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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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NRC STAFF MEETING

WITH STATE OF NEVADA

AGENCY FOR NUCLEAR PROJECTS

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THURSDAY,

MAY 8, 2003

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ROCKVILLE, MARYLAND

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The meeting was held in the Commissioner's
Conference Room of NRC Headquarters, One White Flint
North, Rockville, Maryland, at 9:00 a.m., Mr. Wayne
Hodges presiding.

PRESENT:

HAROLD ADKINS, PNNL

CHRISTOPHER S. BAJWA, SFPO

MERRITT BIRKY, State of Nevada Agency for

Nuclear Projects

DARRELL DUNN, CNWRA

ANDRE GARABEDIAN, CNWRA

ROBERT J. HALSTEAD, State of Nevada Agency for

Nuclear Projects

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M. WAYNE HODGES, Director of Technical Review, SFPO
KEVIN McGRATTAN, NIST
RICHARD C. MOORE, State of Nevada Agency for
Nuclear Projects
MARVIN RESNIKOFF

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

(9:01 a.m.)

1
2
3 MR. BAJWA: All right, I think it's time
4 that we get started. Bob, do you have everyone here?

5 MR. HALSTEAD: Yes.

6 MR. BAJWA: Okay.

7 MR. HALSTEAD: Jamie's not going to join
8 us, right? Yes, we are all here and all of us now in
9 One White Flint as opposed to Two White Flint. We were
10 convening earlier.

11 MR. BAJWA: All right, well, let's get
12 started. First of all, I'd like to welcome everyone
13 that has come to this meeting, Bob, yourself and
14 representatives from the State of Nevada and
15 consultants as well, members of the public. The
16 purpose of this meeting is to attempt to clearly
17 explain the approach and conduct of the analysis that
18 the NRC undertook in its investigation of the
19 Baltimore Tunnel Fire Event and the impact this event
20 could have had on a selected spent fuel transportation
21 cask.

22 Bob, obviously, you and I have had several
23 discussions on what we want to get out of this meeting
24 and I think we are agreed as to what we want to get
25 out of this meeting. So we're going to try our best

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1 to make sure that you all receive what you would like
2 in the way of getting your questions answered.

3 The first thing I'd like to do is to do
4 some introductions. We'll go around the table and do
5 those and then I'll have a few things to say about
6 ground rules for this meeting. We'll go quickly
7 through the agenda and then there are a few other
8 issues that I'll need to mention before we get to the
9 presentations. So, we'll start with Wayne.

10 MR. HODGES: I'm Wayne Hodges. I'm the
11 Deputy Director for Technical Review in the Spent Fuel
12 Project Office.

13 MR. BAJWA: I'm Chris Bajwa. I am a
14 Thermal Reviewer in the Spent Fuel Project Office.

15 DR. McGRATTAN: My name is Kevin
16 McGrattan. I work with the National Institute for
17 Standards and Technology.

18 MR. ADKINS: My name is Harold Adkins and
19 I work for PNNL, Thermal Analyst.

20 MR. GARABEDIAN: My name is Andre
21 Garabedian. I'm a Fire Protection Engineer at
22 Southwest Research Institute.

23 MR. DUNN: Darrell Dunn, Center for
24 Nuclear Waste, Regulatory Analysis.

25 MR. HALL: Jim Hall. I'm a Consultant

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1 with the State of Nevada.

2 MR. RESNIKOFF: Marvin Resnikoff for the
3 State of Nevada.

4 MR. HALSTEAD: Bob Halstead, I'm a
5 Transportation Advisor for the State of Nevada's
6 Agency for Nuclear Projects.

7 MR. MOORE: Rick Moore, Pronghorn (ph)
8 Engineering, Consultant for Nevada.

9 MR. BIRKY: Merritt Birky, Consultant for
10 the State of Nevada.

11 MR. BAJWA: All right, as you know, this
12 meeting is being transcribed, so when you do make a
13 statement, please make sure you're speaking clearly
14 into the microphone and that way we make sure that
15 exactly what you say gets taken down. Just some
16 ground rules for the meeting; each of the speakers
17 that we have presenting today have prepared
18 presentations on their role in our analysis effort and
19 they've provided a great deal of detail in the slides
20 that you have in front of you.

21 What I'll ask is that if you have
22 questions during a presentation, if they're of a
23 clarification nature, go ahead and ask them.
24 Otherwise I would ask that you would hold more
25 detailed questions till the end of the presentation.

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1 Each presentation will be followed by a question and
2 answer time, so you'll have time to ask the questions.
3 What we'll do to make sure that we can facilitate that
4 is one of the practices we have in our public
5 meetings, if you have a question that you would like
6 to ask at the end of the presentation, just take your
7 name tent and do that. Okay?

8 I know it's only a few of us here but that
9 way we can make sure that we get to everyone's
10 question at the end of each presentation. The members
11 of the public that have attended today will have a
12 chance to provide comments or questions at the end of
13 the meeting and to be sure that all the questions from
14 the public are heard and answered, the staff who is
15 presenting today is prepared to stay over the allotted
16 time that we have for the meeting to answer questions,
17 if necessary. To this end, we would ask that the
18 questions following the presentations come only from
19 the participants seated at the table, and then if the
20 public has questions on individual presentations, they
21 hold those until we're done with the meeting.

22 All right, what I'd like to do is just
23 quickly run through the agenda. First of all, we'll
24 have Wayne give some opening remarks and then I will
25 give an overview of the NRC analysis effort, what each

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1 felt and then we'll have any questions on the general
2 overview. Dr. Kevin McGrattan from NIST will talk
3 about the Howard Street Tunnel Fire Simulations and
4 we'll have questions after that. Andre Garabedian and
5 Darrell Dunn will talk about the Analysis of Rail Car
6 Components Exposed to a Tunnel Fire Environment and
7 again we'll have questions.

8 Depending on time, if we feel we need a
9 break and have time to take one, we will do that. I
10 have a feeling we probably will need to take a break
11 at some point. Then following the break, we'll have
12 Harold Adkins from PNNL talk about the Baltimore
13 Tunnel Evaluation. That was a cask analysis that they
14 did for us and we'll have questions on that. And then
15 finally, we'll have any discussion and comments or
16 questions from the public. And then that will
17 conclude the meeting with some closing remarks. So
18 that is the agenda.

19 What we're going to also have is a parking
20 lot and the parking lot is to serve for any issues
21 that are not directly related to what we're trying to
22 discuss here or that may involve a very lengthy
23 discussion. We'll put those issues in the parking lot
24 for further consideration, if time allows, and in
25 order for the staff to have a record of those other

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1 issues that have been raised during this meeting.

2 One of the issues that has been mentioned
3 is the Package Performance Study. And obviously there
4 is somewhat of a link between what we did in the
5 Baltimore Tunnel Fire Analysis and certain
6 considerations for the package performance study but
7 we're not here to directly discuss the package
8 performance study.

9 Like I said, this meeting will be
10 transcribed, so I would ask to that end if when you
11 speak the first time, you just give your name and
12 affiliation and that way we'll make sure that we get
13 that on the record. In addition, for continuity of
14 the transcript, it is preferred that if you can hold
15 your questions till the end, you do that and that way
16 you won't lose that stream of consciousness, so to
17 speak, in the transcript when you go back to review
18 it.

