29?
20 MR. AMMERMAN: The minus 29 is what the
21 NRC regulations -- okay. What I said is target
22 temperature, which is we tried to get the --
23 VICE-CHAIRMAN WYMER: Oh, okay, wrong --
24 MR. AMMERMAN: Yes. Now I understand
25 where your confusion came from. Not the plate, right.

1 Different target.

2 VICE-CHAIRMAN WYMER: That's why I thought

3 it was outside. Okay.

4 MR. AMMERMAN: Okay.

5 MEMBER LEVENSON: I've got a couple of

6 questions. I'm having real problems separating out

7 this hodgepodge of testing to check certification,

8 testing for demonstration and testing to assure the

9 public, because it isn't very clear to me that these

10 aren't conflicting and they're not clearly not clearly

11 delineated what's for what. And for instance, your

12 list of gaps that has to be for pure science, because

13 the first bullet -- I guess I do consider myself a

14 member of the public, and I feel if you did the tests

15 and there was no deformation, it means the design is

16 conservative. That's a basic gap in pure science, but

17 suppose you have to go 175 mile an hour to get

18 deformation. Would you propose to go there till you

19 demonstrate that you've done deformation?

20 MR. AMMERMAN: No. I would say --

21 MEMBER LEVENSON: And by the way, 175

22 miles per hour you know was a number in the draft plan

23 for PPS, so this isn't something I made up.

24 MR. AMMERMAN: Actually, I think that

25 there's no need to go -- from a demonstration point of

1 view, there's definitely no need to go to impact
2 velocities that are higher than the accident record.
3 And when we developed the initial plan for package
4 performance study was before we had done any reviews
5 of the accident record. We were relying on the
6 accident record as portrayed by the Modal study, and
7 I think that they only had impact velocity up to 150
8 miles per hour in there.
9 If we say that the spent fuel
10 transportation experience is maybe not going to be the
11 same as the global transportation experience, for
12 example, freight trains don't go 150 miles per hour.
13 There may be train accidents at that velocity but
14 they're not from freight trains. They would be from
15 passenger trains. Those are the higher speed trains.
16 So the only type of accident that would involve that
17 kind of velocity is a train-to-train collision. And
18 to use that impact speed for other types of accidents
19 is probably not a smart thing to do, if you will.
20 But the accident record definitely does
21 show impacts up to 90 miles per hour for both truck
22 and train collisions, and so where do you draw the
23 line for demonstrations and safety purposes, maybe
24 someplace less than that. If you want to say that our
25 analytical capabilities are adequate to predict

1 failure, if that's the goal to say that our analytical
2 capabilities can predict failure of these various
3 components, then that may drive your velocity to a
4 higher number in order to demonstrate the test shows
5 that you had failure of that particular component and
6 we predicted it correctly.
7 MEMBER LEVENSON: Well, I guess I'd be
8 more interested in feeling comfortable that your codes
9 could predict when I wouldn't have failure than
10 accuracy on predicting failure if failure is beyond
11 reality. This is kind of a generic issue.
12 MR. AMMERMAN: Yes.
13 MEMBER LEVENSON: You raised the question
14 of rigorous and I think that's a little bit of a red
15 herring because I have a great deal of respect for
16 Sandia and I don't have any doubt that all the testing
17 they do is rigorous. That has very little to do with
18 the conditions you pick for doing the tests.
19 I have a follow-up question for George.
20 He's not here so he's not a member of the ACNW at the
21 moment but he is a taxpayer, and his question is isn't
22 it significantly cheaper to extract the data from the
23 old tapes than --
24 MR. AMMERMAN: Yes. It is significantly
25 cheaper, but -- and one of the things I didn't put on

1 my slide but it is a consideration is would you have
2 confidence in the fact that my analysis matched the
3 test results, that I already knew the test results as
4 opposed to predicting a test result before I did it?
5 There's a much higher -- I contend that there's a much
6 higher level of confidence if I predict a test result
7 than if I match a test result.
8 MEMBER LEVENSON: But in this case you
9 don't have the data yet, so you can predict it and
10 then go extract it, so that's not an issue in this
11 case.
12 In your DHLW test, you said the analytical
13 results were generally conservative. Was this by a
14 factor of 50 percent or two orders of magnitude or how
15 far away are we? See, the assumption on the
16 regulatory side is that the regulatory requirements
17 already have conservatism in them, and I'm just
18 curious how many more times we're adding more
19 conservatism.
20 MR. AMMERMAN: The DHLW analysis results
21 -- and part of the reason that they were conservative
22 is because the analysis results were not pre-test
23 predictions. They used minimum material properties,
24 the test unit had real material properties. They were
25 on the order of maybe ranging from conservatism factor

1 of 1.2 up to maybe as high as four. Now, it depends,
2 of course, on what you say is a conservatism. What
3 are you comparing? And that's one of the difficulties
4 whenever you try to compare analysis of test results.
5 If I say that the test result the answer was 120, the
6 analysis result answer was 150, the allowable was 100,
7 the conservatism in my test was 20, the conservatism
8 in my analysis result was a 50, so is my analysis
9 result two and a half times conservative relative to
10 the test result? It's difficult. You have to be very
11 precise in describing what you're comparing to when
12 you say the analysis showed a conservatism of X.
13 MEMBER LEVENSON: Okay. Well, that, of
14 course, is back to John's question: If you're not
15 carrying the calculation out for some indication of
16 risk, you don't what the conservatism means.
17 MR. AMMERMAN: And one of the things that
18 I think that has been lacking in past risk studies is
19 what John suggested is what is the sensitivity of
20 things? Sixty-six seventy-two did some, as you said,
21 in the sampling of parameters, but probably the most
22 important parameter is what is the package response?
23 And there was no sensitivity study at all done on
24 package response. How sensitive is the response to
25 the fact that minimum material properties versus real

1 material properties? How sensitive is it to impact
2 orientation? We did an analysis at CG over corner.
3 What happens if you're two degrees off of that? A
4 whole host of issues with respect to sensitivity to
5 analytical results of the package to the impact
6 environments. We could spend the manpower that's in
7 this room for several years, though, to try to nail
8 that answer down precisely.
9 MEMBER LEVENSON: I know, and that's one
10 of the things that bothers me a little bit. I'm going
11 to do something I don't very often do in public and
12 that's maybe defend what the NRC staff does about
13 something, but their use of minimum properties, which
14 you're kind of poo-pooing a little bit, seems to me is
15 the only thing that in a regulatory safety world makes
16 any sense at all, because, for instance, you want
17 exact dimensions and exact properties. I used to live
18 next to where locomotives were built and I can tell
19 you that each one is a custom one, there are no two
20 that are absolutely identical. So are you proposing
21 to test all the locomotives? I mean I think you have
22 to work with some kind of bounding.
23 And here, again, we're basically coming
24 into conflict between is this test confirmatory for
25 safety or is it to get additional data for scientific

1 research, which is an admirable objective. I spent 45
2 years in research, I never had enough data for
3 anything. But in the real world -- which doesn't --
4 which like John, I have some real problems with
5 defining as gaps, which we're interested in safety
6 gaps, which are gaps in scientific information and may
7 not be relevant for risk. Any of the staff, ACNW
8 staff members want to comment?
9 MEMBER KOBETZ: Doug, I know you were
10 saying that with the casks that you tested in the '70s
11 you didn't know a lot about the fabrication tolerances
12 and things like that, but can you tell us anything
13 about the design margins and design characteristics
14 and how they compare to today's casks? I mean was it
15 stainless steel shell, was it a carbon steel shell,
16 was it bolted closure, was it welded closure, was it
17 a cask inside a cask?
18 MR. AMMERMAN: They were stainless steel
19 casks with bolted closures, very similar in concept to
20 the packages today. They were all designed for wet
21 transport of fuel, in other words, fuel with cooling
22 water in the cask cavity as opposed to today's
23 packages which are designed to transport fuel dry with
24 inert gas in the cavity. That was probably one of the
25 big differences. The closures were not really as

1 robust as modern closures are. You can even see that
2 in certified packages that are still certified. The
3 ones that are older have fewer closure bolts than the
4 newer cask designs, typically. So that is an area
5 that we're still progressing toward increased safety.
6 MEMBER KOBETZ: So they were with water in
7 them?
8 MR. AMMERMAN: Yes.
9 MEMBER KOBETZ: And their closures were
10 not as robust as they are today?
11 MR. AMMERMAN: They were tested with
12 water, and the closures are not as robust. And,
13 actually, the requirements weren't as stringent, I
14 think, in those days. I mean the interpretation. The
15 requirement was to A2 per week and in some of those
16 tests there was actually some leakage of that water.
17 There was a burp, if you will, of the closure, and
18 some of that cooling water was released, a relatively
19 small amount. And then the closure, of course, after
20 the dynamic event was over, came back to its initial
21 position and there was no more leakage.
22 That probably would not be acceptable
23 today. The way that package closures are designed
24 today is such that the dynamic impact that's on the
25 lid does not relieve completely the pre-load that's in

1 the closure bolts, and so that there will not be a
2 burp.
3 MEMBER KOBETZ: Is all that describing
4 those two Sandia reports?
5 MR. AMMERMAN: The fact that the tests
6 resulted in the leakage of a small amount of water is
7 in there. The fact of why that is and what's
8 different today is not in there.
9 MEMBER LEVENSON: Any other presenters
10 have a question or comment? Identify yourself first
11 for the court reporter.
12 MR. BRACH: Bill Brach, NRC. I think it's
13 worthwhile to make just a couple of comments on the
14 package performance study. That's been a topic of
15 much of the presentation as well as the discussion.
16 I think the characterization of, if you will, the
17 competition or the interplay between science and
18 safety is important to recognize here, earlier comment
19 about the speeds. So, clearly, from NRC's
20 perspective, the package performance study and the
21 tests, if we carry the tests out, need to be
22 considerate of water realistic testing scenarios that
23 an actual spent fuel transportation package might
24 encounter as it's being transported, whether it be by
25 road or by rail. So the consideration of the realism

1 of the scenario has to be and it's fundamental.

2 Also, a discussion with regard to the kind

3 of, if you will, the science versus the safety. In

4 earlier discussion, questions to Doug with regard to

5 the material properties -- of the materials used in

6 fabricating the cask design. I think Doug's comment

7 or response was from the perspective of a concern with

8 regard to the modeling and analysis that's done and

9 the accuracy of that modeling in predicting results so

10 that the results when compared to actual physical

11 tests would have as accurate a comparison base as

12 would be possible. And I think we look at too again

13 the extent to which the science or the safety basis

14 would leave that to the extent to which information is

15 needed or sufficient to be carrying out the tests for

16 the comparison.

17 We'd know clearly that the safety

18 responsibility we at NRC have is dependent upon

19 relying on the safety and the technical analysis and

20 basis that we make reference to, so we need to be sure

21 that we're bridging that gap, if you will, so that the

22 safety mission responsibility, we must exercise that

23 we're comfortable and confident with regard to the

24 technical and the science basis that we're relying on.

25 But I think the comments and questions

1 that we've been discussing in relationship to the
2 package performance study and the physical testing are
3 I think representative of the type of interchange and
4 input we're going to be looking for when we provide
5 the draft test protocol, both to the Committee ACNW,
6 as well as to stakeholders in the earlier public
7 meetings that I've mentioned as far as helping us as
8 we take the, I'll call it the draft, and it seriously
9 will be a draft, a draft of the test plan.
10 And we are trying to finalize that plan
11 with regard to what specific testing activities,
12 information, knowledge of materials, et cetera, are
13 needed and appropriate as well as the various test
14 conditions for the actual conduct of the test. But it
15 looks like the interaction we're having is as well
16 what we're looking for in our outreach activities as
17 the package performance study progresses to help us
18 shape and be carrying out tests that --
19 responsibilities but also provide a basis from both a
20 science and technical basis that we're comfortable and
21 confident that we can rely on that basis for our
22 safety decisions.
23 MEMBER LEVENSON: Let me ask one quick
24 question of you since you raised this issue in a way.
25 Will you be viewing these tests symmetrically? And by

1 that I mean now on regulation you assume 100 percent
2 fuel failure. The result of these tests it confirms
3 what is somewhat the previous experience that there is
4 no fuel failure. Let's be utilized to revise
5 regulation based on --
6 MR. BRACH: In response to Dr.
7 Hornberger's earlier question, we'll need to --
8 actually, we need to look at what the results of the
9 tests tell us and demonstrate. As Doug has
10 mentioned, much of the modeling and analysis and
11 actual testing has demonstrated that there's been no
12 breach of a container. So from that perspective, the
13 container that contains the radioactive material, as
14 maintained as leak-tight, whether there's 100 percent
15 fuel failure in the accident or some other lower
16 percentage, we need to step back and look at the
17 results.
18 MEMBER LEVENSON: No. I'm asking a more
19 generic question that all of this will provide
20 upgraded information. Will it be looked at whether
21 it's greater or less than existing situations?
22 MEMBER GARRICK: One aspect, and this goes
23 back to some of the underlying, I'll say, risk-
24 informed or performance-based considerations, we'll
25 indeed take a look at what the test results and test

1 information tells us in relationship to our
2 regulations and our review approach. And if there are
3 aspects of our regulatory process that we need to
4 relook at, both from a risk-informed perspective, and
5 if the margins are such that more than might be
6 reasonably expected, we'll have to look at what those
7 test results tell us from that.
8 MEMBER LEVENSON: You know, Bill, that you
9 are on the right side of this Committee when you say
10 you're moving toward a risk-informed approach.
11 We're running five minutes late but that's
12 pretty good for this morning, so we'll take our 15-
13 minute break now.
14 (Whereupon, the foregoing matter went off
15 the record at 10:41 a.m. and went back on
16 the record at 10:57 a.m.)
17 MEMBER LEVENSON: We'll restart the
18 session. Before we start the next speaker, I sort of
19 cut Doug off a little bit at the end, and he might
20 want to make a final comment or statement.
21 MR. AMMERMAN: Actually, I wanted to make
22 one clarification, and that is that my last slide --
23 and it says, "Where are the gaps?" -- it doesn't
24 really say what the gaps -- what are the gaps to what?
25 And it's to determine what the level of safety is,

1 what the margin of safety is in packages, not to
2 determine if the packages are safe.
3 We have no doubt that the packages, as
4 currently designed and certified, are safe. We just
5 don't know what that margin of safety is, and that's
6 where those gaps are. What more information do we
7 need to know to determine that margin of safety?
8 MEMBER LEVENSON: Thank you.
9 We'll move on to a summary of work at
10 Lawrence Livermore. Larry Fischer?
11 MR. FISCHER: There we go. Okay. First
12 of all, I'll talk a little bit about myself, so that
13 you know how I fit into this industry. Actually, I
14 got into the transportation industry on spent fuel
15 while I was working for GE, and that was in 1979. I
16 was the manager in charge of the --
17 PARTICIPANT: Your microphone is not on.
18 MR. FISCHER: I put this on earlier to try
19 to get around this, but thank you.
20 Okay. I just wanted to say a few words
21 about myself, so that you know where I'm coming from
22 a little bit, and that I worked for General Electric.
23 In 1979, I was the manager in charge of the IF-300
24 cask, and I did a lot of work also out of Morris,
25 Illinois. I was stationed in San Jose, and I went

1 through the consolidation report on the IF-300.

2 And I actually downgraded the IF-300

3 because we supposedly were going to ship fuel wet.

4 Processing went away, didn't make any sense. We had

5 a lot of problems with our pop-it valve shutting, and

6 so we just came up with initially a burst this type,

7 and then finally we ended up just with a blind flange

8 and showed that the cask would be safe. And, of

9 course, we went from water to helium.

10 And then I came to Lawrence Livermore, and

11 I've been here about 20 years. And I've worked

12 primarily on NRC and DOE safety-type programs.

13 Next slide?

14 Okay. I wanted to let you know that since

15 I work for Lawrence Livermore, we had a similar a

16 similar situation that came up and that nuclear

17 testing was suspended in 1991. And so it meant no

18 more big ground/underground testing going on. And we

19 had to be able to certify that our weapons would work

20 when they're supposed to work and not work when they

21 aren't supposed to work.