19 Finally, we do have, for the members of
20 the public and for the participants in the meeting,
21 public meeting, feedback forms. They are over there
22 on the table. You probably got one if you -- when you
23 came in. If you didn't, please pick one up before you
24 leave. You can fill those out and leave them with us
25 or you can fill those out and send them in at a later

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1 time. These forms will give us feedback on how we
2 conducted the meeting, if you found it was useful or
3 not useful and it helps us for the future to make
4 these meetings a little bit better.

5 So what I'll do now is, I'll have Wayne
6 give some opening remarks and then we'll get on with
7 the presentations.

8 MR. HODGES: I'm Wayne Hodges with the
9 Spent Fuel Project Office. The emphasis for the
10 analysis that will be described was once the fire
11 occurred, we had a number of questions, some from the
12 Congress, saying what would happen to a spent fuel
13 transportation package in that fire. The fire was not
14 instrumented unfortunately. Therefore, we don't have
15 much data. We did follow up with the NTSB and their
16 investigation to learn as much as we could from them.

17 It became clear at one point that what we
18 needed to do if we was going to understand the time,
19 temperature, history of the fire was to try to get an
20 analysis done that -- because NTSB was not going to be
21 doing that. We -- in discussions with NTSB, we
22 selected NIST to do this analysis for us, to try to
23 give us their best estimate of what the fire
24 conditions were. They used the calibration from the
25 tunnel fire that had been used as a test in a West

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1 Virginia Tunnel to benchmark our code. And during the
2 process of doing the analysis it also dawned us that
3 it might be helpful to get some independent
4 corroboration for their calculations since there are
5 no data and that's when we asked the Center, who has
6 a number of fire experts, if they would take a look at
7 some samples from the rail cars actually involved in
8 the fire and see what we could learn from some
9 metallurgical examinations, paint examinations, as far
10 as temperatures at various points in the fire as an
11 independent corroboration of what we were seeing.

12 So it was done totally independently and
13 the reports were issued independently and we think,
14 although there's not exact agreement, there is
15 reasonable agreement between some of what the results
16 show and the calculations. So even though there were
17 no thermal couples in the fire to tell us what
18 happened, we think what we have is a reasonable
19 estimate of the fire conditions and we use that then
20 as a boundary condition for the cash when we did those
21 calculations.

22 So what we believe we've done is as
23 reasonable an estimate as you can do and an
24 independent verification as you can do given lack of
25 specific data and I think it's a very good analysis.

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1 And with that, I'll turn it over to the analysts.

2 MR. BAJWA: I'm going to go into a little
3 bit more detail about how we structured our analysis
4 approach and to do that, I'm going to move to the
5 podium.

6 MR. BIRKY: Chris, while you're doing
7 that, Merritt Birky with State of Nevada, can I ask a
8 question. I see there are video cameras. Are those
9 on or off?

10 MR. BAJWA: I believe they're off. This
11 is not being video taped.

12 Okay, in the interest of trying to keep
13 this meeting as working level as possible, I'm already
14 a little bit warm, so I'm going to remove my jacket.
15 Anyone else at the table, feel free to do that. Wayne
16 has already given a pretty good summary of what our
17 actions were related to the Baltimore Tunnel Fire
18 Event. We were asked by the Commission to look at
19 this event and conduct an investigation of it and come
20 up with a reasonable answer as to how this event might
21 effect a spent fuel transportation cask.

22 Obviously, this is a major concern. The
23 Baltimore Tunnel Fire Event was a severe fire event
24 and it's something that we felt we had a
25 responsibility to look at. The first step to this

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1 approach was to gather factual information, as much as
2 we could, as much as was available from the National
3 Transportation Safety Board. We did meet with them
4 several times to discuss details of the accident and
5 their investigation, I believe, is -- has been wrapped
6 up but they are still in the process of putting
7 together all the factual reports and then putting out
8 the final report on the accident.

9 The other -- the next step in the analysis
10 was to model the fire that occurred in the Howard
11 Street Tunnel. We didn't have a lot of good data,
12 obviously, as Wayne mentioned, on the accident fires,
13 so we decided that modeling it would be a good
14 approach to characterizing what it might have been
15 like. We wanted to verify that fire model with some
16 of the physical evidence that was available from the
17 tunnel and the final step was to analyze the spent
18 fuel cask response to the fire that we modeled.

19 The fire model was done by NIST using the
20 fire dynamic simulator, which is their fire simulation
21 code. Dr. Kevin McGrattan will talk about in more
22 detail what they did to put that model together. The
23 physical evidence from the tunnel was examined and
24 analyzed by the Center for Nuclear Waste Regulatory
25 Analysis and Andre Garabedian and Darrell Dunn will

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1 talk about the work that was done there on looking at
2 the materials that actually came out of the tunnel.
3 The thermal analysis model that was put together for
4 an actual spent fuel transportation cask was done by
5 PNNL, Pacific Northwest National Labs, and Harold
6 Adkins will talk about the analysis model that he put
7 together for that investigation.

8 Some of the conclusions probably you
9 already know because there have been several
10 presentations in the past about this particular
11 analysis and some of the work that we've done in it.
12 We believe that the analyses that were completed
13 included conservative and bounding assumptions and we
14 will obviously, talk about those in the presentations
15 today. Our conclusion on the work -- from the work
16 that we've done to this point is that exposure of this
17 particular transportation task to the Baltimore Tunnel
18 Fire or a similar fire would not result in a
19 radioactive release to the environment. That was our
20 conclusion.

21 One of the things that came out of this
22 analysis was the robust nature of these types of spent
23 fuel casks. And now we'll have Kevin McGrattan speak
24 and as he's coming up, I'll introduce him. Yes, I'm
25 sorry, I'll take any questions you have now and then

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1 we'll bring Kevin up.

2 MR. BIRKY: Merritt Birky, I have a --
3 sort of a basic question that perhaps you can answer
4 either now or as we progress during the meeting. And
5 my question is related to the regulation that
6 specifies the temperature and duration, the I think
7 850 C, 30 minutes. And the question is, what is the
8 rationale for selecting those parameters as a
9 regulatory performance of a cask?

10 MR. HODGES: I think that's an issue
11 separate from what we're here to discuss. That's
12 something we can put in the parking lot and if there's
13 time at the end, we'll be happy to discuss that, but
14 the meeting today is to discuss the analysis for the
15 Baltimore Tunnel Fire and those results.

16 MR. BIRKY: Okay, I accept that. My only
17 concern is that everything is benchmarked to that and
18 I just want to put that on the record. And I
19 understand that.

20 MR. HODGES: This fire was not benchmarked
21 to that. The analysis -- this analysis was done
22 independent of that. We're here today to talk about
23 the Baltimore Tunnel Fire and the analysis and results
24 for that. To the extent we have time at the end, I'll
25 be happy to talk to you about the regulatory limits

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1 and how they were arrived at, but that's independent
2 from today's presentation.

3 MR. BAJWA: Yes.

4 MR. MOORE: Rick Moore. Chris, is anyone
5 going to talk about reconstruction of the events that
6 led to the accident or is it best to ask you those?

7 MR. BAJWA: Probably. Yeah, we didn't
8 have a specific presentation on reconstruction of
9 events. That is strictly an NTSB function. What they
10 did determine from the investigation that they did was
11 that the derailment preceded the fire. The derailment
12 that occurred in the Howard Street Tunnel happened.
13 It was 11 out of the 60 cars that were going through
14 the tunnel at the time that derailed and the fire
15 started some time after the derailment. So do you
16 have a specific question about --

17 MR. MOORE: Yes, is there any information
18 on the operating speed of the train at the time of
19 derailment?

20 MR. BAJWA: There is. I believe it was in
21 the neighborhood of 30 miles per hour but I do not
22 know that for sure. I can make sure I get the right
23 number for you.

24 MR. MOORE: And is there a speed limit on
25 the tunnel?

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1 MR. BAJWA: That I don't know for sure but
2 I will find that out for you.

3 MR. MOORE: The reason I'm asking those
4 questions is because of the assumption that the cask
5 would be a certain distance from the fire and
6 depending upon the speed of the train and the nature
7 of the derailment, you could have the accordion effect
8 of cars stacking up against each other and ending up
9 with the cask a lot closer to the fire even given that
10 there was a buffer car.

11 MR. BAJWA: Yeah.

12 MR. MOORE: So that's what I'm trying to
13 get to, whether there's answers by panel members
14 today.

15 MR. BAJWA: For this particular tunnel,
16 it's a single rail tunnel and the geometry actually
17 will be discussed a little bit later. The actual
18 geometry of the tunnel, for this particular tunnel,
19 would prevent that stacking up or accordioning, you
20 know, accordion effect of cars. You really -- you
21 also see on one of the hand-outs the derailment sketch
22 that shows the configuration of the cars after the
23 derailment. So they didn't move a whole lot.

24 MR. MOORE: Right, I recognize that, but
25 the analysis is tending to conclude the performance of

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1 the cask under fire conditions, and I think we have to
2 recognize that there are double-track tunnels in other
3 parts of the country, so it doesn't preclude the
4 stacking up of cars.

5 MR. BAJWA: In other situations.

6 MR. MOORE: Correct.

7 MR. HALSTEAD: Yes, I want to clarify one
8 of the purposes of the meeting for us. Bob Halstead
9 for the transcriber. In addition to discussing the
10 analysis of what actually occurred in the tunnel,
11 we're very concerned about what we believe are
12 unjustifiably sweeping generalizations about the
13 adequacy of the regulations for a range of fires, a
14 range of casks that might be involved in rail fires.
15 I think I'm going to save those comments for the end,
16 but Rick's point about the assumptions about train
17 dynamics is a good example that there are issues both
18 of what happened in the Baltimore fire and what
19 assumptions we can make about the way the Baltimore
20 fire is or is not the maximum reasonably foreseeable
21 accident that we're concerned about for risk
22 assessment purposes. So I just wanted to clarify that
23 in the beginning.

24 MR. BAJWA: Okay, I'd like to bring up
25 Kevin.

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1 DR. McGRATTAN: Okay, good morning.

2 MR. BAJWA: Before Kevin begins, Dr. Kevin
3 McGrattan is a mathematician at the Building and Fire
4 Research Laboratory at NIST, Standards and Technology.
5 He is a specialist in fire modeling, computational
6 fluid dynamics and was recently awarded an honorary
7 membership in the Society of Fire Protection
8 Engineers.

9 DR. McGRATTAN: Thanks, Chris. One of the
10 core missions of my laboratory is to develop fire
11 models and these fire models are used by fire
12 protection engineers for a number of purposes. And in
13 this first slide, you can see just a snapshot of a few
14 of the projects that we've worked on over the years to
15 give you a sense of what fire modeling is all about.
16 We look at everything from the basics of fire
17 dynamics, single fire in a plume that you see on the
18 left, all the way up to very complicated situations
19 where you have, for example, commodities of various
20 types stored in a warehouse. We've looked at oil
21 fires on large tanks, and we've looked at special
22 things like for example, in the upper right-hand
23 corner this project was done for the Library of
24 Congress and they were retrofitting their sprinkler
25 system and they wanted to know where the best location

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1 for their sprinklers should be. So this just gives
2 you an idea of the type of work that we do with fire
3 models.

4 Now, a little bit of specifics about the
5 fire dynamics simulator in particular. This is a
6 computational fluid dynamics model that has been under
7 development for the last 20 years at NIST and in the
8 last four years we have released this model into the
9 public domain. So this model is now widely used by
10 fire protection engineers both in the U.S. and around
11 the world. Now, with all of the projects we work on,
12 we like to make sure that the model works. I mean,
13 theoretically, we're simply solving the conservation
14 equations of mass momentum and energy but, of course,
15 we make assumptions and approximations when we solve
16 these equations with the computer. So we need to
17 validate that these assumptions that we're making are
18 appropriate for the given situation.

19 So we're constantly running the model
20 against experiments in which measurements have been
21 taken. This is just an example of a recent set of --
22 a recent validation exercise that we're doing for our
23 World Trade Center investigation. What you have is
24 just a box that's roughly 12 feet high, 20 feet long
25 and 12 feet wide with some holes at either end and a

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1 large fire in the middle, okay, and a vast number of
2 measurements were made not only of the temperatures,
3 but heat fluxes to the various objects in the room,
4 most important of which are the truss hanging from the
5 ceiling.

6 You can see in the lower right-hand
7 corner, the comparison of the numerical model with the
8 experiment and in this case, we get very good
9 agreement because we know exactly what the fire source
10 is. We know exactly what the geometry of the room is.
11 We know exactly what the fire size is. So we verify
12 here that the model works, that our equations are
13 valid, et cetera.

14 MR. RESNIKOFF: Chris, excuse me, could I
15 just ask you one question of a --

16 DR. McGRATTAN: Sure.

17 MR. RESNIKOFF: -- I don't know,
18 informative nature? Do they actually run a fire test
19 before they built the World Trade Center? Did they
20 actually run a model?

21 DR. McGRATTAN: Before they built the
22 World Trade Center?

23 MR. RESNIKOFF: Exactly.

24 DR. McGRATTAN: I can't say. I don't
25 recall.

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1 Okay, now, when we took on the project
2 that Chris described this morning, of predicting what
3 temperatures were like in the Baltimore Tunnel
4 accident, the first thing we did was we wanted to
5 validate our model with the best set of data available
6 involving a tunnel fire. And this data was collected
7 in the mid-1990's in a decommissioned highway tunnel
8 in West Virginia. This study was sponsored by the
9 State of Massachusetts because in preparation for the
10 Big Dig in Boston, they wanted to see what their
11 ventilation systems in their tunnels were going to --
12 how they were going to perform in the event of a fire.