22 So they had to be highly reliable. We had

23 to understand how they worked, and some of the

24 physical basis. And so we went towards a science-

25 based type technology in trying to understand our

1 weapons, because we could not go out and do a full-up
2 test. We could only do component tests and what we'd
3 call subcritical tests.
4 And we also had an aging problem with our
5 stockpile, because we were no longer allowed to design
6 new weapons or bring new ones in. Always before we
7 would have a new weapon in about five to 10 years'
8 period, and so then the older weapons would be
9 retired. So this was a big dilemma for us in how we
10 were going to do this.
11 And so it came about that we developed
12 what we call a stockpile stewardship program where we
13 certify that the weapons are operable in the right
14 manner. And one of the cornerstones of this program
15 was the development of high-speed computing, greatly
16 expanded memory, and multi-scale, multi-physics
17 computer modeling.
18 And this is just an example of where we
19 are today. This is our ASCI White computer. It's a
20 14 TeraFlop computer. We're already building our 100-
21 TeraFlop machine. We will do full simulation of
22 nuclear explosives and other types of things.
23 Now, we go multi-scale, multi-physics. We
24 go down to the nano level. That's not, obviously,
25 required for this type application, but I want to say

that there's a lot of capability there to go down to the nano. That is below the micron. In fact, some of the stuff, they go down to the atomic level. So we now have these capabilities.

Next slide?

Okay. I, first of all, want to go through the background a little bit. I'll go a little bit more into how we got to where we're using all of this high-speed computing. Then I'm going to talk about four different projects that I led in the past. There was the modal study, shipping port reactor shipment -- that was actually a DOE project.

The plutonium air transport certification -- that's of interest because it was very high velocity types of things, and we did do both testing and analysis for that. And then, on the other extreme, we went to low velocity impact testing and solid billets onto concrete pads for the storage program. And then I'm going to do a quick little summary with some conclusions or recommendations.

Next slide?

Okay. The lab Lawrence Livermore came into existence 50 years ago. In fact, it's our anniversary as you saw on the first slide. And we've been combining testing and analysis over the last 50

1 years in order to evaluate and understand physical
2 phenomena.
3 We developed, in the late 1960s or early
4 1970s, computer codes for structural, thermal, and
5 nuclear transport analysis, very similar to what
6 Sandia did, except we were -- got a lot into the
7 nuclear transport analysis because of the weapons
8 program.
9 And we learned earlier that we had to
10 combine tests and analysis to benchmark computer codes
11 in order to evaluate our system performance. Also,
12 postulated accidents, natural phenomena, and sabotage,
13 because you can't go run thousands of tests for every
14 situation.
15 So what we would do is go out and
16 benchmark our codes, try to find out how well they
17 work, and then we would then apply them to a whole
18 variety of situations and environments, and so forth,
19 to see how, whatever enters the system, how it would
20 respond.
21 And this includes seismic, and so forth,
22 so we set up that methodology or paradigm, whatever
23 you want to call it, to combine the two together,
24 because you can only run so many tests but you're
25 interested in much more than just what you tested.

1 Of course, massive parallel processing has
2 come along, and so we have exploited that. Also, the
3 multi-physics modeling has developed over the past 10
4 years or so. And so now we can do a lot of things we
5 could not in the past, and it really reduces the need
6 for large-scale modeling and multiple tests.
7 Next slide.
8 This gives you an idea how the computing
9 world has exploded since 1952. We had a Univac out at
10 the lab, and we had 1,000 Flops per second -- 1,000
11 Flops per second. Of course, this is an old tube-type
12 machine. And then, once we got up to CDC and 3600,
13 well, by this time, we were going to solid state with
14 transistors, and so forth. So we made a great jump in
15 going from 52 to 72.
16 And suddenly we're starting to talk about
17 going into MegaFlops. And then there's a CDC 7600.
18 I'm sure many of you remember that machine. Then we
19 went through the CRAY type, I think. And then finally
20 we went into the multi-processing, massively parallel
21 processing.
22 We're now up around 14 TeraFlops with ASCI
23 White, and that's been online for about two years now.
24 And we have under construction our 100 TeraFlop
25 machine. It looks like a huge double parking garage,

1 and it's all going to have computers and servers in
2 it. It's really an unbelievable structure when you
3 look at it to just think it's going to contain
4 computers.
5 Also, very important is the fact that our
6 desktops and workstations have gone up greatly, and we
7 can see that a Macintosh G4 and Pentium 4 is
8 equivalent to like our CRAY YMP of just a few years
9 ago. It's incredible, and we can see that this is
10 going to make another jump, because we now have the
11 extreme ultraviolet light -- lithography coming
12 online, so we're going to see this thing jump another
13 factor of three or 10, maybe even a factor of 100.
14 Well, that's great to have all that
15 capability. But if you don't have the codes to use
16 it, nothing happens. So as part of this thing, we had
17 to go out and improve our codes, and we've been doing
18 that over the years. We started out with simple
19 things like paper-scaler type of setting. It's cards
20 -- remember the cards? We used to drop them and
21 forgot to number them, and then we had to go and
22 scramble and have to redo them all.
23 Also, we got into paper and teletype, and
24 then finally microfiche. And by this time, we're
25 getting to 2/3D type of codes. And next we went on up

1 and got some good graphics and then some more
2 improvements in our 2/3D codes -- that is, our
3 capabilities, just having a 2/3D code that doesn't
4 have slide lines and that kind of stuff, and a lot of
5 good materials, models, doesn't do you much good.
6 So you've got to have the so-called sub-
7 routines or materials modeling that fit in with those
8 codes. And then we came out with our L code, which
9 does not only structure but also fluids, interactions,
10 and the different types of contacts between surfaces,
11 so that we could do better analysis.
12 And, finally, we're up here where we're
13 doing massive parallel type of stuff, 3D rendering or
14 simulations. And I'll show you one simulation today.
15 Unfortunately, it's not on a cask. It's on a dam.
16 And the codes go on up to great improvements, again,
17 in the materials modeling with the multi-physics and
18 auto contact and auto meshing, and so forth.
19 So these models have gotten to look more
20 and more like actual tests, once you get down to it,
21 if it's done properly -- and, of course, that's why
22 you do some benchmarking.
23 Okay. Modal study was the first thing
24 that we did for the NRC, and it was the first time
25 that we used quantitative computational modeling and

1 analysis to evaluate responses of representative casks
2 to severe accident conditions to estimate the
3 radiological releases.
4 And the overall objective of the modal
5 study was to look at NUREG 0170. There was complaints
6 from intervenors that they didn't look close enough at
7 spent fuel, and at that time all we did is severe,
8 extremely severe, severe, and so forth, and it was a
9 qualitative type of judgment. It was not a
10 quantitative thing that tied from the cask design to
11 the estimated radiological release.
12 And so what we wanted to do -- evaluate
13 the safety of the cask provided under severe accident
14 conditions. And this has met conditions that went way
15 beyond the regulatory test conditions to show that
16 there is significant margin built into the cask. And
17 what happens is that under regulatory conditions the
18 cask remains essentially in elastic mode.
19 So we knew there was a lot of capability
20 in it for deformation and to exceed very high
21 loadings, and especially if they're using ductile
22 materials, such as 304 stainless or high grade, small
23 grain steels. Then we knew it could actually deform,
24 store up a lot of energy, and not fracture or break.
25 That it had what we would call a graceful failure

1 versus a catastrophic failure. And so that was the
2 way we went into the study, and it pretty much went
3 the way we thought it would.
4 We used a CRAY 1 machine at that time --
5 it was a one GigaFlop -- to form our analysis. We did
6 primarily 1D and 2D analysis, because the costs were
7 very high and the time limited. We spent about 25 to
8 30 percent of our budget just on computer time,
9 believe it or not, and that was very expensive for
10 those days.
11 We did do one single 3D analysis in order
12 to show that by doing a 2D analysis that the results
13 were comparable. In fact, we were conservative.
14 And we did have a problem, then, and we
15 are constantly attacked for it. We did not have any
16 benchmark for the code for cask. We had weapons that
17 we'd benchmark, weapons components, and closed form
18 solutions. So that was a bit of a gap at that time.
19 Here are some results. You can see what
20 we used. We would have liked to use a more refined
21 one, but, again, it's a problem of cost and
22 computational time. So we used this one for the
23 railroad cask, and we did do finer measures in order
24 to see if this one was adequately representative and
25 it didn't put in a lot of error.

1 And we decided that this one was a good
2 compromise between getting good results and
3 satisfactory results that were not misleading. And
4 this was a 90 mile an hour impact onto an unyielding
5 surface, and you can see there's lead slump. This was
6 a lead cask.
7 The next slide shows where we did the 3D
8 model. We used the truck cask for that, because it
9 was smaller. And we impacted at 90 miles per hour and
10 put the impact limiter on it. We wanted to see how
11 the impact limiter interacted with the cask, and as it
12 came on down and we could see it starting to collapse
13 here, and collapse a little bit more. By the way, the
14 impact limiter flew off in this particular analysis.
15 But anyway, the result here with the most
16 deformation matched up well with the 2D model. So we
17 felt satisfied that we were getting valid results.
18 The next project I worked on was the
19 shipping port reactor vessel. We, by this time, had
20 our CRAY YMP, and that's the one we used in 1988 in
21 order to run these analyses. We used computational
22 analysis with scaled modeling to obtain certification
23 for the shipping port reactor package for shipment.
24 This was a DOE certified package, not an NRC one, but
25 a DOE one.

1 The other thing, too, is that the shipping
2 port reactor had no fuel in it, and so it was what we
3 call a Category 2 package, which is -- the
4 requirements are less stringent than that for a
5 Category 1 or spent fuel package.
6 And so we proceeded to try to incorporate
7 the important features in a 1/10 scale model. This
8 thing weighs 1,000 tons. We would have liked to use
9 a larger scale model, but when you're down to -- when
10 you're looking at a 1,000-ton drop test, it's way too
11 high. So we backed off onto a 1/10, which was around
12 a one ton type of system. And we got really quite
13 good at --
14 MEMBER LEVENSON: Do you really mean 1,000
15 tons?
16 MR. FISCHER: What?
17 MEMBER LEVENSON: Do you really mean 1,000
18 tons?
19 MR. FISCHER: Yes. It's a reactor vessel.
20 I'll show you. It's a reactor vessel. I'll show you.
21 Yes, yes. It was a big one. I'm trying to show that
22 we can do big things, small things, and things in
23 between, basically.
24 We got what we thought was fairly good
25 agreement, given that the size of the package and the

1 instrumentation, and so forth, and the state of the
2 art at that time. We got much better as time went on.
3 But we were able to get a 30 percent agreement between
4 the scale model testing.
5 And then using that benchmark Dyna code
6 with -- which used the 1/10 scale data, the -- we then
7 dropped the full reactor package in three, four
8 different orientations, a bottom drop, a side drop,
9 and a corner drop.
10 And we were able to show that we met the
11 regulatory drop requirements with good safety margins.
12 That means that the package would not fail and that
13 also it included a 30 percent difference in our
14 benchmarking. So we wanted to make sure that we
15 included that as part of the margin, and so the
16 package was able to get certified.
17 Here's a -- next slide?
18 CHAIRMAN HORNBERGER: Just a quick
19 clarification on that. So when you say a good safety
20 margin, that --
21 MR. FISCHER: That means --
22 CHAIRMAN HORNBERGER: -- some quantitative
23 measure, a factor of three or --
24 MR. FISCHER: That means like a factor of
25 one and a half.

1 Now, this was only a Category 2 package.
2 Usually, we'd like to have more like a safety factor
3 of three on a Category 1. So there is a difference.
4 This is the test that we ran. It was
5 dropped, and you can see we had about a six and a half
6 inch flat spot on it, and then this was the analysis
7 we ran. And we predicted about a five inch flat spot
8 on it, and some voiding here. And when we cut it
9 open, we did find some voiding here. That was a big
10 surprise that we were calculating that. And then
11 actually when we cut the package open we did see that.
12 And then the next slide is the reactor
13 package. As you can see, it's over 40 feet long and
14 about 18 feet in diameter. We had to put a new
15 lifting beam on top, and we had to put the screws in
16 here, or the bolting, long bolts. And we put in 16 of
17 those, and we took out some of the closure studs on
18 the reactor and used those, and there are 28 of those
19 left.
20 We had some insulation in between, and
21 this was all filled up with grout. And then this was
22 also filled with grout, and the bottom was filled with
23 grout. That was all modeled.
24 Next slide?
25 Okay. This is the actual finite element

1 model we put together. Here is the grout inside of
2 the reactor pressure vessel. Here is the pressure
3 vessel itself with the nozzles. Here is the head
4 closure, and here's the insulation that was in
5 between. There is a ringer around it, and then there
6 is concrete in between the reactor vessel and the
7 thermal shield.
8 These are the bolts. We actually modeled
9 those, so that we could see if they stretched or bent.
10 And this was the lifting beam. So that was all
11 modeled.
12 Now, I've also had some problems in
13 retrieving old files. Unfortunately, we ran all this
14 on the YMP computer. It's a classified compute, and
15 nowadays it's hard to get unclassified work off of
16 classified computers.
17 We are downloading it, and we will go
18 ahead and run some of these new drops, and so forth.
19 But it got a little too tight to make it for today.
20 But we did have good results. And like I said, it did
21 pass the certification test.
22 The next one I want to talk about is PATC
23 tests. That is, the plutonium air transport package
24 or certification package. This was -- believe it or
25 not, was done on a Silicon Graphics, Incorporated

1 workstation. Guess what? We owned it. It was cheap
2 to run. We did not have high cost of trying to run it
3 on a CRAY YMP, and we had complete control of the
4 machine. We did not get bumped for weapons work or
5 other higher priority work. We were in control of our
6 own destiny.
7 Obviously, it took us longer to run it on
8 this machine, but it was a 200 MegaFlop type machine
9 with double precision. And so we were able to do all
10 other computational analysis with this machine. These
11 were very high impact velocities, went up to over 600
12 miles per hour, or about 950 feet per second.
13 We made up a 1/6 scale model, because we
14 knew that we had to benchmark the model against our
15 code, or our code against the model. And we used
16 grout for the impact limiter, because we had
17 experience with the grout, with the shipping port
18 package. And it was well characterized, and so we
19 felt very comfortable using it as an impact limiter,
20 rather than crushing it. It basically deforms and
21 moves mass to the side, and that's how the energy is
22 absorbed.
23 We put a little aluminum ball inside to
24 get the peak G's, to see what type of G-forces this
25 was subjected to. And then we did tests, impact

velocities, from about 17 to 157 meters per second on a steel surface, basically an unyielding surface, and then we did a couple of shots on a concrete surface which was -- there's a typo here -- it was -- 288 was the other number.

We got good agreement with the impact limiter deformation -- was demonstrated between the scale modeling and computational analysis. Whereas with the peak G thing it was within a factor of two or something like that. We always seem to be having little problems with correlating accelerometer test data with our analysis. But the next project we did we resolved that, so there is hope.

Next slide, please.

Okay. Here it shows a picture. This is the model that we built. We shot this out of a six-inch Howitzer gun. It was a Navy gun that we had in our bunker, and we just loaded it in just like a regular old shell, put in some powder and shot it out against these targets.

And these are the way they looked, and the little ball was right in here in the containment vessel. It was high strength, whereas this was the grout with the deformable 304 stainless steel package. And this is where it went at 516 feet per second onto

1 an unyielding surface, and you can see it got pretty
2 close to the end.
3 And we were trying to determine what the
4 equivalent velocity was for an unyielding surface
5 versus a soft rock type surface. In this case, we
6 used the grout.
7 And this is the 288 or 945 feet per
8 second. You can see that we didn't quite hit it
9 straight on. This is one of the problems with
10 shooting it out of the gun. You don't get exact
11 straight-on hits, and you can see that a little bit
12 here, too, that it's flattened a little bit off to the
13 side. And this one it tilted a little bit this way.
14 So having gotten that -- next slide -- how
15 do we match up with our analysis? Now, we used
16 essentially the same grout, same computer model for
17 the grout that we had used for shipping port. And so
18 this is where, you know, it was really amazing how
19 well we could still benchmark this thing.
20 You can see there is the little ball that
21 was -- the little aluminum ball, and here is the mesh
22 here. And it kind of -- it looks like it lined right
23 over the top of it. Again, we got very good
24 correlation with deformation, but we were still having
25 problems with correlating with acceleration.