13 So we took this opportunity to use the
14 data collected in some experiments to validate our
15 fire model for use in the Howard Street accident. The
16 tunnel in West Virginia known as the Memorial Tunnel,
17 is very similar in cross section to the Howard Street
18 Tunnel. And the two tests that we were most
19 interested in were tests with no ventilation present.
20 One test was a 20 megawatt fire and one test was a 50
21 megawatt fire. And for those of you aren't ready to
22 think about fire energy output, a 50 megawatt fire
23 would be roughly comparable to a house fire.

24 Okay, when we compared our calculations
25 against the experimental measurements, we got very

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1 good agreement. We were within 50 degrees Celsius of
2 the peak temperatures on both cases, both the 20 and
3 the 50 megawatt case. In the case of the 50 megawatt
4 case, which is a more appropriate situation in
5 comparing with the Howard Street Tunnel, the peak
6 temperatures that they recorded were 800 degrees C or
7 1500 degrees Fahrenheit.

8 Okay, so once we had confirmed that our
9 model was working well for the West Virginia Tunnel
10 experiments, we then took our model and we applied it
11 to the Howard Street Tunnel fire and like I said, the
12 tunnels are similar in cross-sectional area. However,
13 the Howard Street Tunnel is longer but less sloped.
14 The West Virginia Tunnel had a two and a half percent
15 grade. Howard Street Tunnel had about a .8 percent
16 grade.

17 I think you have a handout which shows the
18 basic layout of the train derailment. This
19 information was provided to us by the NTSB and we used
20 as much as we could of the information that they
21 provided about the accident in setting up our
22 numerical calculations, including the position of the
23 rail cars relative to the side walls of the tunnel.
24 Shown here is just a snapshot of one of the
25 calculations in which we're assuming a certain pool

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1 size, that is, we're assuming that the liquid spilled
2 from the tripropylene car formed a pool of a given
3 size, burned, and what you see here in orange would
4 represent the flaming region and that's all I'm
5 showing at the moment, just the flaming region and the
6 red and green objects would represent the rail cars
7 within the pool. Now, it's important in a study like
8 this to vary as many of the parameters as you can
9 because we simply did not know how big the pool size
10 was. We knew how big the hole in the tank car was,
11 okay, and we could estimate based on the hole size how
12 quickly the fuel was spilling out. However, because
13 the floor of the tunnel was filled with track,
14 ballast, several drains, and the tunnel was sloped,
15 it's hard to know precisely how big the fire bed or
16 the fuel bed was.

17 So we ran dozens of calculations in which
18 we varied the size of the fuel bed, the location of
19 the fire, the properties of the walls, and to some
20 extent the ventilation into the tunnel. What you see
21 here are just a few snapshots of results and keep in
22 mind that this is just one set of results. We ran
23 dozens of calculations and the temperatures that we
24 ultimately reported to the NRC represented the highest
25 temperatures that were achieved in the various

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1 calculations.

2 So the top two slices, these are slices
3 through the middle of the tunnel from the ceiling to
4 the floor. The fire is obviously where you see the
5 high temperatures. And in this case, what we noticed
6 time after time in these calculations that in the
7 beginning of the calculations, say the first five or
8 10 minutes, when the tunnel has enough oxygen to
9 sustain a robust fire, we see the highest temperatures
10 early on. So these -- the peak temperatures of 1800
11 degrees Fahrenheit or 1,000 degrees Centigrade, are
12 achieved early on in these calculations and over time,
13 what happens is the tunnel becomes oxygen limited.

14 So what happens is because the fresh air
15 to feed the fire has to come from the ends of the
16 tunnel, the tunnel becomes filled with hot gases and
17 exhaust products from the fire, so what eventually
18 starts happening is the fire starts to be fed by not
19 fresh air, but air and exhaust products mixed
20 together. Okay, that tends to weaken the fire. It
21 doesn't put the fire out, obviously, but the highest
22 temperatures are no longer achieved after the first
23 five or 10 minutes.

24 You can also see from the lower picture if
25 you look at the oxygen concentration, down the middle

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1 of the tunnel, okay, early on the red color in these
2 pictures represents ambient oxygen, 21 percent oxygen
3 concentration, and over time you can see how the
4 oxygen concentration has been reduced to on the order
5 of 14 or 15 percent and this is the type of
6 concentration where fires begin to get under-
7 ventilated.

8 MR. BIRKY: For clarification on your
9 graph --

10 DR. McGRATTAN: Yes.

11 MR. BIRKY: -- a clarification on this
12 graph you have shown here, I assume time is going down
13 this plot?

14 DR. McGRATTAN: Right. For each pair of
15 snapshots, the first image is from five minutes after
16 ignition, the second is from 30 minutes after
17 ignition. So, you're right, it's five minutes, 30
18 minutes, then five minutes, 30 minutes, five minutes.

19 MR. BIRKY: This is five minutes up here?

20 DR. McGRATTAN: Five minutes.

21 MR. BIRKY: And this is 30 down here?

22 DR. McGRATTAN: No, I'm sorry. The first
23 two are temperature.

24 MR. BIRKY: Yes.

25 DR. McGRATTAN: Okay, so the first one is

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1 temperature after five minutes. The second one is
2 temperature after 30 minutes. Then going down, the
3 third one would be oxygen after five minutes and then
4 the fourth one is oxygen after 30 minutes. And the
5 range of values for the colors are shown by the bars
6 on the left and the right.

7 So the oxygen concentrations are shown on
8 the left and the temperatures on the right.

9 MR. BIRKY: I'm sorry, I'm confused. Do
10 you have a pointer you could point to when you say
11 this is --

12 DR. McGRATTAN: Okay, this is the
13 temperature after five minutes. This is the
14 temperature after 30 minutes. This is the oxygen
15 concentration after five minutes. This is the oxygen
16 concentration after 30 minutes.

17 MR. BIRKY: I gotcha.

18 DR. McGRATTAN: These two bars tell you
19 what the temperatures are for these two plots. This
20 bar here gives you the oxygen concentration for these
21 two plots. Sorry, it's a little busy but I tried to
22 pack it all onto one slide.

23 Keep in mind, when we run these
24 calculations, we generate hundreds of pictures like
25 this and this is just a representative sample.

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1 MR. HALSTEAD: And just another
2 clarification; this is based on -- this is benchmarked
3 from the two 15-minutes fires that were done in
4 1995/1996 in Massachusetts?

5 DR. McGRATTAN: Right, the same code was
6 used for these calculations as was done for the bench
7 marking exercise.

8 MR. HALSTEAD: And has anybody -- have you
9 or anyone else run any fires longer than those 15-
10 minute fires for benchmarking purposes?

11 DR. McGRATTAN: Yes, for the -- I'm sorry,
12 for benchmarking purposes?

13 MR. HALSTEAD: For benchmarking purposes.

14 DR. McGRATTAN: No, we don't have any --
15 we don't have any data longer than 15 minutes.

16 MR. HALSTEAD: Okay, well, that's an
17 important point for us to establish here that, in
18 fact, -- that, in fact, all of your modeling is based
19 on a somewhat limited amount of tunnel fire testing,
20 experimental testing.

21 DR. McGRATTAN: Right.

22 MR. BIRKY: May I pursue that just a
23 little bit? Does that mean the 30-minute data you
24 have in this, this particular slide, is basically an
25 extrapolation from the 20 -- 15-minute data?