1 And then here's the other one that was 900
2 -- 288 meters per second on a soft rock, and you can
3 see it's right near the end here. Now, this is
4 symmetrical, whereas the other one was not, because it
5 can shoot it straight.
6 Next slide.
7 Now we got over to billet testing. We did
8 this also for the NRC. Again, we went to the SGI
9 workstation, because of the cost consideration and the
10 fact that it was conveniently available. And the
11 thing that we're looking here at was primarily tipover
12 drops onto a concrete pad. This is for storage casks.
13 And when we use an unyielding surface it
14 -- the answer always came up you've got to put an
15 impact limiter on top of the cask. And what the
16 problem there is is that, number one, they are
17 expensive. They are difficult to put on, and you
18 expose people when they're putting them on.
19 The other thing is that you're going
20 around and monitoring the cask. You have to some of
21 the times take them off in order to get access to the
22 monitoring equipment.
23 So it would be very desirable to take
24 these impact limiters off or not require them. And so
25 the thought was that the concrete can, of course,

1 absorb energy and could maybe eliminate the need for
2 an impact limiter. So that was the thing that got
3 this testing going.
4 Now, we decided to use a 1/3 scale model
5 for the storage cask. It was just a steel billet. It
6 was very cheap. And we used a reinformed concrete
7 pad, meaning we had concrete with rebar in it. And
8 all of this was 1/3 scale. The actual rocks and sand,
9 and so forth, is all 1/3 scale in order to try to get
10 a valid test.
11 The next thing we did is very precision,
12 well calibrated accelerometers. And then the most
13 important thing is we developed a methodology for
14 determining the cutoff frequency. There had been
15 problems in, where do you cut it off at?
16 If you cut it off too high you get too
17 high of G-forces. That is, you are not really putting
18 that much energy into the cask system. You cut it off
19 too low, well, then you're actually having deformation
20 or energy being deposited into the cask, and you're
21 coming up with too low of decelerations.
22 This is very important with respect to the
23 spent fuel basket, because these forces, as it goes to
24 the spent fuel basket, and the spent fuel basket is
25 the most fragile part of the whole design, because it

has heavy spent fuel in it, and they try to make the basket as light as possible. And so it could buckle or bend, and also the fuel can be affected itself.

And so it was very important that we know the exact G-forces that are being translated not only into the cask but to the spent fuel basket and to the fuel. And so we developed a methodology for determining the cutoff frequency by looking at the different modes. We also worked with our weapons people on this to make sure that we were up to speed with them, and they were going through the same sort of thing, how do you have these things correlate?

And we then did a computational analysis to benchmark the Dyna 3D code. We got good to excellent agreement, as demonstrated between the scale model testing and the computational analysis, and I'll show you a little bit more on that.

MEMBER GARRICK: Larry, can you comment briefly on that? What were some of the most critical requirements of the computational analysis for getting that good agreement?

MR. FISCHER: Okay. That's going to be the next slide.

Anyway, when we got done and we had this benchmark, we then looked at a full-size cask. It was

1 a very typical cask. And we did a tipover without an
2 impact limiter on it, and it passed the test. And, of
3 course, we could come up with examples where it was a
4 tall, skinny cask. It wouldn't make it. It would
5 have to put an impact limiter on it.
6 But most casks they did not need an impact
7 limiter, and so it could tip over onto concrete and
8 the basket could take the forces.
9 Okay. Next slide.
10 This is where we show -- okay. What we
11 discovered -- in this case we did a Foray analysis,
12 and we also did the -- performed it on the data, too.
13 And this was after we did a considerable amount of
14 analysis on determining the response of the cask, and
15 what frequency would be best to cut it off and capture
16 anything that could deposit a significant amount of
17 energy versus just ringing, because the ringing does
18 not do any damage to the cask.
19 And so we determined 450 Hertz was the
20 correct one for the billet, and these are the results
21 for the four different tests that we are -- our two
22 tests and two accelerometers. This is what we
23 calculated.
24 But notice we also filtered at 450. So
25 when you do your analysis, you know, you can get

1 ringing inside your analysis, so you have to use the
2 same Foray technique to cut that off and smooth it
3 out, so that you're not getting a bunch of ringing
4 going on.
5 And so this was the big thing that we
6 developed in this particular test sequence and could
7 justify why the 450 in both of these. And that was
8 done for all of these, and we had anywhere from 1 to
9 15 percent agreement.
10 CHAIRMAN HORNBERGER: Presumably, you
11 could go back to your previous data and analyses and
12 do the same thing and improve your agreement on the
13 acceleration. Is that true?
14 MR. FISCHER: Yes, we probably could.
15 Yes.
16 Okay. Next slide.
17 I just wanted to show you what it -- this
18 is -- again, this is the tipover. This was very
19 crucial, because that's what we were trying to do is
20 get that impact limiter off.
21 Next slide.
22 Okay. Here is the actual billet tipover
23 test that we have here on the pad. And we just let it
24 slap down and took the measurements, and then this is
25 the finite element model. We included all of the

1 soil, concrete pad, and the billet for doing all of
2 the analysis. And, again, that was done on an SGI
3 station.
4 MEMBER GARRICK: How did you decide on the
5 mesh size?
6 MR. FISCHER: Actually, we did several
7 different trial and error, to see when there would be
8 a difference. When you saw that you didn't have any
9 difference between the previous one, then you probably
10 -- then you know that you've got enough elements.
11 First of all, it's an experienced analyst
12 who is putting this together, who has done similar
13 type things. But what we do is we also put in larger
14 blocks and smaller elements, and so forth, and then
15 look at the results. Did the results change
16 significantly or not? If it does not change
17 significantly, then you can most likely go with that
18 number of elements.
19 MEMBER GARRICK: So mesh size has got to
20 be very critical to the --
21 MR. FISCHER: Yes, absolutely.
22 MEMBER GARRICK: -- to the ability to have
23 the computational analysis agree with the test.
24 MR. FISCHER: Yes.
25 MEMBER GARRICK: And do you have any

1 specific criteria, other than trial and error, for
2 determining that?
3 MR. FISCHER: Get a good analyst.
4 (Laughter.)
5 If you get a good analyst, they can
6 usually get it right there to begin with. But we
7 always do perturbations in order to see if we've got
8 too big a mesh size, too small a mesh size. Usually
9 we worry about too big of a mesh size.
10 MEMBER GARRICK: Yes. Yes.
11 MR. FISCHER: Okay? Yes?
12 MEMBER RYAN: Just a follow-up. I mean,
13 there's some calculational questions about convergence
14 or lack of convergence when you do that. Is that the
15 kind of approach that you take? I mean, numerically,
16 things might blow up with large mesh sizes, for
17 example. Is that --
18 MR. FISCHER: It's not a convergence
19 thing. It's, do you see a difference in the answer?
20 Like the G-forces or any kind of deformation occurring
21 or displacement of, say, the concrete pad. Those are
22 the sort of things that are important.
23 Also, you want to make this large enough
24 so that you have the right boundary conditions for any
25 wave formations, to make sure that you have the right

1 boundary conditions. But, again, this is why we want
2 to have a good analyst that sets the problem up.
3 But we also go through what we call a
4 design review type of thing. We bring in our people
5 and critique it and say, "Well, did you do this? Or
6 when you did this, what happened?" And so forth. So
7 it's kind of like a mini design review on these
8 complicated models. It usually involves three, maybe
9 five, analysts.
10 And like I said, the extra check is we do
11 bring our weapons people in to take a look at it, too,
12 to make sure we're using the code properly.
13 Any other questions?
14 Okay. Next slide.
15 This is not a cask.
16 (Laughter.)
17 I want to show you what we can do.
18 Actually, we could go back and try to do this with
19 some of the cask things now that we have these
20 capabilities, and a lot of things have been cleaned
21 up. But this is a -- oh, they already started it.
22 This is a seismic analysis of Morrow Point
23 Dam. One of our young analysts, Charles Noble, or
24 Chad, is the one who did this. It's in -- southwest
25 of Denver, about 250 miles southwest. And we're

1 looking at a 6-1/2 to 7.0 magnitude earthquake, and
2 most of the people in Colorado would say, "Wait. That
3 can't happen. We never knew." And they said, "Well,
4 these will probably return ever thousand years." So
5 you haven't been around for 1,000 years, so you can't
6 say it would never happen.
7 What is interesting with this dam
8 construction is it is a segmented dam. It's columns
9 that were poured, and then they put what they call
10 interlocking pins. It's actually kind of like
11 corrugated steel interlocked together.
12 And the reason why it's built that way is
13 for expansion and contraction, because it has to have
14 it for the summertime and the wintertime. And then on
15 the back side they put a rubber sealer, a very tough
16 rubber sealer, so it can expand and contract and not
17 leak the water through.
18 And so the other thing is is that this one
19 is a little more exciting than the final one. They
20 put the earthquake ground motion right in the bottom
21 of the dam rather than to the ground. And so what's
22 happening is the top moves much more than it should
23 be, but it makes it a little more exciting to see the
24 capabilities of these types of tools, of the friction
25 in between, and be able to get the slide lines and

1 things to move.

2 And as you can see, we did mesh the water,

3 so you can see the water sloshes.

4 CHAIRMAN HORNBERGER: Play it again.

5 MR. FISCHER: Yes, I'm going to have him

6 play it again. Just let me finish the explanation

7 just a little bit more. I want to make sure you

8 understand what's going on.

9 I live in Los Gatos, and we had the --

10 Loma Primetta, yes, there we go -- thank you. It's

11 only 10 miles from my house. We used to go up there

12 and buy our Christmas trees, chop them down.

13 Anyway, it was a 7.1, and I was,

14 unfortunately, here in Washington, and had a tough

15 time getting hold of my wife. And everyone keeps

16 showing what happened in San Francisco, and I wondered

17 what happened in Los Gatos, not in San Francisco.

18 Well, anyway, I finally got home. The

19 very next morning I got on a plane. And she was

20 worried about all of this water all over the place.

21 Well, what happened, about three to four feet of water

22 jumped out of our pool and went all over the place.

23 So slosh is extremely important, and a lot of people

24 said, "Why don't you do a mesh on the water?" I said,

25 "It's simple. It's called slosh."

1 So anyway, go ahead and play it again, so
2 you can see some sloshing here and reaction of the
3 dam.
4 Now, this is amplified 50 times; 50 times
5 it's amplified -- the displacement. So it's really
6 not this bad. So you can see some opening up and
7 sliding between the columns.
8 Again, there is a rubber seal on the back,
9 so the water is not coming through.
10 Do it one more time.
11 (Laughter.)
12 But this is what you can do. They can do
13 this with cask simulations. We can run one
14 simulation, another simulation. Somebody else wants
15 water -- wants a low side drop, they want a side drop,
16 we want it to go tumbling down, and whatever, we now
17 have that capability to show this to the public and
18 say, "This is the way it reacts."
19 Now, we can also zero in where are the
20 high stress points, where are the places of concern.
21 You can zoom in and look at those areas. You can
22 always do the graphics, just print them out in place.
23 You can even, if you want to, print out your data
24 sheets for that region, and your computer sheets, so
25 you have single point data.

1 But the simulation, this was very
2 important to the weapons program in order to see
3 what's going on. There is tons of data going on, and
4 if you don't have a simulation you don't know where to
5 look to see where the potential problems are.
6 So this is a great new technology that has
7 come about, and it can be done on small clusters of
8 deck machines, Dell machines, or whatever. You don't
9 have to get into our TeraFlop machines for this type
10 of thing.
11 Okay. I kind of want to summarize what
12 I've been talking about now. And we have -- as I
13 said, today's analytical capabilities allow more
14 comprehensive analysis of shipping packages. We still
15 want to do our benchmarking, believe me. But now we
16 can emphasize, where do we want those benchmarks to
17 be?
18 We want to understand the package design
19 margin. We want to quantify it, not just say, "Well,
20 it stayed together. It's okay. We don't know how
21 close it is to failure, how safe is safe." Well, if
22 you don't look at the design margin after you've done
23 these tests, you're begging the question, especially
24 with respect to the public.
25 So there are things we also can do. The

1 public keeps bringing up, what about metal bending,
2 machining, welding, lead depleted uranium pouring,
3 annealing? What about all of these manufacturing
4 processes? We can do those now. Those models are
5 being developed. They are going to be made available
6 to everyone.
7 And these are very important, not only in
8 the weapons program but also in the automotive
9 industry and other places, too. We can do detailed
10 analysis of bolted closures requiring large complex
11 computer models. In fact, we can do tests just on the
12 full scale bolt closures, rather than a whole cask.
13 We can devise those type of tests, and then do your
14 benchmark, and then your computer modeling, and look
15 at the closure. How does it act with the side drop
16 and the end drop or low, shallow drop?
17 We found with some of the drum packages we
18 had about a 15-degree shallow drop, and it would take
19 the lid off. Whereas when it was a CG, over center
20 drop, the lid stayed on. So by doing these
21 simulations, you can determine where the weak points
22 are. What do you need to do to improve it and put
23 more safety in it and put the safety in the right
24 spot?
25 Of course, using the contemporary high

speeds we can use a lot of these multi-physics types of stuff that's unique to both our labs to be able to do this sort of thing. Of course, we have extra good physics models and that sort of thing to study things. But eventually you're going to have to put this out to the applicants.

And so once we've gone through all of this, we have to come up with a methodology that we hand over to the applicants, like what we did for the tipover accidents for the storage casks. We wrote out the methodologies. They could run it on their smaller machines, and they could come up with believable, good results.

And that's what we're going to have to do is transfer that technology over to the applicants and also that -- even members of the public. If they want to do some of the stuff, they can do it, too.

MEMBER GARRICK: I can't help but ask this. One of the issues in the Yucca Mountain cask is the heat treatment of the welds for the lids on the inner and outer waste package. And the concern there is, of course, that that's the weak link as far as the possibility of stress corrosion, cracks, and --

MR. FISCHER: Right.

MEMBER GARRICK: -- creating a pathway

1 into the fuel. Is this tool something that could
2 better quantify the realism of that as a pathway?
3 MR. FISCHER: Can you believe they're
4 doing that today?
5 MEMBER GARRICK: Well, I hope so.
6 MR. FISCHER: They're doing it.
7 MEMBER GARRICK: Okay.
8 MR. FISCHER: That's exactly why I can say
9 these things --
10 MEMBER GARRICK: Okay.
11 MR. FISCHER: -- for us, because that's
12 actual.
13 MEMBER GARRICK: Very good. Thank you.
14 MR. FISCHER: Okay. Recommendations or
15 conclusions. I don't know which one to call these,
16 but anyway based on my experience and the things we've
17 done there -- out at their lab, we'd say let's go
18 ahead and perform some kind of drop and thermal tests
19 on typical transportation casks. And let's just use
20 a hypothetical accident conditions, at least mesh the
21 -- maybe they want to do more, but I think you can
22 learn enough about the systems with that.
23 And they use state-of-the-art
24 instrumentation to record the cask response,
25 especially in the closure and weld regions. And,

1 obviously, we determined the cutoff frequencies
2 properly, and so forth.
3 Benchmark at least one finite element code
4 against the test for recordings. Use at least 1/3
5 scale model. Otherwise, you lose too much detail, but
6 you don't have to use a full scale cask, I don't
7 believe.
8 You do perform drop and thermal tests and
9 simulation for full-size casks in all different
10 orientations, and so forth. You can also do that for
11 the scale model test, and use a high-speed computer
12 system's physics codes for getting the basic things
13 done and a better understanding. And once you feel
14 comfortable with looking at all of those variables,
15 then you provide the methodology and data such that
16 the applicants can benchmark their own finite element
17 codes and perform analysis for their own casks.
18 And, of course, we would make all of these
19 simulations available to the public, and let them
20 decide what they want. And if they say, "We want
21 another simulation," okay, well, tell us what new
22 simulation you want. And it's a low cost, easy way to
23 do it. You don't have to go out and run another test.
24 And that's the basis of our stockpile stewardship
25 program.

1 Any questions?

2 MEMBER LEVENSON: Thank you, Larry.

3 MEMBER RYAN: No, thank you.

4 MEMBER LEVENSON: John?

5 MEMBER GARRICK: Just a couple of simple
6 ones. You mentioned early in your presentation the
7 nuclear weapons transportation experience. How much
8 of that experience is now declassified? That is to
9 say, one of the most convincing pieces of evidence as
10 to the safety of the shipment of nuclear materials is
11 experience.

12 And, of course, we know about the NRC
13 experience. We know about the DOE experience on non-
14 weapons material. Is the weapons experience data not
15 available now, just in terms of the number of
16 shipments and the incidence associated with those
17 shipments, etcetera?

18 MR. FISCHER: I can at least make the
19 request. I would think that we could present it such
20 that it wouldn't be classified.

21 MEMBER GARRICK: Yes.

22 MR. FISCHER: But I would have to -- you
23 know, we have to go through the usual scrub and --

24 MEMBER GARRICK: Well, I would think that
25 would be an important --

1 MR. FISCHER: Okay.

2 MEMBER GARRICK: -- piece of data.

3 A second question is: in the original
4 protocols for the package performance study, there
5 were some tests having to do with the fuel elements
6 themselves, to better understand the disposition of
7 the fuel in terms of the damage, and, therefore, to
8 get a better handle on the source term should the cask
9 actually fail.

10 Is what you have been doing here something
11 that could simulate the conditions inside the waste
12 package as well as the conditions having to do with
13 deformation and penetration of the waste package?

14 MR. FISCHER: Today I say that that's
15 possible. Right now, we're doing all the nano-type
16 scaling with reactor vessels with embrittlement. And
17 we're getting pretty good results with Bob Oddet out
18 of University of California.

19 MEMBER GARRICK: Yes. The specific issue
20 is, what's the condition of the fuel under these
21 severe conditions, such that if we have a puncture we
22 could make an intelligent analysis of what the release
23 conditions would be. That's --

24 MR. FISCHER: Yes. I think that we can
25 model the cladding of the fuel and its shape and the

1 extent of, say, corrosion, pinholes, or whatever. We
2 now have that capability. Already people are doing it
3 in other fields that could help us out.
4 MEMBER GARRICK: Okay. Thank you.
5 MEMBER LEVENSON: Ray?
6 VICE-CHAIRMAN WYMER: Yes. I have a
7 follow-up on one of your answers to John's question,
8 which goes out of what you've presented here today.
9 But he asked what you were doing with respect to
10 stress corrosion cracking, welds and welded areas, and
11 you said, "Would you believe that's going on today?"
12 Do you actually mean that you're modeling corrosion or
13 you're just modeling the stresses near the welds?
14 MR. FISCHER: We're actually going into
15 the physics and chemistry of stress corrosion cracking
16 at the nano level.
17 VICE-CHAIRMAN WYMER: So you're modeling
18 the corrosion?
19 MR. FISCHER: Yes. We're working with Bob
20 Oddet -- a review with those folks. There's a whole
21 field out there. Maybe I could send you a magazine
22 article, so that you know what's going on.
23 VICE-CHAIRMAN WYMER: Yes, something
24 simple.
25 MR. FISCHER: Oh, no, no, no, no. No, no.

1 (Laughter.)

2 This is definitely for the lay person.

3 No, it doesn't -- it just tells you what's going on.

4 I could make that available to the panel or the board.

5 VICE-CHAIRMAN WYMER: It seems to be

6 pretty tricky, because the stresses are a function of

7 distance from the weld, and you've got to take all of

8 that into account. I'd be interested to see what you

9 -- I'd like you to describe what you do there.

10 MR. FISCHER: Okay. Well, it's down to

11 the nano level right now where a lot of these -- show

12 that one slide that was near the beginning, where I

13 showed you the -- the first slide after I did the

14 introduction. That was a nano level type thing of

15 materials, and you can see how it's not homogenous,

16 and that there are a lot of things that are going on.

17 VICE-CHAIRMAN WYMER: Yes. But it really

18 would have to include some experimental results on

19 various kinds of stress material as input to the code,

20 doesn't it? Or --

21 MR. FISCHER: Well, we include the

22 stresses on it, yes, and the environment -- the stress

23 to the environment and the material --

24 VICE-CHAIRMAN WYMER: But then you need

25 experimental corrosion results in those stressed

1 environments. That's pretty tricky stuff.

2 MR. FISCHER: Yes. Well, we have a very

3 large program with Yucca Mountain on stress corrosion

4 cracking under different conditions. And that's what

5 we're doing now, we're starting to correlate our

6 models with that data.

7 VICE-CHAIRMAN WYMER: Different degrees of

8 stress. Okay.

9 MR. FISCHER: Yes. Yes. Yes, definitely.

10 Different degrees of stress, environment, and

11 chemistry, and so forth. Yes.

12 CHAIRMAN HORNBERGER: If the article is

13 for a lay person, you can send it to me, and then you

14 can send Ray the real chemistry.

15 (Laughter.)

16 First of all, I just have a comment. I

17 must say that your presentation to me -- very

18 impressive computational results. And it does strike

19 me that if -- if we can move forward and do a full

20 computation of a thermonuclear explosion, it does seem

21 to me that we should be able to figure out what

22 happens if a cask tips over. So order --

23 MR. FISCHER: Three orders of magnitude

24 less?

25 (Laughter.)

1 CHAIRMAN HORNBERGER: My one question --
2 in some sense it would be argumentative, but that's
3 okay.
4 MR. FISCHER: Yes.
5 CHAIRMAN HORNBERGER: Would it be safe for
6 me to infer from your whole presentation that the
7 purpose for a test on a full scale cask is simply
8 demonstration and not necessarily technical? That is,
9 can I infer that if you do 1/3 scale testing, and
10 benchmark your codes, you're going to be able to learn
11 everything you need to know about safety?
12 MR. FISCHER: Yes, I believe that. The
13 reason being is that all that you can do with a full
14 scale cask test, unless you do the same thing you do
15 with the 1/3 -- I mean, the full computational, and so
16 forth, you're only showing it for that one cask. And
17 there's more than one cask that's going to be there.
18 And you have to be fair to everybody.
19 Everyone should have an equal chance for their cask
20 design to be certified and be able to demonstrate that
21 it can meet the overall intent of the regulations and
22 not incur any undue risk to the public.
23 MEMBER LEVENSON: I have on question
24 related to the fuel. There is obviously a lot of
25 conjecture, if you're going to do fuel testing, what's

1 the right test to do. What are appropriate loads,
2 etcetera? From the analysis you've done, or for what
3 can be done, it would be relatively easy for you
4 people to identify what are the appropriate loads that
5 the fuel itself would actually be subjected to inside
6 casks undergoing other kinds of tests.
7 MR. FISCHER: Yes, that can be done.
8 Through simulation you determine what the loads are,
9 and then determine what happens to the fuel rod, given
10 the condition of the fuel rod.
11 MEMBER LEVENSON: But that has not been
12 done yet.
13 MR. FISCHER: No. But I think now you can
14 do it, that we're in a state where we can start doing
15 that sort of thing. And I don't think you have to
16 take a real spent fuel rod out and drop it --
17 (Laughter.)
18 -- inside of a cask.
19 MEMBER RYAN: One question from several of
20 the comments you've made and several points in your
21 presentation, but, first, I agree with George. It's
22 pretty impressive computing technology.
23 For example, when you picked 450 Hertz as
24 the cutoff --
25 MR. FISCHER: Right.

1 MEMBER RYAN: -- you know, I think about
2 sensitivity analysis and uncertainty analysis and
3 stability of the answer at a given end point. Could
4 you talk a little bit about how you address that?
5 Because from a performance confirmation point of view,
6 sometimes those are the real key issues of
7 uncertainty, stability of a model, and parameter
8 selection.
9 MR. FISCHER: First of all, we had four
10 experts working on that. It was not just one person.
11 We had Jerry Mock, who had the lead on it, and he
12 determined by human hand analysis what the best cutoff
13 frequency was, and then we had weapons people come in
14 on it. And then we had T.F. Chen, who is the primary
15 analyst for doing all of those analyses. And we also
16 brought in people from a diagnostics lab to help
17 determine that.
18 Once it was done, we have a methodology.
19 So it's not like we -- you have to come to these guys
20 every time you want something done.
21 Now, I'll have to point out, they use the
22 same methodology for the cutoff frequency on a full-
23 size cask, which was much lower because it's much
24 larger. So we did not use 450 cutoff for the full-
25 size cask, because that would be ringing, and so

1 forth.

2 So the methodology goes to the size of the

3 cask, the shape of the cask, and etcetera. It's cask-

4 specific, and the methodology can be applied to

5 whatever you have.

6 MEMBER RYAN: Sure. No, I appreciate the

7 fact that you have, you know, true experts that can

8 select that value. What I'm more interested in is the

9 question of: does a particular calculation at

10 whatever value you pick have stability? And is it --

11 you know, what -- how do you assign or assess

12 uncertainty?

13 In other words, if I changed it from 450

14 to 440, or 425, how much does the answer change? How

15 much does my ability to predict change? And how do

16 you assess that? You haven't really talked formally

17 about uncertainty analysis, but I'm curious of how you

18 -- how well you know your answer.

19 I know you're comparing experiment to

20 calculation, but then when you go strictly to just

21 calculation, how do you express confidence?

22 MR. FISCHER: Okay. Let's, first of all,

23 back up. There is not a stability problem. The code

24 calculates the stable -- the tests are done, and the

25 accelerometers are stable. What the problem is,

1 you've got all of these -- I should have probably
2 brought an example here. You have all of these spikes
3 going up and down, and you wonder, is that doing
4 anything to the cask? Will it damage the contents,
5 especially will that be transmitted down to the
6 basket, down into the fuel?
7 So you want to filter it, or else you will
8 come up with false results, but it's not going to
9 damage anything.
10 On the other hand, if you filter it too
11 much, then some loading will go into the fuel. Some
12 loading will go into the basket that could damage it.
13 And so that cutoff frequency has to be determined very
14 precisely. And in that particular case, it was
15 probably about 400 to 500, didn't make too much
16 difference. But if you start saying, well, it's 200,
17 then it's way too low. And if you say it's 700, it's
18 way too high.
19 So there, obviously, is going to be some
20 judgment involved. But like I said, there are ways of
21 decomposing this and saying, "This is the analytical
22 cutoff frequency," and it should be also for the
23 actual test.
24 That's been part of the problem with all
25 our accelerometer data. Where do you cut it off at?

1 And the answer can vary quite a bit, depending on
2 where you cut it off.
3 CHAIRMAN HORNBERGER: But the point is --
4 I think you answered it -- is that it doesn't depend
5 critically on an exact value of 450.
6 MR. FISCHER: No.
7 CHAIRMAN HORNBERGER: It could be 425. It
8 could be 475.
9 MR. FISCHER: Yes. Yes.
10 CHAIRMAN HORNBERGER: And presumably, you
11 can't get a complete square-away filter anyway, and so
12 you have some --
13 MR. FISCHER: Right.
14 CHAIRMAN HORNBERGER: -- leakage.
15 MR. FISCHER: Right, right. Exactly.
16 You've got to accept some uncertainty. Yes. But it's
17 -- but you can get it in the right range, where you
18 feel very confident that it's not 700 and it's not
19 200.
20 Okay? Does that take care of your
21 question?
22 MEMBER RYAN: In part. I appreciate that.
23 I only want to focus on this frequency question, but
24 I'm questioning and just need a little more
25 information about your general uncertainty analysis.

1 Typically, when you model something, you
2 have a set of parameters, some measured, sometimes
3 some estimated. And in any system model, if you vary
4 those parameters you will get a different result
5 perhaps, perhaps not. And that whole assessment of --
6 I don't mean stability in the sense of mechanical
7 stability. I mean stability of the calculation that,
8 you know, if I vary parameters I'm going to get some
9 reasonable range of answers. Do you do that kind of
10 numerical assessment of --
11 MR. FISCHER: Oh, yes. That's --
12 MEMBER RYAN: -- and how they work?
13 MR. FISCHER: Yes, that's what's good
14 about this, that you now have good physical models
15 that you understand and can use. So you can do your
16 sensitivity analysis -- given that you don't know the
17 exact answer or the exact conditions, you can now do
18 the sensitivity analysis to see what has happened.
19 Has it changed the whole answer, like
20 before you said it doesn't fail, and then we change
21 two or three parameters or conditions, and all of a
22 sudden we see failure? Yes, those sort of things can
23 be seen.
24 MEMBER RYAN: I mean, you haven't reported
25 on that kind of sensitivity analysis today. But, I

1 mean, that's something you routinely do?

2 MR. FISCHER: Yes. Yes. Well, we did

3 that in all of these tests, actually. Maybe I should

4 have emphasized it more.

5 MEMBER RYAN: Thanks. That answered my

6 question.

7 MEMBER LEVENSON: Any questions from the

8 ACNW staff? Any of the other presenters have any

9 questions or comments?

10 MR. YAKSH: I have a comment.

11 MEMBER LEVENSON: Yes.

12 MR. YAKSH: Mike Yaksh, NAC International.

13 MEMBER LEVENSON: Pull your mike down.

14 MR. YAKSH: Oh, sorry. Mike Yaksh, NAC

15 International.

16 With respect to the basket, baskets really

17 are very fragile. They may be a little bit weaker

18 than the thick outer shell, the inner shell, and the

19 nine-inch lids, but I don't really think they're

20 fragile.

21 MR. FISCHER: Okay. I'm sorry. Fragile,

22 like 70-G capability versus a few hundred G's.

23 MR. YAKSH: You didn't --

24 MR. FISCHER: In fact, that's the reason

25 why we went through all of that. We felt that the

1 baskets could take it --

2 MR. YAKSH: Right.

3 MR. FISCHER: -- and that's why we did go

4 to the tipover, saying, yes, they are very robust. On

5 the other hand, you'll always ask the question, can a

6 basket take 200 G's? In a lot of cases, they can't.

7 MR. YAKSH: Some people interpret fragile

8 as like being a real liability, extremely weak, and I

9 don't think they are very --

10 MR. FISCHER: I apologize. I used the

11 wrong terminology.

12 MR. YAKSH: Thank you very much.

13 MR. FISCHER: I used the wrong

14 terminology.

15 MR. YAKSH: The other comment I have is on

16 the tipover test, over the steel billet. Can't

17 emphasize how important that test was to ourselves and

18 the other vendors here.

19 There is a particular beauty about that.

20 Steel is a very complex material, and what they did

21 was they used an elastic modulus. And that prevented

22 people from having to go out and perform very

23 expensive soil testing and really provide no

24 additional assurance that the calculations were

25 accurate or more assurance that there were baskets

1 that were much more robust or the design was more
2 robust.
3 And he is correct about the bounding
4 conditions. These -- what he showed there was a
5 block, and what you don't realize is a lot of times
6 people apply certain bounding conditions, and it may
7 or may not be correct. And one of the things that the
8 NRC reviewed is to question, why did you use this
9 bounding condition? What affect does it have? And
10 you have to justify that bounding condition.
11 So the report that they did was a very
12 important step for all the vendors in being able to
13 justify and defend that their designs are adequate.
14 Thank you.
15 MR. FISCHER: Thank you.
16 MR. YAKSH: You're welcome.
17 MR. FISCHER: I'm glad it helped you.
18 MEMBER LEVENSON: Any questions or
19 comments from anyone in the audience? Come to a
20 microphone and identify yourself.
21 MR. REZNIKOFF: My name is Martin
22 Reznikoff. I always --
23 MR. FISCHER: Hey.
24 MR. REZNIKOFF: Hi, Larry.
25 MR. FISCHER: It's been a while. Oh, my

1 goodness.

2 MR. REZNIKOFF: I always appreciate your

3 honesty. I wanted to find out a little about the

4 cladding and whether you've actually taken cladding

5 that's been irradiated to the kind of levels that fuel

6 is going to be irradiated to, say 45,000 megawatt days

7 per metric ton, and actually tested that cladding for

8 various physical properties.

9 MR. FISCHER: Yes. I did that when I was

10 at GE. We did it out at Vallecito. We irradiated the

11 cladding up to the levels that it would be exposed in

12 the reactor, and then we went forth and did bin tests

13 on them, and a hardness test, and so forth. We did

14 quite a number of tests, and it is in the IF300

15 safety --

16 MR. REZNIKOFF: Is it written up in some

17 paper that you --

18 MR. FISCHER: It's in the IF300 safety

19 analysis report.

20 MR. REZNIKOFF: Okay.

21 MR. FISCHER: Yes, it was very extensive.

22 MR. REZNIKOFF: And I have a question for

23 Sandia, if I could do that. I was involved on the

24 Advisory Panel of the TRUE study that was done in

25 1980, transportation of radionuclides through urban

1 environments.