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1 DR. McGRATTAN: No.

2 MR. BIRKY: No?

3 DR. McGRATTAN: We simply used the West
4 Virginia experiments to insure that our model was
5 working properly.

6 MR. BIRKY: For 15 minutes.

7 DR. McGRATTAN: Well, we could only say
8 for 15 minutes because the data was only collected for
9 15 minutes.

10 MR. BIRKY: All right, that's what I
11 wanted to establish, okay.

12 DR. McGRATTAN: But one of the things
13 about this type of model is that we're essentially
14 solving the conservation laws of mass momentum and
15 energy. So we have to make an assumption when we do
16 our modeling that we can validate for a certain period
17 of time, but we're assuming that the equations, the
18 laws of physics are appropriate for all time.

19 MR. BIRKY: But did the Howard Street
20 Tunnel have oxygen limitations in their calculations
21 as well, in the experiments?

22 DR. McGRATTAN: In the experiments, no,
23 because they tunnel was sloped more steeply than the
24 Howard Street Tunnel. What they found was they had
25 adequate circulation coming in from one side. So they

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1 had uni-directional flow coming into the tunnel
2 towards the upper end. So those fires were not oxygen
3 limited.

4 MR. HODGES: Kevin, this is Wayne Hodges,
5 just a point of clarification as follow-up to that
6 question; have you analyzed other fires that were
7 oxygen limited and compared an analysis with this
8 data?

9 DR. McGRATTAN: The experiment that I
10 showed in the beginning for our World Trade Center
11 investigation, those are oxygen limited fires. That's
12 one of the key issues with the World Trade Center
13 investigation is the oxygen limitations in the
14 building.

15 MR. HALSTEAD: While we're on these kind
16 of issues, let me throw one more in. How does FDS
17 input a fuel evaporation rate versus time, because
18 that's also important to this analysis? My
19 understanding is that you -- that the West Virginia
20 experiments, you know, you basically got to round that
21 by calculating the surface area of the pans that were
22 used but how significant is that in a case like this
23 where you're talking about liquid dripping from a
24 tanker, not knowing what happens on the floor of the
25 tunnel with the coarse media.

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1 DR. McGRATTAN: In the West Virginia case
2 we were told what the heat release rates were based on
3 the mass loss of the fuel so we essentially dialed in
4 those heat release rates in our calculations. In the
5 case of the Howard Street Tunnel fires, what we did is
6 we let the fuel evaporate based no a Clausius-Clapyron
7 type algorithm in the code. So based on the heat flux
8 to the floor, we would evaporate the fuel naturally.

9 Now, like I said, we varied the size of
10 the pool dramatically from very small to very large
11 and what we found in the end was that we could only
12 achieve about a 50 or 60 megawatt fire in that tunnel
13 which means that the fire was oxygen limited, not fuel
14 limited, so it didn't matter how much fuel we pumped
15 into it. It was only so much energy output we could
16 get based on the amount of oxygen coming into the
17 tunnel. So we -- that was the one parameter that we
18 varied the most because that's something that we were
19 most uncertain about, the nature of the fuel pool.

20 Okay, I just have one slide to finish up.
21 So in the end, we found for the dozens of calculations
22 that we performed for the Howard Street Tunnel fire
23 accident, we found peak temperatures of 1,000 degrees
24 C or 1800 degrees Fahrenheit in the flaming regions,
25 and by the flaming regions, I'm talking about

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1 essentially where you see the reds in the pictures on
2 the top and over the length of a few rail cars, the
3 temperatures were on average 500 degrees C or 900
4 degrees Fahrenheit. Peak wall temperatures we saw
5 were 800 degrees C or 1500 degrees Fahrenheit where
6 the fire was directly impinging on the walls. And
7 elsewhere, we saw temperatures of on an average 400
8 degrees C or 750 degrees Fahrenheit.

9 Now, of course, when I say we saw a
10 certain temperature here and a certain temperature
11 there, clearly from the hottest regions, the
12 temperatures would decrease gradually over distance
13 but when we averaged things out, the 500 C for the gas
14 and the 400 C for the walls were sort of the average
15 temperatures. And like I said, one of the things that
16 we spent a lot of time doing was varying the
17 parameters in these calculations to make sure that we
18 bounded the results in an appropriate way and of
19 course, for his work, Chris chose the large -- the
20 highest temperatures for the cask analysis.

21 Okay, thank you and I'll take any further
22 questions if you have any. Yeah.

23 MR. RESNIKOFF: Kevin, I have your name
24 right this time. I notice that the Center study said
25 that an air brake valve under the tripropylene car

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1 about 10 meters up wind from the fire reached a fused
2 -- an aluminum alloy -- aluminum iron alloy at 2667
3 degrees Fahrenheit. How does your study -- is your
4 study consistent with that temperature?

5 DR. McGRATTAN: We didn't see temperatures
6 that high in our study and I'm skeptical that you
7 could achieve those kinds of temperatures in a fire
8 like this. Based on my fire testing over 10 years,
9 I've never seen those high temperatures in a fire test
10 like this one.

11 MR. RESNIKOFF: Well, let me ask you one
12 other question as a follow-up. If the fire were not
13 oxygen deprived, what would be the maximum
14 temperature?

15 DR. McGRATTAN: We did some follow-up
16 calculations after this report in which we simply
17 opened up a large number of holes in the tunnel and
18 there our temperatures, instead of 1,000 degrees, we
19 bumped up the temperatures about 1100 degrees C --

20 MR. RESNIKOFF: But that's the max that --

21 DR. McGRATTAN: -- Fahrenheit and that's
22 all we saw, yeah.

23 MR. BIRKY: That's without any oxygen
24 depletion.

25 DR. McGRATTAN: Right, so that's typical

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1 free burn type conditions and that is not inconsistent
2 with many fire tests. In fact, if you'll look at the
3 standard furnace test for structural material in
4 buildings, you'll see 1100 degrees C used in the E119
5 test. So 1,000 degrees C, I think for the Baltimore
6 Tunnel case because of the oxygen limitations, 1100
7 degrees if we were to simply open up that tunnel.
8 Again, our objective in this study was to study the
9 Baltimore Tunnel and that's what we did.

10 MR. RESNIKOFF: I understand. Are you
11 talking about the flame temperature, just so we're all
12 on the same page here? The maximum flame temperature
13 is 1100 degrees C?

14 DR. McGRATTAN: This is a subtlety.
15 Maximum flame temperatures as in an adiabatic flame
16 temperature, could conceivably be much higher than
17 these numbers that I'm quoting. However, these
18 numbers are never achieved in large scale tests
19 because the flame is not stationary. So as the flame
20 moves back and forth, you can never achieve these
21 ideal flame temperatures. Plus there's a tremendous
22 amount of radiative loss when you have a very large
23 sooty fire. So those maximum theoretical flame
24 temperatures are reduced for two reasons. One is the
25 large radiative loss and the other is the fact that

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1 these are turbulent fires.

2 So the flame is rarely anchored in one
3 place but it moves about and as the flame moves about,
4 you average out over a certain volume those maximum
5 temperatures.