2 And I was wondering whether Sandia is

3 going to do the same thing, have an Advisory Panel for

4 these actual physical tests. I think that would

5 improve the public confidence in these tests, if the

6 public can have a hand in the design of the tests.

7 MR. BRACH: I'm Bill Brach from NRC. I

8 mentioned to Doug -- let me perhaps answer that or

9 respond to it. The Package Performance Study Test I

10 tried to briefly describe before has a -- what we've

11 called an enhanced -- but let's not focus on the word

12 "enhanced."

13 It has a public participatory process that

14 began with the very outset of the study. Moving into

15 the next phase, which will be our providing to the

16 members of the public and stakeholders the draft test

17 plan for public review, comment, feedback to us, as to

18 the test plan, what we're testing, why we're planning,

19 what considerations, what materials, what type of

20 tests, extremes for the test, etcetera, should be

21 considered. That's the process we will be moving to

22 in the next few months.

23 Following that, part of the process as

24 well will be actually, then, conduct of the test. Our

25 plans are to have the actual conduct of the test, to

1 the extent we can, also have public, if you will,
2 participation from the standpoint of observation --
3 better phraseology.
4 Following that, the test results that are
5 obtained, we're planning to make the test results part
6 of the public process, so that the outcome of the
7 test, what the test results are, will be available.
8 Our analysis of those test results would as well be
9 made available. And then, leading from the analysis,
10 what the recommendations, conclusions, findings are we
11 have -- would be part of -- would be shared with and
12 open to the public.
13 So from that perspective, there is not per
14 se a public advisory committee or council that we're
15 planning or forming. But we've had very much of an
16 open, public, involved, and engaged process from the
17 very outset of the study, where we were asking the
18 basic fundamental question -- if we carry out this
19 test, what type of test and type of parameters and
20 conditions should be considered to all aspects of
21 conduct?
22 MR. REZNIKOFF: I think that's good -- not
23 as good as an advisory panel, because it's rather
24 discontinuous. You do things, and then you say, "Are
25 we doing it okay?" And then you ask for other input.

1 And the advisory panel that I've been familiar with
2 had a more continuous role and a greater interplay,
3 you know, with Sandia.
4 MR. BRACH: Well, let me take that as a
5 comment or recommendation and for consideration.
6 Thank you.
7 MEMBER LEVENSON: I want to point out that
8 Mr. Reznikoff was correct in not limiting his
9 questions to the last paper. This is public comment.
10 Anybody can ask questions or comments on any of the
11 presentations this morning.
12 Before I turn to the audience, again, as
13 was introduced in this last discussion, the urban
14 study, the TRUE study, was not mentioned by anybody
15 this morning. And, I don't know, Bill, are you in a
16 position to give a two-minute summary? Because is it
17 or is it not something relatively important? Should
18 it be part of this workshop record?
19 MR. BRACH: I have to explain my lack of
20 full knowledge of the study. I apologize. If
21 appropriate, maybe I could check with staff and come
22 back later during the conduct of the workshop, if
23 that's appropriate.
24 MEMBER LEVENSON: Any other questions?
25 MS. GHEE: Thank you, Mr. Chairman,

1 members of the committee. I am Lisa Ghee with Public
2 Citizen.
3 And I wanted to make three general
4 comments, first of all, related to the presentation,
5 yet again, of the Sandia videos from the full scale
6 tests in the '70s. And I just wanted to I think
7 clarify for you an element of the public concern here
8 that I think hasn't been fully acknowledged, and just
9 draw an analogy perhaps.
10 If, for example, a member of the auto
11 industry were to present a new car design for
12 certification based only on analytical models of crash
13 testing confirmed through physical tests done on
14 obsolete models three decades ago, that would
15 certainly not meet with regulatory approval, much less
16 be worthy of public confidence.
17 And I think it is critical to have those
18 tests from the '70s updated through the planned
19 package performance study, but I hope that the NRC
20 will make it clear in its presentation of the PPS also
21 of its limitations, that this is not a change in the
22 regulatory requirements that would -- this is not a
23 requirement for physical testing of the casks that the
24 NRC certifies. Rather, it's a one-time confirmatory
25 test still taking into account the boundaries of the

1 test parameters, of course.

2 And I guess that brings me to my second
3 point, which is that if we are to be limited to a one-
4 time confirmatory test, we would be very happy if this
5 committee would recommend that the PPS consider test
6 to destruction, because, you know, just taking for
7 example, the fire test that I've heard -- the
8 contemplated parameters of the fire test, a 90-minute
9 fire at the regulatory temperature, it's three times
10 longer than the regulatory requirements, but still
11 much lower than actual -- some actual fires that do
12 occur in the transit of materials that are already on
13 the roads.

14 And I don't want this comment to be
15 dismissed, as often it is, as a situation that's
16 highly improbable, because all of these -- as a member
17 of the public, the issue of -- or the weighting of
18 these risks by low probabilities becomes irrelevant,
19 because we all know that unlikely accidents do happen
20 on the roads and rails.

21 And at the moment when that unlikely
22 accident happens and results in a catastrophe in my
23 neighborhood, it's not very comforting to know that it
24 was unlikely. And I think that given the large,
25 unprecedented scale of transportation that's being

1 contemplated to Yucca Mountain, the test to
2 destruction are, more than ever, necessary.
3 Finally, there has been a lot of
4 discussion here about the need for extra regulatory
5 tests to test the performance of casks beyond the
6 requirements in the regulations. And there seems to
7 be a widespread acknowledgement that the regulatory
8 parameters drastically underestimate the accident
9 conditions, again, on today's roads and rails.
10 And, once again, we would be very happy if
11 this committee would go beyond acknowledging this in
12 the context of one-time extra regulatory tests, and
13 recommend a rulemaking to update the routine
14 requirements for cask certification to more
15 realistically take into account the accident
16 conditions through a higher impact requirement of a
17 hotter fire, a longer fire, a more realistic
18 submersion test.
19 So those are my comments for right now.
20 Thank you.
21 MR. FISCHER: Do you mind if I answer?
22 MEMBER LEVENSON: No, go ahead.
23 MR. FISCHER: Okay. I think you're
24 presenting some good arguments and some good
25 questions. Certainly, we would want to run some tests

1 on some -- today's cask.

2 The other thing is is that if a cask has

3 a unique feature different from the one that's

4 actually tested, I think it behooves the applicant to

5 go out and run some tests on that, like a different

6 impact limiter or something that is significantly

7 different or innovative. But he doesn't have to do

8 the whole test, the whole thing.

9 So if there are differences -- it's kind

10 of like what we do -- criticality analysis. We go out

11 and we benchmark our criticality codes against various

12 critical experiments.

13 Now, if we start going into other areas

14 that do not look like the critical experiments that we

15 just ran, then we have to go out and run additional

16 critical experiments. And we're starting to have to

17 do that now, since we're looking at nuclear waste,

18 whereas most of the stuff was done for more fresh

19 fuel, and so forth.

20 So just -- I want to say that we don't

21 just run one test, and that's it forever. But we run

22 the test and get the general knowledge, and then, if

23 there is some deviations from that general

24 configuration, then more tests will have to be run and

25 modeled.

1 The second thing is you had asked about
2 testing to destruction. How about if we do that
3 through simulation? We can show different levels of
4 destruction by simulation. We can show different
5 levels.
6 And there is at some point where it turns
7 out there were -- that there's not going to be any
8 catastrophic consequences. That's the study we did,
9 a modal study. And that's because we used ductile
10 materials. So we do not expect catastrophic failures
11 to occur.
12 Things that are designed under regulation
13 do -- let's say, fail gracefully. With the current
14 regulation, we essentially require zero release, and
15 that's very simple to measure. Zero, in this case, is
16 easy to measure.
17 Then, you say, "Okay. Well, let's go to
18 the next level. What are we going to allow to
19 release?" 10? 20? 30? 40? We get, then, into a
20 judgmental thing. And I think that it's better for us
21 to concentrate on the fact that 99.9 percent of the
22 accidents all fall within zero release, and the other
23 ones that occur and go beyond maybe the regulatory
24 thing, even those releases are quite small as shown by
25 our risk studies that have been done.

1 And so to say we -- I think you'd have a
2 very difficult time in testing the package to
3 destruction, whatever that means. That's my comment.
4 MS. GUE: Well, I think, graceful or not
5 graceful, information about the failure points of
6 these -- of these canisters is going to be critically
7 important for -- obviously, for public safety, not to
8 mention public confidence.
9 And I think the point that I was making
10 was that it's one thing to say, you know, you're safe
11 if it's only a 30-minute fire. Or if you can expand
12 that to say you're safe if it's only a 90-minute fire
13 -- but when we have the folks in Baltimore, for
14 instance, familiar with a fire that lasted for five
15 days, those analyses become less useful.
16 And I guess when I talk about the -- well,
17 I guess we have -- I can mention the experience of
18 these tests in the '70s with regards to the fire test.
19 And the information that was not portrayed in the
20 Sandia videos was what happened after 90 minutes of a
21 fire, what happened in terms of valve failure and, you
22 know, the lead lining of the cask.
23 And those are -- I mean, a test to
24 destruction maybe is graceful, but at what point is
25 that zero release regulation violated? What kinds of

1 -- what kinds of -- what situation and how realistic
2 is that situation would result in that kind of
3 failure.
4 MEMBER LEVENSON: Bill?
5 MR. BRACH: Bill Brach, NRC. A couple of
6 comments.
7 One, Lisa, I appreciate your coming to the
8 microphone to make the comments after Dr. Reznikoff,
9 but, Lisa -- and your organization has been involved
10 in I believe just about all of our prior package
11 performance study meetings that I described before.
12 And I appreciate that what we're asking
13 for -- again, it will be in the test -- in the draft
14 test plan asking, again, for comments. And I
15 recognize comments come from those in the industry,
16 come from those in government, come from those who
17 represent public interest groups. Appreciate the
18 input.
19 There are a couple of other additional
20 comments that I did want to make. I had mentioned
21 before in response to a question by Dr. Hornberger
22 that the package performance study is envisioned on
23 our part as a confirmatory test.
24 Based on all of our modeling and analysis
25 and scale model testing to date, we are fairly

1 comfortable and confident that the test standards that
2 are currently in the NRC's regulations, 10 CFR
3 Part 71, provide for an adequate level of safety and
4 protection of material in transport.
5 The confirmatory nature of these tests
6 we're looking for to provide us information with
7 regard to the predictability and confirmation of the
8 predictability of much of the modeling and simulation
9 that we're using.
10 In response to an earlier question, too,
11 I had noted that, clearly, our eyes are and must be
12 wide open, that based on the results of the test, what
13 information that tells us we will be reacting on. And
14 if there are a few, if you will, surprises or
15 information we didn't anticipate, we have to be in a
16 position to respond to what that information might be.
17 A couple of other aspects, with regard to
18 carrying out these extra regulatory tests, if you
19 will, on all transportation packages. Our efforts in
20 developing the test plan and the whole approach and
21 concept -- we are trying to develop a concept so that
22 the confirmation and the information we learn from the
23 tests will provide results to us that will tell us if
24 the modeling and the computer simulation techniques
25 that we're using that are broadly used, not just used

1 on one individual cask design but are broadly used in
2 almost all of the cask designs, if that -- if those
3 modeling computer techniques and simulations are, in
4 fact, confirmed through the testing. So we're looking
5 for that to give us a broader base of information, not
6 just information on the one transportation package
7 that was dropped.
8 And the last point I'd like to make is --
9 and you brought up the reference to the Baltimore
10 Tunnel fire. Yes, that was a fire that lasted for a
11 significant period of time.
12 There will be a paper this afternoon that
13 Chris Bajwa, who is a scientist in the Spent Fuel
14 Project Office, will be giving on our information that
15 we've developed in working with the National
16 Transportation Safety Board, Department of
17 Transportation, as well as the National Institute of
18 Standards and Technology, with regard to our review
19 and analysis of the Baltimore Tunnel fire.
20 And if you were hypothesizing, had there
21 been spent fuel -- a spent fuel package on that train,
22 in the tunnel, in a fire, what would have been the
23 consequences or outcome?
24 It was mentioned briefly this morning our
25 preliminary information is very positive. But Chris

1 will go into much more detail as we, too, are looking
2 at that, because that -- not just because Baltimore is
3 local to where we're located here, but that type of
4 scenario and event to the concern, from the standpoint
5 of our being able to assure that the continued safe
6 transportation of spent fuel under different accident
7 conditions can be assured.
8 I appreciate your comments.
9 MEMBER LEVENSON: I'd like to add one
10 comment that might be slightly relevant, and that is
11 the existing regulatory requirements all pretty much
12 pre-date risk-informed or risk-based time. And so I
13 presume that in the foreseeable future most of these
14 will be reviewed to find out, are they still current
15 and are still valid, and are they underestimates, are
16 they overestimates.
17 So I don't think we should look forward to
18 regulatory requirements of 20 years ago being those of
19 the next 10 years.
20 Any other comments from the audience?
21 MR. REZNIKOFF: Just one more.
22 MEMBER LEVENSON: Very patient until you
23 start interfering with --
24 MR. REZNIKOFF: I know this perhaps will
25 come up this afternoon, but you mentioned the fire,

1 the Baltimore Tunnel fire, and I just wanted to make
2 a comment or two about that.
3 It's my understanding the National
4 Transportation Safety Board is not going to look at
5 the temperature of the fire. They're only going to
6 look at the cause of the fire, and that's why the NRC
7 took on National Institute of Standards and Technology
8 to actually look at the temperature of that fire.
9 I would like the NRC to release that
10 report that NIST has prepared. I think the committee
11 -- the Advisory Committee should also look at that
12 report.
13 It's my understanding that NIST produced
14 a report that the NRC was critical of, and the NRC, in
15 turn, hired another organization -- Southwest Research
16 Institute -- to do another study on the temperature.
17 Could you comment on that?
18 MR. BRACH: Well, let me -- the results of
19 our review will all be made public. You are correct
20 in that we have engaged the National Institute of
21 Standards and Technology, as well as the center down
22 in San Antonio, to assist us in the review.
23 Chris Bajwa this afternoon will be
24 providing an overview of the results. The study, when
25 it's completed, will -- when we have a response on our

1 part to respond back to the Commission with regard to
2 the results of our review, the study results will be
3 made public.
4 Right now, I'm not in a position to
5 discuss the preliminary information referenced. I've
6 referenced the NTSB, and I've commented, too, before
7 on our coordination with NTSB. We have taken the lead
8 in working with NTSB and the other contractor
9 mentioned to be sure that we understand the
10 temperature profiles of the fire that occurred, as
11 well as the duration of those profiles in the tunnel
12 in Baltimore.
13 MR. REZNIKOFF: We asked for the NIST
14 study three months ago under the Freedom of
15 Information Act, and it still hasn't been produced.
16 MR. BRACH: I apologize. I'm not familiar
17 with the FOIA, but the review is currently underway,
18 so I -- my initial perspective is that the study
19 report -- as well as, I know, our report -- is not
20 final and not yet publicly available.
21 MEMBER LEVENSON: Any other comments? If
22 not, we'll adjourn for the morning. And I'd like to
23 start promptly at 1:30, so as to not cut into time for
24 speakers this afternoon.
25 (Whereupon, at 12:24 p.m., the

1 proceedings in the foregoing matter were
2 adjourned for a lunch break until 1:33
3 p.m.)
4 MEMBER LEVENSON: I think we are ready to
5 start the afternoon session. We are going to hear
6 from several vendors, and their programs. And the
7 first one is Kris Singh.
8 MR. SINGH: All right, can you hear me? I
9 hear no negatives, so I will proceed.
10 My name is Kris Singh, I'm Holtec's
11 president. And I have been asked to give the first
12 vendor presentation.
13 Our system is called HI-STAR. Is there a
14 pointer? All right, okay, good.
15 Now I got the equipment under control
16 here. Our system is called HI-STAR. A standard
17 package will consist of six components. I'm going to
18 give you an understanding of the package itself.
19 The analysis that we have done to qualify
20 the package, to evaluate its characteristics, I'm
21 going to be rather brief on that. I will use the 20
22 precious minutes I have, that is all that has been
23 given to me, to give you an understanding of the
24 package, because all analyses evolve from the design.
25 If you don't understand the design you can't really do

1 a good analysis.

2 So I'm going to give you an understanding

3 of what we really have put together, about ten years

4 ago. There are several dual purpose systems available

5 in the industry, they are all very good, they are all

6 very capable, they are all very reliable, I'm just

7 going to focus on the system that our company designs,

8 because I'm most familiar with it.

9 HI-STAR is a dual purpose cask, it is

10 licensed for storage and transport, under two separate

11 dockets. The item that goes inside the overpack is

12 the multi-purpose canister.

13 The multi-purpose canister, as the name

14 implies, is good for storage and transport. And in my

15 opinion is the single most significant development in

16 dry storage in the 20th century.

17 The reason I say that is because when you

18 talk about transport, ensuring that the fuel is

19 contained in a robust container outside, in addition

20 to the overpack, is critical to the security of the

21 package. And the multi-purpose canister provides

22 that function.

23 The cask has two impact limiters, one at

24 each extremity, designed to limit the maximum G load

25 that the package will sustain, if it is dropped from

1 a height, say, nine meters, that part 71 requires.

2 It requires a transport cradle, rail car,

3 and personnel barrier, which is strictly a non-

4 structural barrier, so people, insects, animals, can't

5 get too close to the cask.

6 I'm going to talk, principally, about the

7 first five components, personnel barrier is non-

8 structural, so we won't talk about it. Let's go on to

9 the next expensive piece.

10 We have the docket numbers for the storage

11 and transport, if you are interested in studying the

12 cask in detail. You see a voluminous amount of

13 material in those dockets.

14 You are looking at some photographs of

15 actual casks, HI-STARs, which are deployed at certain

16 sites, I think this particular is in Illinois. These

17 are actual HI-STARs you are looking at.

18 The design mission of the cask was to, for

19 purposes of this particular meeting, was to provide

20 what I call a virtually impregnable physical barrier

21 to protect the MPC, that is the first performance

22 mission.

23 The second mission is to be able to

24 transport, on rail car, at temperatures as low as

25 minus 40 degrees fahrenheit. Now, as you know, at low

1 temperatures material ductility decreases, therefore
2 the design of the cask has to be capable of dealing
3 with brittle factor concerns at such low temperatures.
4 It should be capable of being stored on a
5 pad, free standing, or anchored. This cask has, below
6 the base plate, anchoring locations. It can be
7 anchored to a pad, although its most common deployment
8 is free-standing.
9 And then the last mission is to keep the
10 weight under 125 tons. Now that is, the weight, as
11 you know, is directly related to shielding capability.
12 Weight is also directly related to how much material
13 you have available to develop, to build the structural
14 rigidity in this structure.
15 And therefore weight, although it sounds
16 like an innocuous number, provides a great challenge
17 to a designer. Let's go on to the next transparency.
18 You are looking at a view of the same cask
19 that you saw earlier. I'm just going to give you a
20 quick overview of what it contains.
21 This is the multi-purpose canister shown
22 in a cutaway view. Inside this is the basket. And
23 I'm going to show better views of these. This multi-
24 purpose canister is a completely welded confinement
25 boundary, in the lingo of the trade.

1 It is, essentially, a completely welded
2 pressure vessel. Outside it is your overpack. The
3 overpack itself consists of a large heavy forging at
4 the bottom, heavy forging at the top, connected by a
5 shell, inner shell, which is the -- what the NRC has
6 christened containment boundary.
7 And around the containment boundary is a
8 number of shells, five intermediate shells. And then
9 we have a neutron absorber material that we call
10 holtite, and that basically constitutes the cask.
11 Let's go on to the next transparency.
12 This is the man who made the drawing, it shows you how
13 large the cask is compared to a typical man. The
14 cask, these are geometric dimensions, I'm not going to
15 go into details, I'm just providing this in case you
16 need to refer back to this material, you have some
17 concise information here.
18 Let's go on to the next transparency. Now
19 I'm going to show you some features that are
20 engineered into the cask to provide rigidness, to deal
21 with the very kind of concerns that analyst would have
22 with respect to its performance.
23 First item the cask has attached in its
24 transport mode, you can see, that the bottom is a
25 complete base plate, the top is a bolted closure. In

1 order to, on top it also has a gasket joint.

2 We want to protect that joint. To protect

3 that joint we provide another plate that bolts onto

4 the top of the cask. This makes a diametrical

5 rigidity to the cask, in addition to the top bolted

6 plate, in the transport mode.

7 So this plate is used strictly during

8 transport. Let's go on to the next transparency.

9 Here it shows you, we have dual gasket closure, we

10 have the man bolts, and here is the buttress plate

11 bolted on to the extension of the over back forging.

12 Notice here, one of the speakers in the

13 morning pointed out that designers now make casks so

14 the joints are protected. You see how this joint is

15 protected. There is a bolt, there is a series of

16 bolts, and these bolts basically provide the

17 compression load on the gasket, to create the seal

18 worthiness of the joint.

19 Then you see, outside, there is a forging

20 extension here that protects this bolt, in case of a

21 tip-over in an impact blow. This lip will have to

22 bend, and impact the bolt, before this bolt will see

23 any direct impact force.

24 This buttress plate is also secured to

25 this lip to give it strength so it will not, under an

1 actual impact load, deflect. Of course it is very
2 rigid by virtue of the geometry, to begin with. But
3 it is further buttressed by the buttress plate.
4 Let's go on to the next. Now, here, you
5 will see something that we were, it is a small
6 innovation, but it is important when you deal with
7 large loads, impulsive impactive type of loads.
8 The bolted closure has a recess in it. Do
9 you see this recess here? And the MPC is down here.
10 If the MPC lid were to impact, attempts to hit the top
11 cover, the force will be located in the peripheral
12 region of the cover, as opposed to loading the central
13 region of the cover, which is not that strong.
14 The idea being to make the joint more
15 rugged, it has the impulsive effect in the type of
16 loads. This here is the part for lifting the cask.
17 Let's go on to the next transparency.
18 Here we are looking at a section at mid-height. At
19 mid-height you have the inner shell, this inner shell
20 which is two and a half inches thick. All materials
21 in this cask are made out of either nickel steel
22 which, as you know, other than asthenic stainless
23 steel, has the best brittle factor properties of all
24 materials used in the pressure vessel industry.
25 The enclosing shells are made up of 10

1 carbon steel. Which, again, would give you 10, so it
2 has good impact fracture property. We chose nickel
3 steel because nickel steel is stronger, it has a
4 higher yield strength, and still has excellent
5 fracture resistance at low temperatures. That is why
6 we chose nickel steel instead of asthenitic stainless
7 steel.
8 We have a number of layers around the
9 inner shell. And the idea here is we make the steel
10 shell thin, and at the same time we have multiple
11 layers to get the total thickness for gamma
12 attenuation that we need.
13 You can see, quickly, if you do factor
14 type of analysis, that a crack from the outside cannot
15 propagate to the inside. So if there is, if there
16 were a large impact force, and a crack were to
17 develop, the crack will not propagate.
18 Outside is holtite, which is a material
19 that is a rigid type material, and therefore it has
20 very high damping properties, but it is not a
21 structural member, per se.
22 The general idea is to make the cask
23 extremely resistant to impact impulsive bolts. Let's
24 go on to the next.
25 I mentioned that materials are nickel

1 steel, or 10 carbon steel. They are all qualified to
2 remain fracture resistant at minus 40 degrees. Let's
3 keep going.
4 You are looking at, here, the MPC in a
5 cutaway view. The key piece of information here, for
6 those of you who don't load casks, is that this entire
7 structure is manufactured in the shop, the top lid is
8 welded after the fuel is inserted.
9 So this top lid joins to the shell, is a
10 cause for concern, because it is a field weld. And we
11 have done a great deal of investigation to ensure that
12 that weld will perform, will not fail, actually, under
13 very, very high g-loads.
14 We have, on the computer, dropped the
15 canister from 25, 30 feet, and seen that the weld will
16 not, we will not have a fracture, without an impact
17 limiter cushioning the fall.
18 Let's go on to the next one. You are
19 looking at the basket. I think one of the speakers in
20 the morning said the basket is your biggest concern.
21 Indeed it is, because it does contain the fuel. And
22 we have taken the steps to ensure that this basket,
23 which is made of, basically, plate type members, in an
24 octagonal grid, every single seam is continuously
25 welded at every junction, wherever the plate meet, all

1 junctions are continuously welded along the entire
2 length.
3 Which makes it an extremely rigid
4 structure. As a matter of fact, it is so rigid that
5 under loads that you will apply, say in the central
6 span, you don't see much deflection. It is a multi-
7 flanged rigid beam.
8 Also, having the welds along the entire
9 length provides for good heat transfer under storage
10 conditions, storage and transport conditions.
11 The cask has two impact limiters at both
12 ends, as I said earlier. Now, if you look at this
13 structure, the impact limiters themselves protect the
14 cask at the end.
15 If you are looking at a missile kind of a
16 load, that load, of course, the most vulnerable region
17 is the central region of the cask. And that is where
18 we have layered shells to keep any fracture from
19 propagating.
20 So the cask, essentially, is protected
21 from the wide variety of loads that now we envision,
22 after 9-11. It will not only take a direct fall, but
23 it will also take localized impact loads.
24 Let's go on to the next. This show you
25 the impact limiter. The impact limiter is made of

1 aluminum, so it will be resistant to fire, and it will
2 not change its property depending on humidity and
3 temperature. If it were made of wood, you would have
4 a concern about humidity dependence for properties.
5 The impact limiter is the external body is
6 made of stainless steel, inside is aluminum
7 compressible material. It is a honeycomb material
8 that is made to deform easily at low loads, and
9 actually provide a plastic kind of response under a
10 contact load.
11 Let's go on to the next one. This shows
12 the rail car that we have. We took the private fuel
13 storage car that they had designed some years, and we
14 designed a cradle to go with it.
15 The idea with the cradle is to keep the
16 center of gravity of the cask as low as possible. And
17 to also provide for very high axial load bearing
18 capability. I'm not going to go into the details of
19 the cradle design, there is not time for it. But the
20 design mission is to, essentially, make this
21 structure, again, extremely energy absorbent.
22 Let's go on to the next. Now, this is an
23 artist rendering of our HI-STAR cask headed to the
24 repository. The cask, as you can see, the central
25 region of the cask is where you can have a direct

1 impact from a foreign object.

2 The ends of the impact limiter, there is

3 a good deal of technical detail that characterizes

4 this impact limiter, but the -- it suffices to say

5 that under loads that the rail car is designed for,

6 nothing happens to the package at all. The stresses

7 will be minimal.

8 This is the last one, or is there another

9 one? All right, let's go to it. The availability of

10 the cask. Four HI-STARs are currently in use at

11 Exelon's station. I think we showed you, the first

12 photograph was that one.

13 There are three HI-STARs are used at

14 Southern Nuclear's Plant Hatch. We had built one HI-

15 STAR in 1998, using all the regulations of 10CFR70.1,

16 but at the time we did not have the license, we did

17 not have the certificate. And, therefore, the task

18 theoretically was not certifiable, even though it met

19 all the requirements.

20 Exelon purchased that cask from us. This

21 presumably is available from Exelon for testing

22 purposes, if you folks do make a full scale testing

23 program.

24 Let's go on to the next one. Now, I'm

25 going to talk to you, very briefly show you, how many

1 half minutes do I have left? Five, okay.

2 We made a simplistic model. I would not

3 brag about the model, but it is a good model, because

4 it characterizes the behavior of the package under an

5 impacted load.

6 We, incidentally, we ran a number of

7 benchmark tests, actual tests, on the impact limiter,

8 as prototype, many years ago. And all the data is in

9 the literature, so I'm not going to talk about them

10 here.

11 I'm going to show you how this cask is

12 predicted to perform if one were to subject it to a

13 missile load, such as from a jet engine. We took a GE

14 engine that is used in Boeing 767, it weighs 13,000

15 pounds, and we decided to apply, have it impact the

16 cask, in the center, away from the impact limiter, in

17 the most vulnerable region, with a force of 500 miles

18 an hour.

19 And the object here is to study what

20 happens to -- whether the cask would separate from the

21 cradle, or is the cradle well enough designed that the

22 cask and cradle remain together.

23 That was the object of this test, this

24 particular numerical simulation. We have also

25 performed a much more detailed simulation where the

1 entire cask is modeled as an elastic plastic body in
2 a large finite element program.
3 That I will not present to you in main
4 presentation, if questions are asked we will show you
5 that visual in the discussion period.
6 We are going to see two movies now, so I'm
7 going to -- this is the last one, right? Another one.
8 Well, here is the actual visual of the engine
9 impacting the cask.
10 And this, as I said, these are modeled as
11 rigid bodies. Now, you are looking at what happens to
12 the package. Now, realize, this model is limited in
13 the sense that the cask can separate from the rail
14 car, but you will not see actual deformation of the
15 cask, you will only see the -- you will see, if they
16 were to separate, you would see the separation
17 develop.
18 The next one is with a different
19 coefficient of restitution, meaning that the amount of
20 energy, the first one we assumed that there is no
21 energy absorption. The entire kinetic energy, the
22 coefficient of restitution is one.
23 Here we assume the coefficient of
24 restitution is .25, which means there is some
25 dissipation of energy.

1 Now, these solutions in the post-impact
2 response, it is already written for me, the package
3 remains with the vehicle during rollover for a
4 specified impact angle, which in this case is 30
5 degrees from the horizontal.
6 One can, this model is capable of studying
7 additional level of refinement, in the sense that we
8 can study the separation between the rail car and the
9 package, we could separate other main components, and
10 determine whether they make them separable in the
11 model, and determine actually whether they separate
12 under an impact load.
13 This will be more of a solution for a day
14 to day study. We have made a complete model, done a
15 3-D model of the package, with the impact limiter, the
16 cask, represented by thousands of finite elements, so
17 is the impact limiter, and the MPC inside it, is to
18 characterize the deflection response of the cask, the
19 actual deformation of the cask under the impact load.
20 We have the visuals for it, we will show
21 you later. But let me just tell you, what we find is
22 that at 500 miles an hour, the same engine impacting
23 the package, the multi-purpose canister is not
24 affected at all, the cask withstands the entire
25 impact.

1 We will continue our own study, funded by
2 our own company, to characterize the behavior of the
3 cask over the coming months and years. And we will,
4 of course, work with the laboratories to -- we will do
5 our piece.
6 I think it is important that we do
7 interact with the laboratories because they have much
8 larger computing capabilities, as you heard, and they
9 are able, they will be providing information on the
10 physical design details, so they can do their work
11 more effectively. Thank you.
12 MEMBER LEVENSON: We are going to keep
13 most of the discussion on these three papers for the
14 end. But at this point, do any of the committee
15 members have a question of clarification?
16 (No response.)
17 MEMBER LEVENSON: The next paper is by
18 Peter Shih of Transnuclear.
19 MR. SHIH: Good afternoon, my name is
20 Peter Shih. In the next 20 minutes I'm going to
21 present Transnuclear's response in regard to design
22 analysis and testing of the transport cask.
23 By doing this, today, I'm going to -- the
24 topic I'm going to discuss this afternoon, first I'm
25 going to give a very brief discussion about

1 Transnuclear. And now I'm going to show how the cask
2 as designed by Transnuclear complies with rules and
3 regulations, by using analysis and testing.
4 By doing this, first, I will go through
5 the U.S. design criteria, based on Part 71, NUREG, and
6 ASME code. Then I'm going to touch a little bit about
7 the European design criteria based on IAEA and the
8 ASME code.
9 The reason I'm doing that is because some
10 of the casks designed by Transnuclear licensed in the
11 U.S. we also design to meet the IAEA requirement. And
12 in the analysis I'm going to describe the methodology
13 used by our company, and also what kind of computer
14 code we use in our company.
15 In the testing, first I'm going to
16 describe a symptom test during the fabrication stage,
17 then I'm going to describe the impact test, and how we
18 do the test, the purpose of the test, and the result
19 of the test.
20 Then I'm going to list the cask designed
21 by Transnuclear licensed in the U.S. and Europe, by
22 using analysis and testing.
23 In conclusion I'm going to summarize based
24 on the past experiments, and what we can do from here.
25 Next slide, please.