6 MR. RESNIKOFF: One final question on a
7 slightly different subject, did you model it just for
8 three hours or did you also look at the temperature of
9 the tunnel as the brick and the ballast reradiated the
10 heat?

11 DR. McGRATTAN: Right. We noticed in our
12 calculations and we've noticed this for many other
13 studies, that after about half an hour of simulation,
14 the gas and wall temperatures come to a steady state.
15 Now, again, subsequently after these calculations for
16 the Howard Street Tunnel, Chris and I, along with
17 Harold, did calculations in which we simulated 30
18 hours in the tunnel, seven hours burning and then the
19 rest of the time being the -- what was the --
20 actually, what was the --

21 MR. ADKINS: It was seven hours burning.

22 DR. McGRATTAN: Seven hours burning and
23 then --

24 MR. ADKINS: Three hours cool-down.

25 DR. McGRATTAN: Okay, so it was a 30-hour

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1 simulation with the seven hours burning and then --

2 MR. ADKINS: And then there was one that
3 we did seven and 26.

4 DR. McGRATTAN: And this was to answer the
5 question what if the water main had not broken because
6 there's been a lot of discussion about the fact that
7 in the Howard Street case the water main broke and
8 after three hours, I think, the fire was dramatically
9 weakened by the presence of the water. So we went on,
10 subsequently, and said, well, what if the water main
11 hadn't broken and what if there was more ventilation
12 in the tunnel to see how much hotter we could get it.

13 MR. RESNIKOFF: Has that been written up
14 anywhere and could we get a copy?

15 DR. McGRATTAN: It hasn't -- my part of it
16 hasn't been written up but we could write that up.

17 MR. BAJWA: Eventually, the results of the
18 initial analysis that we did will be documented and
19 that will be available, so as soon as that becomes
20 available, I will make sure that you all get copies of
21 that.

22 MR. HALSTEAD: Kevin, I'm looking at the
23 conclusions on page 28 of the NIST report, NIST
24 IR6902, and I'm trying to summarize based on your
25 conclusions what the worst case fire within a five to

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1 10 meter region would have been and when I look at
2 your conclusions and it seems to me that they would
3 support an interpretation that if we were trying to
4 translate that into an engulfing fire, which is what
5 we look at for cask performance, that your analysis
6 supports a conclusion, first, that the worst case fire
7 in that five to 10 would be three hours at 1,000
8 degrees C. Is that a reasonable conclusion to draw
9 from your conclusion on page 28?

10 DR. McGRATTAN: Where are you drawing from
11 that?

12 MR. HALSTEAD: Well, it says, "The peak
13 calculated temperatures within the tunnel during the
14 first three hours (before the water main rupture) were
15 approximately 1,000 degrees C (1800 degrees
16 Fahrenheit) within the flaming regions or about half
17 the length of a rail car and approximately 500 degrees
18 C or 900 degrees Fahrenheit when averaged over the
19 length of the tunnel equaled to the length of three or
20 four rail cars". And I'm going to get to that past
21 three hours and path regions in a minute.

22 DR. McGRATTAN: The term "peak" refers to
23 both space and time.

24 MR. HALSTEAD: That's right.

25 DR. McGRATTAN: So we hit the peaks early

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1 on but that doesn't necessarily mean that those
2 temperatures would be sustained for three hours. It
3 would be on the conservative side.

4 MR. HALSTEAD: Well, are you prepared to
5 say that that -- that a three-hour fire could not have
6 averaged that temperature? That's what we're trying
7 to ascertain here. What's your bottom line for
8 helping us determine what fire we need to subject a
9 cask to, to validate this performance?

10 DR. McGRATTAN: Right, right, since no
11 ventilation studies were done on the tunnel, we can't
12 say for certain how much air was reaching that fire
13 because a tunnel like this has many cracks and
14 crevices, okay. In our analysis, we assumed that the
15 air was coming in from the portals but that doesn't
16 necessarily mean that air couldn't be coming in from
17 some other place to sustain the fire at the 1,000
18 degrees longer. So what we're saying is that peak
19 temperatures could be 1,000 degrees during the flaming
20 period of the fire.

21 MR. HALSTEAD: And that could be three
22 hours.

23 DR. McGRATTAN: Yes.

24 MR. HALSTEAD: So what we're trying to do
25 here is understanding that the train was not properly

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1 instrumented for our purposes, is to try and figure
2 out what the worst case averaged over three hours
3 would be.

4 DR. McGRATTAN: Well, it was stated in the
5 beginning that this accident may not be considered the
6 worst case.

7 MR. HALSTEAD: No, I understand that and
8 in fact, as we have studied this accident more, I
9 think that's one of the conclusions that we've come to
10 and understand when we did our preliminary analysis of
11 the fire in September 2001 which Dr. Resnikoff and
12 Matt Lamb worked on, of course, we didn't have the
13 benefit either of the NTSB findings or your modeling
14 and actually, I think a lot of our assumptions
15 frankly, are not that different from yours because now
16 then I want to turn to the next three hours of the
17 fire. It's difficult because of the water main burst
18 to know what happened, but it certainly seems
19 reasonable -- let me strike that.

20 Does it seem reasonable to you to assume
21 that after that three-hour peak fire at 1,000 degrees
22 C, we might have had a continual burning for up to
23 three or four hours in the range of 500 to 800 degrees
24 C and understand we probably can't be much more
25 precise than that?

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1 DR. McGRATTAN: It all depends on how much
2 fuel is available and how much oxygen is available.

3 MR. HALSTEAD: Well, no --

4 DR. McGRATTAN: And we know in this case
5 how much fuel was available to start with. We don't
6 know exactly how much of that fuel ran down the hill,
7 ran into drains, et cetera. And we don't know exactly
8 how much oxygen was available for that fire.

9 MR. HALSTEAD: Let me rephrase this and
10 ask you, if I said based on your study, that I thought
11 a reasonable worst case characterization of what
12 happened in the Baltimore Tunnel within the five to 10
13 meter flaming region closest -- region closest to the
14 fire, that a three-hour fire at 1,000 degrees C
15 followed by three to four hours at 500 to 800 degrees
16 C probably represents the worst fire that could have
17 occurred given the facts that we have in hand. Would
18 you say that that's an accurate characterization or is
19 it possible that something of higher temperature and
20 higher duration should be assumed?

21 DR. McGRATTAN: Well, it's difficult to
22 use the term "worst case" when there are so many
23 uncertainties.

24 MR. HALSTEAD: Okay, maximum credible
25 event given the particular scenario --the particular

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1 accident that we are talking about here. I realize
2 worst case is a very vague phrase. But given what you
3 know about this fire --

4 DR. McGRATTAN: It is conceivable right --

5 MR. HALSTEAD: -- what is the worst thing
6 that could have happened in the Baltimore fire
7 averaging time and temperature in a way that allows us
8 to look at the regulatory standard?

9 DR. McGRATTAN: If I have to say it's
10 dangerous. If there was more ventilation into that
11 tunnel, if the fuel was confined within a container of
12 some sort, that would lead to a longer robust fire
13 simply because it would have more oxygen and the fuel
14 would be contained so that it could burn down rather
15 than just, you know, wash down the drain. So there
16 are scenarios that would be more hazardous than what
17 actually occurred.

18 But it's hard to speculate, you know, on
19 these scenarios.

20 MR. BAJWA: I'm going to have to
21 interject.

22 MR. RESNIKOFF: I have a quick question if
23 I could.

24 MR. BAJWA: Okay, go ahead and then I have
25 a statement and then we need to move on.

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1 MR. RESNIKOFF: Maybe this should be
2 directed to NTSB but do you have a theory as to why
3 the water main broke, that is to say what thermal
4 forces existed at the roof of the tunnel?

5 DR. McGRATTAN: My expertise is not in
6 metallurgy, so I'm not going to --

7 MR. HODGES: I think you're right. That
8 should probably be directed to NTSB.

9 MR. BAJWA: One thing I think we all need
10 to keep in mind here, Bob, when you're saying a three-
11 hour fire at 1,000 degrees C, do you mean an average
12 temperature of 1,000 degrees C or do you mean a peak
13 temperature of 1,000 degrees C?

14 MR. HALSTEAD: I'm trying to take the
15 admittedly speculative analysis of a real world fire
16 and translate it into a fire environment that those of
17 us who have worked on cask performance are more
18 familiar with. And while I don't want to have to
19 parking lot this issue by mentioning a package
20 performance study, obviously the reason that we are
21 doing such a careful analysis of this fire at this
22 particular point in time, is because we need to give
23 the NRC our best advice on what type of engulfing fire
24 might be used in a cask test to replicate the worst
25 conditions that we think occurred in the Baltimore

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1 fire.

2 MR. HODGES: One thing to bear in mind, I
3 believe, is that you still have to have a source of
4 oxygen coming into the fire and that's generally --
5 whether it's this tunnel fire or another tunnel fire,
6 you're going to have some regions that are cooler than
7 in others. You're going to have peak temperatures
8 near the top of the tunnel, which is what we're
9 talking about. You're going to have areas that are
10 cooler and so to try to say you should have a fully
11 engulfing fire at that very peak temperature does not
12 make sense for this kind of a fire.

13 MR. HALSTEAD: Well, first of all, I would
14 dispute some of your assumptions. I think given the
15 configuration and size of the tunnel, it's very
16 possible that you could have a train pile-up in which
17 the lid end of a rail cask is within the five to 10 --
18 I would say within five meters of the hottest zone of
19 the fire and it could be that it's upright like this
20 towards the ceiling. So I think we need to be careful
21 here about how many assumptions we make about what
22 could or couldn't have been and that's why I've
23 carefully stated this to say if I'm trying to
24 replicate the worst type of thermal environment that
25 a cask could be subjected to for the purpose of

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1 designing a test that replicates the worst conditions
2 that could have been in this fire, because it goes to
3 the question, Kevin, maybe this isn't the worst case
4 fire that we want to think about for cask performance
5 and that my thinking has evolved a lot on that over
6 the last couple of years particularly because we've
7 studied some other real world fires that may, in fact,
8 created more severe conditions and those were fires
9 that were located along rail lines that are potential
10 shipping routes either to Yucca Mountain or to Skull
11 Valley.

12 So the issue here is simply trying to take
13 you conclusions on page 28 and it seems to me that
14 we're agreed that it's unlikely that there could have
15 been a sustained three-hour fire averaging
16 temperatures greater than 1,000 degrees C. Now, the
17 question of whether that is an accurate replication of
18 what actually happened is one thing, but if I'm
19 looking at this for the purposes of a bounding
20 scenario and I understand your -- and I appreciate
21 your qualification that if there's more oxygen, in
22 fact, the temperatures could have been higher, but
23 that's an area of speculation that I think would be
24 hard for us to support.

25 DR. McGRATTAN: But the original question

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1 was, could they get up to 24 or 2600 degrees
2 Fahrenheit and I still don't believe that.

3 MR. HALSTEAD: Well, this was Marvin's
4 question.

5 DR. McGRATTAN: Okay, we see temperatures
6 -- even for open large pits of oil burning, you still
7 don't see temperatures higher than about 1,000 degrees
8 C or 1800 degrees to 2,000 degrees Fahrenheit. And
9 now, it's just a question of duration and of course,
10 if you simply have enough fuel outdoors, you can
11 sustain a fire for as long as you want.

12 MR. BAJWA: Bob, the reason I asked the
13 question is because in the five to 10 meter region
14 surrounding the fire, I just don't want anyone to get
15 the impression that the average temperature was 1,000
16 degrees C because for five to 10, you know, meters
17 around the fire, it -- from what we analyzed and from
18 what we generally know about pool fires, it wouldn't
19 be that high. The average temperature would not be
20 that high for either this fire in the tunnel or even
21 a pool fire.

22 MR. HALSTEAD: Do you want to venture a
23 speculation as to what that average temperature might
24 be, what the range would be?

25 MR. BAJWA: Well, if it's a hydrocarbon

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1 fire, the average temperature is around 800 C and
2 that's probably part of the reason why the regulations
3 are at 800 degrees C.

4 MR. BAJWA: Yes, Merritt needs to ask a
5 question about the radiation and then we're ready to
6 move on.

7 MR. BIRKY: Can I ask one quick question?
8 You mentioned that you had done some calculations
9 beyond this 30-minute period or beyond the three
10 hours, I think, we're talking about. Can you give us
11 some feel for how that temperature decays because of
12 the radiation from the walls and that sort of thing?
13 Does it stay high for many, many hours and how high?

14 DR. McGRATTAN: After the fire goes out,
15 the temperature drops rapidly. Now, not of course
16 back to ambient but it drops rapidly because the loss
17 from a hot wall goes like the temperature to the
18 fourth power. So if you've got the wall up at around
19 800 degrees or 900 degrees C, okay, take that to the
20 fourth power and that's your radiative loss. You see
21 the temperatures in the first couple of minutes drop
22 down dramatically, but of course, they're not going to
23 drop down to ambient but they're going to drop down
24 into the several hundred degree range.

25 MR. BIRKY: So supposing we have the walls

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1 at 800 and how long will it take to get down to 400,
2 say, the half-life, if you will?

3 DR. McGRATTAN: I'd have to sit down with
4 my calculator but I'd say tens of minutes, tens of
5 minutes or less.

6 MR. BAJWA: Okay, I'd like to move onto
7 the next presentation. It will be from the Center for
8 Nuclear Waste Regulatory Analysis, Mr. Andre
9 Garabedian and Darrell Dunn. Mr. Garabedian is a
10 group leader in the engineering and research section
11 of the Southwest Research Institute's Department of
12 Fire Technology. He holds a bachelor's degree in
13 civil engineering, a masters degree in fire protection
14 engineering and is a licensed fire protection engineer
15 in the State of Texas. His primary role is a large
16 scale fire test engineer and fire investigator.

17 Mr. Darrell Dunn is a senior research
18 engineer at the Center for Nuclear Waste Regulatory
19 Analysis. He has a BS in metallurgical engineering
20 and an MS in material science and engineering. He is
21 involved in the analysis of materials degradation and
22 metal corrosion at Southwest Research Institute. And
23 they're going to be talking about analysis of rail car
24 components exposed to a tunnel fire environment.