1 Transnuclear we have over 30 years
2 experience in design, license, and fabrication, and
3 operation of a package, for both storage and shipping
4 of spent fuel, radioactive waste and other radioactive
5 material. Our experience include design, analysis,
6 testing, fabrication, certification, and operation.
7 Next slide, please. The U.S. design basis
8 of the transport cask that is based on 10 CFR Part 71.
9 In the Part 71 specify all the design requirement,
10 including the normal condition, and the action
11 condition load.
12 And the NUREG 7.6 describe the structure
13 design criteria of the transport cask containment
14 boundary. And the NUREG 7.8 summarize the load
15 combination required.
16 ASME code, Section III, Subsection NB and
17 Subsection WB, we use this to code for design,
18 fabrication, inspection, and testing of the transport
19 cask containment boundary. And we use Subsection NG
20 for design, fabrication, testing, again inspection of
21 the basket. And we use NUREG 607 for the lip
22 analysis.
23 Next slide, please. In the Europe, most
24 of the country use the guideline specified in the IAEA
25 for the design. And they also use ASME code as

1 applicable for inspection, fabrication, whatever.

2 And if you have designed a transport cask

3 for use in Europe you would pay special attention to

4 this transportation constraint, especially the outside

5 diameter cask is longer compared with the cask in use

6 in the United States.

7 Next slide, please. The acceptance

8 criteria basically you divide into normal condition,

9 and an accident condition. The normal condition

10 basically we base on ASME code, delivery allowable.

11 And, of course, we need to maintain the containment.

12 And in the accident condition we base on

13 a level allowable, again, you know, we also need to

14 maintain containment. Next slide, please.

15 In the Transnuclear basically we use

16 ANSI's finite model for both structural and a thermal

17 analysis. And, of course, we also use some

18 calculation, you know, we use NUREG 607 for LIPO

19 analysis, and we use the COCASE N-284 for the bucket

20 analysis extra.

21 And the rest of this, you know, we use, in

22 the criticality, we use scale -- we are KENO-5A with

23 a scale of 4.4, and a containment we use ANSI 14.5,

24 and use MCMP code for gamma and neutron dose rate

25 calculation. Next slide please, thank you.

1 And this is a sift and testing during the fabrication
2 stage, and it is pretty self-explanatory. I'm not
3 going to address this too much.
4 Thank you, next. Scale model testing --
5 by the way, you know, because I put a lot -- try to
6 put as much material in the preceding slides. So if I
7 go a little fast, you know, please excuse me.
8 And since everybody have a handout -- the
9 scale model test, this test is for a cask dropped to
10 a surface from the 30 feet with impact limiter. And
11 the purpose of this test is to validate the G value
12 predicted by the computer analysis.
13 And in the same time we also use this
14 testing to validate the cross distance predicted by
15 the computer. And we also demonstrate adequacy of the
16 impact limiter attachment design, and in the same time
17 one of the impact limiter during the test, we put it
18 to the freezer, and it is chilled for a minus 20
19 degree temperature for 24 hours. Then we take out,
20 attached to the test model, on a truck, in 30 foot to
21 an unyeilding surface.
22 And last, you know, we do a 40 inch punch
23 to a puncture bar. Next slide, please. And this
24 scale relation we generate from the scale alone. Next
25 slide, please. And this overhead, you know, describe

1 the justification and advantage of a scale model test.
2 And basically there is three report I show
3 from Lawrence Livermore, Sandia, and Ecole
4 Polytechnique, you know, it describe in very detail,
5 so I'm not going to elaborate too much about this, you
6 know?
7 Next slide, please. This is one of the
8 test program performed by Transnuclear in January
9 2001. And this is one third scale NUMOS-MP197
10 transfer cask. We perform this test.
11 This is a test body, and the top and the
12 bottom impact limiter. And we also have twelve
13 accelerometers mounted to the cask body. And this
14 accelerometers are used to measure the accelerations
15 during the drop.
16 And this is a three orientation we drop,
17 side drop, 20 degrees slap-down, and a 90 degree end
18 drop. And a median up to 90 degree end drop. We
19 raised the damage the impact limiter 40 each above the
20 ground, and an impact to a one-third scale punch bar.
21 Next slide, please. And in the next few
22 slides I'm going to show you the drop orientation, and
23 a before and after. This is zero degree set-up. The
24 distance from the bottom of the impact limiter to the
25 test target is 30 foot plus one inch, minus zero inch.

1 Next slide, please. This is after the
2 drop. And each time after the drop we not only record
3 the G-load, plus go through thorough inspection,
4 measure the deformation on impact limiter, attachment
5 bolt, and also measure the torque of the bolt.
6 Next slide, please. This is acceleration
7 versus time history, record by one of the
8 accelerometers. And this is a field by 1000 hertz.
9 And you can see, based on this, the maximum G-load is
10 about 180-G, this one-third scale. And the transfer
11 to a full size scale about 60-G.
12 Next slide, please. This is the test
13 setup for 20 degree model. And it is about a 20
14 degree, in this line, to the perpendicular, to the
15 horizontal impact cervix.
16 Next slide, please. And this after the
17 drop, and our engineer inspect, you know, after the
18 drop condition.
19 Next slide, please. This 90 degree end
20 drop, next slide, and it is of a 90 degree end-drop.
21 Next slide please. And immediately after a 90 degree
22 end-drop we go to the punch, to the bottom of the
23 impact limiter.
24 Next slide, please. And this is the
25 measured G-load during the zero degree, twenty degree,

1 and a ninety degree. Again, you know, during the
2 structure analysis we add additional safety factor at
3 least like a 15 to 20 percent more than the measured
4 G-load used for structure analysis.
5 You can see 61, we have 75, and at 65 we
6 also have 75. And this one normal 32, 53, we have a
7 60, 196.
8 Next slide, please. We are talking about
9 a scale model test. In the next few slides I'm going
10 to describe two full size train crash tests. One of
11 these performed by the Sandia this morning, he already
12 described, so I'm not going to elaborate that
13 particular one, because we already go through that
14 pretty much, pretty detailed.
15 And this particular two-thirds, basically,
16 is for public acceptance purpose. I'm going to be
17 talking about a CEGB test, you know? This is talking
18 about central electricity generating bolt at UK.
19 Next slide, please. This test basically
20 actually is two kind of test. The first kind of test
21 is the full size model is dropped to, from 30 foot to
22 an unyeilding surface, with string gauge, okay?
23 So you measure all the force of
24 deceleration, and the whatever, you know. Then after
25 the drop the damage to the package was refocused, then

1 placed this package on the railroad truck. Then the
2 train, 240 ton train, drive 100 mile per hour impact,
3 smash into this particular package.
4 And we find out, you know, the cask had
5 survived for the train crash without any leakage. And
6 at the impact force, from the train crash, was less
7 than the 30 foot impact test.
8 So basically our conclusion is the full
9 scale testing give public confidence, and conform to
10 regulatory test are realistic when compared to the
11 real accidents.
12 It is very important to find out, you
13 know, accident 30 foot drop to an unyeilding surface
14 give you a much, much higher impact force compared
15 with this train crash.
16 Next slide, please. This, the package,
17 next slide, and a train crash, you know, diagonal to
18 the package. Next slide. And this see from a
19 distance, you know, so you can see the whole picture.
20 Next slide, please. In addition to a 30
21 foot drop to an unyeilding surface, Transnuclear also
22 had some experiments on the high speed impact testing.
23 And we performed this by simulator, the F-16 and F-18
24 fighter jet.
25 And what we do in this, you know, the test

1 was performed on missile, or model with missile
2 representing the real hardness of a jet engine, and
3 the impact condition.
4 And at the impact velocities, 336 to --
5 between 336 and 481 miles per hour. And we test, it
6 was performed using one-third scale of TN24D and TN24G
7 cask, okay?
8 And following component was modeled in the
9 cask, steel shell, neutron shared in the containment
10 vessel including forged steel shell, weld at the
11 bottom, and the bolt lipped with metallic seal.
12 And the next slide will show you the
13 picture, please. Okay, this is the high speed missile
14 representing the jet flight just before impact to our
15 TN24D cask. And these three slides, you know, that
16 show you how the missile impact to the cask.
17 Next slide, please. The test result, the
18 only deformation is local deformation at the outer
19 shell, and a not deformation of the force containment
20 vessel, or the closure lid.
21 The lid tightness was unchanged, because
22 we measure lid tightness before and after the impact
23 test. And virtually is identical. And this, by the
24 way, we have 24D and 24G, we perform a lot of tests,
25 you know, and because of time, I don't have time to

1 show you the picture.

2 But based on all the tests our conclusion

3 is that the dual purpose metal cask can survive very,

4 very severe impacts.

5 Next slide, please. And this slide show

6 the cask designed by Transnuclear, and licensed in the

7 United States, based on analysis and testing. And

8 from here you can see most our testing is about, oh,

9 one-third scale, and one of this half-scale.

10 And one thing I wanted to mention, the TN-

11 68, this particular cask is dual purpose cask. We

12 are not only licensed for transport, but also licensed

13 for storage.

14 And a new NP197 cask, this particular cask

15 is not only designed to meet the Part 71 requirement,

16 but we also design to meet IAEA requirement, and also

17 meet European transport constraint.

18 Next slide, please. These are the casks

19 that we license in Europe. And also you can see the

20 testing scale. Most of them are from one-third scale

21 to half-scale, and this one is one scale.

22 One thing I ought to mention, you know,

23 TN24D, TN24G, these two casks not only do we perform

24 a 30 foot drop test, but also perform a missile impact

25 test to simulate the jet flights.

1 Next slide, please. In conclusion this,
2 Transnuclear's past experiments in design the cask,
3 and analysis, and testing, and it combine ways of
4 today's advance technology, especially computer, high
5 speed computer. And we conclude that, you know,
6 analytical thought can actually predict the test
7 behavior.
8 Scale model test result provide valuable
9 benchmarking data. Reduced scale tests is just, is
10 fully justified. Scale one test on large package is
11 not required.
12 Then, basically from the four side, the
13 public demonstration test, to prove that the current
14 regulation give adequate safety margin to real
15 accident conditions. That is what I tried to show,
16 that four side package test.
17 Based on the G-load, based on the force
18 measured from the 30 foot drop, compared with the
19 train crash, you know, we find that the force from the
20 30 foot drop is much higher near the train crash.
21 Thank you.
22 MEMBER LEVENSON: Any committee members
23 have a question?
24 VICE-CHAIRMAN WYMER: What is the
25 shielding, the gamma shielding material?

1 MR. SHIH: Well, we have a neutron, we
2 have a reason that we also have a stainless steel
3 shell.
4 VICE-CHAIRMAN WYMER: So what is the gamma
5 shielding material, again?
6 MR. SHIH: Rayzor.
7 MR. SINGH: Gamma shielding.
8 MR. SHIH: Oh, gamma shield, okay. The
9 stainless steel shell, stainless steel.
10 VICE-CHAIRMAN WYMER: All stainless steel?
11 MR. SHIH: Yes.
12 VICE-CHAIRMAN WYMER: Okay, thank you.
13 MR. SHIH: Thank you.
14 MEMBER LEVENSON: For clarification, is it
15 still true that casks built to the IAEA standards are
16 usable for shipments into the United States, not from
17 one place in the United States to another, but from
18 anywhere in the world into the United States, the IAEA
19 cask can be used, is that right?
20 MR. SHIH: I think I will refer to NRC to
21 answer this question.
22 MR. BRACH: This is Bill Brach, NRC. That
23 is actually a role and responsibility of the
24 Department of Transportation has for countries, or
25 companies, that are importing into the U.S., they must

1 apply for approval through the DOT, the Department of
2 Transportation, for authorization to a non-NRC
3 certified package.
4 MEMBER LEVENSON: Okay, thank you. Now we
5 will go on. Our third speaker is Michael Yaksh, from
6 NAC.
7 MR. YAKSH: My name is Michael Yaksh, NAC
8 International. I appreciate the opportunity this
9 afternoon to describe some of our experiences, and
10 analysis, and testing.
11 Next slide. These are associated, of
12 course, with COC, this is a list of our COCs that we
13 currently hold. The NLI1/2, and the NAC-1, And NAC-
14 LWT, these are legal weight truck casks.
15 The unique feature about the NLI-1/2, it
16 is an older cask that we purchased back in the late
17 '70s, and it, as a shielding, uses uranium. The other
18 cask we use is basically lead.
19 The difference with the NAC-STC and the
20 MPC, and the UMS, these are what we call our high
21 capacity casks, 24 or more PWR fuel assemblies, 56 or
22 more PWR fuel assemblies.
23 If you look over the column of the number
24 of applications, and NLI, and NAC-LWT, you see that
25 those numbers are rather high. It just shows you just

1 a variety of types of fuel that is used, and
2 radioactive materials that are transported in these
3 casks.
4 Next slide, please. This is a slide
5 showing our overall usage of these casks. There is 8
6 LWTs being used throughout the world, 5 NLI-1/2s, use
7 over 3,300 shipments, over six and a half million
8 miles, so it is quite extensive.
9 When we do campaigns, that are usually --
10 when we ship fuel out of Taiwan, there was quite a
11 number of shipments. Some of these other locations,
12 like Colombia, and European, Scandinavia, those are
13 just maybe one or two shipments.
14 As far as modes of transportation, we ship
15 over trucks, boats, and when we ship the weapons grade
16 fuel out of Iraq, after Desert Storm, that was done in
17 Soviet aircraft. So these casks have been used world-
18 wide, and the only accidents I'm aware of is when an
19 empty NLI-1/2 cask, the truck jackknifed, the cask
20 fell off the truck, damaged the bolts and impact
21 limiter, falls on impact, and it was repaired and put
22 back into service.
23 So far as major accidents to these casks,
24 over the six and a half million miles, there has been
25 none, none that we would tally.

1 Next slide. Each one of these casks has
2 a license, and this license is supported by a
3 combination of testing and analysis. The testing is
4 used to confirm the analysis.
5 Because ultimately you want to demonstrate
6 what the intent of 71 is. The integrity of the cask,
7 and so we use both testing and analysis to do this.
8 Testing confirms the structural response of some
9 things that, early on especially in the '90s, it was
10 demonstrated best through tests, as the impact
11 numbers, what happens to the impact limiter bolt, does
12 the wood, and the other type of crushable material,
13 does its maintain its orientation.
14 So those sorts of tests demonstrated and
15 validated our assumptions. Now, the view of
16 analysis, though, once we've benchmarked the
17 methodology is, if we need to do what-if type study,
18 it is much easier done with the analysis, as opposed
19 to going out and performing a test, temperature
20 variations, variations of density, variations of
21 manufacturing, those sorts of things.
22 So the bottom line is we use the test to
23 confirm our analysis and technically our manufacturing
24 methodology as well.
25 Next slide. When we speak about

1 containment, there is really a number of systems that
2 are involved here. There is an impact limiter that
3 limits the acceleration to which the fuel clad will be
4 exposed, the basket structure will be exposed, the
5 cask body shells will be exposed, the lid, the bolts,
6 those sorts of things.
7 And there is the cask shells. Our gamma
8 shielding is lead, it is in between two thick
9 stainless steel shells, and then there is this very
10 robust bolts that maintain the containment at the top.
11 The main thing, criticality control of the
12 fuel within the basket, the basket is a very robust
13 basket made out of stainless steel. And each one of
14 these, COCs, that we developed in our design
15 licensing, we feel like the testing experience has
16 been rather extensive.
17 Next slide please. This is a slide
18 showing some of our high capacity casks, as well as
19 our truck casks. That is 24 spent fuel assemblies,
20 PWR 56, for BWR, total design weight is 260,000
21 pounds, fuel weighs about 40,000, so you can see that
22 this is canister fuel, we are dealing with about
23 220,000 pounds worth of packaging to protect, 40,000
24 pounds, roughly, worth of fuel.
25 Impact limiter is attached to both ends,

contained within the stainless steel shell. We use redwood and balsa. We find those are very economical materials, and very stable materials, as we will point out in just a little bit.

As far as testing type, in order to do your analysis you have to have certain input, material data to do that analysis, and that is what we call material testing.

We just received the COC, that testing involved dynamic testing of the redwood and the balsa, that was performed at the Naval Surface Warfare Center. The actual quarter scale model testing of the impact limiter is down to the anti-limiter bolts, the net area is modeled to a quarter scale, the shells, the impact limiter are modeled to the quarter scale.

The way we would manufacture the impact limiter and the full scale is the exact same way we did it in the quarter scale model. We started the test at Oakridge, and then we completed the test at Sandia National Laboratories.

The CY-STC has 26 fuel assemblies for canister fuel for Connecticut Yankee type fuel. We did both material testing here, same material testing we did for the GMS, we just applied that to the CY-STC design.

1 The reason why we went back and did a
2 quarter scale model is that we realized that we could
3 cut 30 or 40 percent of the weight of the impact
4 limiter, convert that to fuel weight, and make it a
5 much more efficient design.
6 We learned quite a number of things from
7 the EMS, and from the STC down in the early '90s, and
8 we wanted to employ that in the CY-STC design. So for
9 that reason we returned back to Sandia, confirmed, do
10 some more confirmatory drop test.
11 The NSC-STC is primarily for loaded fuel,
12 and two of those are being fabricated in Spain, for
13 use in China, to transport fuel for Diambay to a
14 processing plant and back to Diambay for reuse.
15 And that was one of our earlier designs,
16 that was done back in the early '90s, and at that time
17 we used primarily static crush test, and we used some
18 dynamic data from one of the national laboratories to
19 extrapolate for the dynamic data.
20 Now, the unusual thing about the NSC-STC,
21 not only was the impact quarter scale modeled, down to
22 net area on the impact limiter attachment bolt, but it
23 had a quarter scale basket, as well, all the shells
24 were quarter scale, the inner shell called for XM-19
25 pedigree, that is what went into the quarter scale

model.

As far as stainless steel, the pedigree that was used, and the full scale design, we also used in the quarter scale model. So it was a very detailed test, not only of the impact limiter, but also of the cask body. And that -- those particular tests were done in the UK, at Winthrop.

Earlier casks, legal weight truck casks is NFC-LWT, for that cask we use honeycomb. Why didn't we use honeycomb for the larger one? Just from an economic standpoint we converted from honeycomb to wood, because legal weight truck cask is a much smaller cask, the internal diameter is about 13 and 3/8ths, the internal diameter of the larger casks are 67-plus inches.

For LWT we used dynamic data from the manufacturer of the material. We also had an impact limiter that was down to a quarter scale. The impact limiter skin was fabricated out of aluminum. The impact for the quarter scale, those skins were also made out of aluminum.

So we were very meticulous in using quarter scale just exactly what it would be in the full scale materials, and from the manufacturing standpoint.

1 The cask body also was at quarter scale.
2 We had poured lead, just like we did for the NSE-STC
3 quarter scale model, we poured lead for the shells,
4 for the gamma shielding, so it was an exact replica.
5 In fact, at one time, we thought about
6 selling the NSE-STC as an actual cask, because we had
7 all the pedigree to it.
8 The NLI-1/2 is a cask that we purchased.
9 The reason I mention it is that it uses a balsa impact
10 limiter. Those casks are still in service. We didn't
11 do any of the testing for those.
12 I mentioned the Californium, that was a
13 specialty cask developed for Californium. In the
14 micro gram the level of Californium is a very
15 fissionable, very highly radioactive material. Most
16 of the cask volume is comprised of NS-4, that is our
17 neutron shielding material.
18 During the review process one of the
19 reviewers said, what can you tell us about the
20 integrity of your NS-4? So we immediately said, well,
21 that means go out and do some drop tests.
22 So we went out and did material testing of
23 the NS-4. A cask is not shown here, but we have done
24 analysis for recertification, was the Paducah overpack
25 for transporting UF-6 to and from Paducah.

1 We had the data, this data is rather old,
2 but we went back and modeled it, and we got excellent
3 agreement.
4 Next slide. With material testing,
5 material testing is the basis of your analysis. And
6 it obviously uses samples and would determine stress-
7 strain curve. Now, we realize that some of the data,
8 perhaps, that was out in the literature for stress-
9 strain data for the wood, maybe there was some gaps in
10 it.
11 So we contracted with Naval Surface
12 Warfare Center to perform a whole array of tests. And
13 more importantly about these tests is they include the
14 strain weights of, rather low strain weights quasi-
15 static, we did static as well, strain weights all the
16 way up to 375 strains per second.
17 Now, that is a bizarre high strain, but we
18 wanted to see what happened to the stress-strain data
19 as we really approached astronomical strain rates to
20 kind of review the fact that what if somebody wants to
21 do an 80 mile an hour, a 100 mile an hour test, or do
22 something other that was not quite in the regulations
23 at that time.
24 We also had testing that covered all the
25 way from minus 40, based on the regulations, to 200

degrees. That is our normal operational condition. Because wood is orthotopic, just like honeycomb, we performed a whole array of tests, in both directions, to ascertain the weak direction, as well as the strong direction.

Then, of course, with any natural material you want to observe the variability of the properties. Whatever criteria that we used in performing these specimen tests, it is the same criteria that we used to build the quarter scale limiter, it is the same criteria that we are using to build the full-scale limiters for the redwood impact limiters over in France at this time.

So the materials we've tested, that we have been involved with, is redwood, balsa, honeycomb, and NS-4 and some foam.

Next slide, please. The importance of this testing, it helps us define the extent of variabilities associated with the materials, such as the moisture, such as density.

But once we've ascertained what the variability, and we've clamped down on, we will only accept this type of material, then we get rid of the effect, basically, we fact out the effect of the variability of material we see in the natural

1 materials.

2 And here, again, as I point out, the
3 reason for the importance of this, if you want to
4 produce accurate results, in your tests, as far as
5 predictions are concerned, then you need to start with
6 your material testing.

7 This is not only with the maximum
8 acceleration, it would also, how well does your
9 acceleration time history compare to that of the
10 acceleration time history of the actual test itself.

11 Next slide, please. So in analysis, what
12 kind of things are we looking for? Well, obviously we
13 are going to qualify against a code. But we specify,
14 in the beginning of the design an acceleration basis
15 based upon our experience, 15 year plus worth of
16 designing transportation casks.

17 And we do that to allow the analysis to be
18 decoupled so that we can proceed in parallel paths.
19 One group will go off and perform stress analysis of
20 the basket and the cask body, the other group will go
21 off and design the actual impact limiter to be tested.

22 When we do these analyses we make sure
23 that we implode the temperature conditions, both hot
24 and cold, and then in addition to that, to take into
25 account any kind of manufacturing variation, we push

1 the cold properties ten percent higher crush strength,
2 and we take the hot properties, and lower them by 10
3 percent, to make sure that whatever is covered, as far
4 as manufacturing is concerned, that those, indeed, are
5 covered.
6 The other thing we do in the analysis, we
7 obviously look at the different drop orientations, the
8 end drop, the corner drop, the side drop. And then,
9 in some cases, we will even look at the slap-down.
10 Slap-down is a pretty interesting topic,
11 a lot of -- a great deal of studies have been poured
12 into the slap-down shallow angle. When it comes to
13 large casks, which have very small type ratios, length
14 versus radius of gyration, you don't really have a
15 slap-down effect.
16 And we did a series of analyses to come to
17 that conclusion, as well as we used some drop tests to
18 reach that conclusion. Now, with respect to the scale
19 model, the full scale design, we obviously do it to
20 envelope, the worse case conditions, in terms of crush
21 depths of the impact limiter, as well as the
22 accelerations to the cask body, and the basket will
23 see.
24 When it comes to the scale model we are in
25 a different track. At this point we are interested in

1 how close can we come to the prediction for the actual
2 drop test. In that case we want to use the best
3 properties we have.
4 When we specify a temperature, for these
5 we specify approximately 70 degrees for the
6 temperature of these analyses. When we go do the drop
7 test, and just as Doug pointed out, we showed up in
8 the winter to do a 70 degree drop, you obviously have
9 to heat the limiter up.
10 We showed up again, in the summer, to do
11 a 70 degree drop, and out at Sandia it gets rather
12 warm in the canyon, there, so we had to cool the
13 limiter. So we are very careful of making sure that
14 what we analyze is what we are going to drop test.
15 Next slide, please. We use the
16 commercially available LS-DYNA code, it is a five
17 element code, but that is where the similarities
18 between that and other codes like NSSS and COSMOS,
19 that is where the similarities end.
20 It is an explicit code, it accommodates
21 large strain, it accommodates finite rotations, finite
22 displacements. Not all codes can do that very well.
23 And it is a code that was born out of the DYNA code
24 out of Lawrence Livermore, that was described this
25 morning.

1 This is a rather detailed model, starting
2 here, the impact limiters are modeled explicitly, the
3 shells in the impact limiter are modeled explicitly.
4 Different portions of the wood, which is balsa, those
5 strain rate sensitive properties, we use strain rate
6 sensitive properties, we used a modified foam.
7 It is called modified because the standard
8 foam model in DYNA does not accommodate strain rate
9 sensitive properties. We accommodate strain rate
10 sensitive properties in the analysis.
11 When you get down to the details of
12 trunnion, we model the trunnion just as it actually
13 occurs in the design. If you notice the elements
14 don't match up here, the elements don't match up here.
15 When it comes down to attaching the
16 trunnion to the actual cask body, there is some really
17 -- material code features allow you to more or less
18 weld these two pieces together. Because this region
19 is a fairly rigid region.
20 And so far as the impact limiter what we
21 do is we specify an interface with it, compression
22 only. So it is allowed to slide. We actually model
23 the bolts themselves, so that we can see if the bolt
24 is going to maintain their integrity during the
25 impact.

1 And as far as the cask body is concerned,
2 while our full scale design, or quarter scale design
3 too, as far as that goes, would have a steel lead,
4 steel design, what you see are just two elements.
5 Now, we are very careful to match the
6 frequency content of the full scale steel edged steel,
7 with this here, and we confirm that, but then extract
8 the modes. Now, when you do the perfectional modes it
9 is obvious went into your model, and we go to an ANSIS
10 code like that, which does a very good job of
11 extracting the modes.
12 Some important issues about the scale
13 modeling I would like to bring up. Whatever material
14 requirements we have for full scale, we employ that
15 for the quarter scale, as well.
16 However the material is oriented in the
17 full scale design, the same criteria, the same
18 orientation material is used in the quarter scale
19 design. As far as simulated components, the impact
20 limiter, the bolts, whatever we use in the full scale,
21 we make sure that the net threat area is either equal
22 to, or less than, so it is conservative.
23 Whatever materials are specified for the
24 impact limiter attachment bolts, that are made of
25 highly ductile stainless steel, we make sure the same

1 material is used in those bolts.

2 Whatever acceptance criteria, in terms of

3 moisture, and density, crush strength, pressure

4 strength, whatever is used in the full scale, we make

5 sure that is used in the quarter scale as well.

6 So at this point scale model, then, can

7 give us data that allows us to compare to our

8 predictions how much the impact limiter crush, what

9 were the maximum accelerations experienced by the cask

10 body.

11 Now, the code we are using, this is a

12 confirmatory test, it is important not only to get the

13 numbers, it is also important to understand what is

14 happening in physical phenomena.

15 And what we found was that no matter how

16 rigid is, the cask body is basically still an elastic

17 body, and you can -- how much weight you can put into

18 your body, next slide please, you are going to get

19 some oscillatory behavior.

20 Now, we have a great deal of test data, so

21 I just brought a typical curve. The little curve here

22 is the drop test data, and this is the LS-DYNA curve.

23 You notice those are rather smooth curve.

24 Now, that will give you a clue, real

25 quick, that we are filtering this data. And you say,

1 what is your criteria? Because there was some
2 discussion about that this morning. And that is a
3 very important criteria.
4 One of the features that you can do in
5 post-processing, with electronic data, is you can
6 perform an FFT. BaSically what you are doing there is
7 looking at acceleration versus the frequency content.
8 And for every test that we do we examine
9 that FFT to make sure that it is a good test.
10 Accelerometers, there is a great deal of technology in
11 accelerometers. If you notice we shopped around at
12 the different national labs. That is only half the
13 story. We didn't tell you which ones we did look at,
14 and didn't go to.
15 And so accelerometer technology is not a
16 trivial matter. And even when you get the data you
17 still must carefully examine it. And the FFT is a
18 good way of saying what should the filter frequency
19 should I use?
20 And one of the questions that the reviewer
21 is always going to ask you, please justify your cutoff
22 frequency. Because I know when you make it lower, it
23 goes away. And there is a reason for that. When you
24 make that filter frequency too low, you are actually
25 cutting out exciting modes in your cask, when you do

1 that, you are actually going to reduce your
2 acceleration.
3 So we approach it both ways. Before we go
4 out and do the test, we've actually submitted these
5 results to the NRC, because they were curious how,
6 they didn't want us to change the results after we did
7 the test, so we presented to them the results, before
8 we actually went out and did the test.
9 And so we did a careful examination of our
10 mode extraction to make sure that what we are going to
11 see in the FFT, are we going to see our mode of
12 extraction, we got excellent agreement.
13 So not only is the -- did we look at the
14 maximum acceleration, we also look at the overall
15 frequency content, as well as the time duration. The
16 thing to keep in mind is, we are looking at,
17 approximately, 180 Gs here, which is 45 in the full
18 scale design.
19 Actual acceleration used, and the stress
20 evaluation is for 60 Gs. So there is another 30
21 percent of conservatism before we do anything else.
22 Next slide, please. So one of the reasons
23 why we conclude that the design is safe is that we
24 feel that there is inherent conservatisms and margin
25 in our design.

1 One thing to keep in mind is, drop testing
2 uses a rigid surface. Now, you could technically say
3 nothing is rigid in this world, but the amount of
4 elastic energy stored in that pad, there is not enough
5 significant digits to compare to the amount of energy
6 being absorbed in the impact limiter.
7 We've done a whole series of analyses.
8 When WTC happened last year one of the first things
9 our engineering department did was, let's go analyze
10 a fully loaded 747 crashing into one of the vertical
11 concrete casks.
12 And we presented those results to the NRC
13 staff last year, and concluded that we would not have
14 a breach of containment.
15 Some other kind of conservatisms when we
16 do our analyses, we try to concentrate the load in our
17 simplified stress analysis. Now, I say simplified
18 stress analysis, but in reality these are very complex
19 models, with a number of interfaces. So they are not
20 as simple as you would think.
21 One thing that we noticed, in our force
22 deflection curves, which are easy to compute, you take
23 the mass times the gravity, acceleration of force, you
24 double integrate the acceleration, you get the
25 displacement, you plot, and you get a force deflection

1 curve.

2 We noticed that we got extra capacity in

3 our displacement. So if we would just take the curve

4 lower, the force over, and you look at the end of the

5 curve, we have 20 to 30 percent more, as a minimum

6 margin, in much of our designs on impact limiter.

7 So we could take quite a bit more surface

8 from energy reporting if we run into a problem. As

9 far as the stress analyses of the system, if I could

10 point out, the accelerations that we were seeing in

11 the drop test are significantly lower than what we

12 used in the actual design in stress calculations.

13 The other thing to keep in mind is the

14 analysis used the ASME code, and we elected to use the

15 elastic evaluation in the ASME Code. They do have an

16 appendix that allows you to use elastic behavior. But

17 you just get less questions if you just go with the

18 elastic analysis.

19 The important thing that you have to

20 realize, when you do an elastic analysis with

21 stainless steel, you completely neglect the ductility

22 of the stainless steel. This is a massive, massive

23 conservatism.

24 So the acceptance criteria was very

25 conservative. The other thing, too, is that if you

1 notice on that previous curve, there were some
2 oscillations in that acceleration. Now, we didn't
3 filter those out.
4 And yet when we do our analysis, we take
5 into account another DYNA factor, so in some ways we
6 actually double count in the acceleration. Slide,
7 please.
8 Continuing on with the inherent
9 conservatisms. In the early '90s we were developing
10 our NAC-STC cask. And that was, as pointed out, that
11 was a quarter scale model. The basket was quarter
12 scale, the shells were quarter scale, the bolts were
13 quarter scale, the pedigree of the materials used
14 everywhere.
15 We ran into a little problem with our
16 impact limiter because we had done static tests, we
17 were using aluminum shells in order to try to conserve
18 some weight. And when we did the side drop, the
19 aluminum didn't quite keep the correct orientation, so
20 the impact limiters didn't quite work.
21 As a result the cask body impacted upon
22 this massive steel block in two locations, producing,
23 on the quarter scale model, 1,200 Gs, which is 300 Gs
24 full scale, which is over five and a half times what
25 our design G load.