25 MR. GARABEDIAN: Thanks, Chris. Good

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1 morning, all. My name is Andre Garabedian. I
2 represent Southwest Research Institute Center for
3 Nuclear Waste Regulatory Analysis and I'll introduce
4 Darrell Dunn a little bit later on.

5 Our tasks in this project were to review
6 the antidotal information on the Howard Street Tunnel
7 fire. That included photographic documentation and
8 initial reports. We visited the site to collect some
9 data, inspect the damaged rail cars, and then we
10 analyzed the recovered train components using
11 metallurgical techniques. The last step was to verify
12 those analyses with a simple convection radiation
13 model backed up with a "reality-check" small scale
14 test that we conducted later on.

15 Our ultimate goal was to use the physical
16 evidence backed by numerical modeling to estimate the
17 fire duration and temperature witnessed by components
18 during the post-derailment and fire. I think we all
19 know why we're here and the idea behind getting those
20 data were to submit to the NRC to give them an idea of
21 the exposure in an effort to aid in policy. The
22 analyses performed, two type of analyses will be
23 covered in the presentation. One, a materials
24 analysis, those type of analyses include studies of
25 paint degradation, blistering, peeling of paint.

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1 Materials analyses, including oxidation of steel, how
2 the steel reacted to the fire. That was backed up by
3 some empirical computational analyses using transient
4 heat transfer models onto various components in the
5 tunnel and specifically the aluminum air brake valve
6 components. We noticed them melting, so the transient
7 heat transfer model was focused around those elements.

8 Data collection, as I mentioned before, we
9 visited the tunnel, spent a day on site and a day at
10 NTSB, collecting antidotal data, photographing the
11 rail cars, taking measurements of what we saw and
12 here's just an idea of what some of the rail cars
13 looked like. You saw the picture on the right
14 earlier. The picture on the left is a -- I believe
15 that's they hydrochloric acid rail car, that's car
16 number 53, the one right after the trypropylene car,
17 similar in size 28,700 gallons.

18 Some of the samples that we collected
19 included some steel scale that was pulled from car
20 number 51. If you refer to your hand-out, that's one
21 car uphill from the spill source, approximately 30
22 feet away. We collected a section of the roof plate
23 from car number 50. This was the source of
24 substantial exposure due to a long-burning paper fire.
25 This is a boxcar containing paper, so for a duration

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1 the contents of that paper car and their impact on the
2 steel were -- we were interested in. We also
3 collected some sand, small sand samples from the base
4 of one of the rails near the derailment point and the
5 reason that was interesting was the sand appeared to
6 be clumped to the rail, so we wanted to take a quick
7 look at that sand to see if any changes in the
8 material structure of the sand due to heating.

9 Here's a quick overview of the rail car
10 components that we were very interested in. This
11 image to the right is the air brake, ABDX air brake
12 and you get an idea from the scale of the unit, it's
13 mainly a cast iron body with a lot of aluminum covers
14 that cover components on either end of the unit.
15 These are very interesting witnesses to temperatures.

16 So talking about the ABDX air brake valve,
17 we collected the remainder of the valve on car number
18 52, which was the car of origin, the spill source car.
19 This air brake valve, obviously, exhibited the most
20 notable damage, so we were very interested in how the
21 steel in the bolts and the remaining components of
22 that air brake valve looked. And this was very
23 comparable to other air brake valves throughout the
24 train. Every car has an air brake and the location
25 and spacing of these units is fairly uniform

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1 throughout the train. So it was a very good tool to
2 use to compare car to car.

3 Again, as I mentioned, on that air brake
4 there were some exposed bolts that were analyzed and
5 these bolts were the bolts that were holding one of
6 the aluminum air brake covers onto the cast iron body.
7 That aluminum air brake cover completely melted only
8 leaving the bolts, so it was a very good indicator of
9 what the temperatures were in that area. And then we
10 analyzed or evaluated a new air brake valve cover,
11 just to get an idea how these things perform. We
12 wanted to see one melt. That was supplied directly
13 from the manufacturer.

14 So to start with the material analyses,
15 the paint analysis, I'll introduce Darrell Dunn.

16 MR. DUNN: Thank you, Andre. The rail
17 cars on the train were painted with a Dupont alkyd-
18 enamel paint. And we know that the blistering
19 temperature of this paint is about 700 degrees
20 centigrade or just under 1300 degrees Fahrenheit. We
21 studied the burn patterns on the rail cars and looked
22 for signs of paint damage on both the tripropylene car
23 and also some of the other cars, including some of the
24 box cars that were hauling paper.

25 What we observed was that there was no

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1 blistering on rail car number 53. This was adjacent
2 to the tripropylene car and about 50 feet away from
3 the tripropylene car and this suggests that the
4 temperature observed by this car was less than 700
5 degrees Centigrade. We did observe blistering on some
6 of the box cars that were hauling paper even though
7 these were further away than the rail car number 53.
8 These particular cars, however, had secondary paper
9 fires so the temperature was likely caused -- would
10 blister the paint, the temperature that would blister
11 the paint was likely caused by the internal materials
12 in the car burning, rather than the fire caused by the
13 tripropylene spill.

14 Now, I'm going to move to that materials
15 analysis. The graph here shows the way that we
16 analyzed our steel components. One of the things we
17 did was to look at the formation of oxide films on the
18 steel components because this is a known function of
19 time and temperature. I show a couple of different
20 rate constants here. One of them is for the formation
21 of an oxide layer thickness and the other one is for
22 the reduction in metal thickness due to oxidation of
23 the steel. These rate constants are available over a
24 wide range of temperatures and for different alloys.
25 I've shown a couple of different alloys here. We used

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1 the rate constants for iron, since our components were
2 basically low carbon steels.

3 Okay, the photographs here show sections
4 of the roof of car number 50 and I'm going to point
5 here, we're looking at the cross-section going this
6 way across this particular sample and for here we're
7 looking at the cross section going in this direction.
8 The thickest portion of this roof is shown here on the
9 graph, about 1700 microns and the thinnest portion,
10 which was exposed to the fire was substantially less
11 than that. Based on the loss in metal thickness, we
12 observed some spalling of the outside layer for this
13 particular component, so getting an estimation from
14 oxide layer thicknesses is probably not a good method.
15 So we looked at the reduction in metal thickness and
16 from that, we can estimate that if we have a four-hour
17 fire, this particular component saw temperatures in
18 the range of 750 to 850 degrees Centigrade.

19 It's important to note that this
20 particular item or this particular component was on a
21 car that had a secondary paper fire, so the actual
22 exposure to elevated temperature was quite likely
23 longer than four hours. This is a -- this slide here
24 shows a cross-section of a bolt. This bolt was
25 recovered from the air brake valve of rail car 52 and

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1 again, I'm going to use the pointer here. What you're
2 seeing this kind of dark gray area is actually the
3 epoxy that we mounted our sample in. Over here on the
4 right side of this picture, you'll see the bright
5 area. This is the steel base metal and then you see
6 a thin layer in between that is actually the oxide
7 layer and the second picture here that's kind of inset
8 is actually an x-ray image map so and we'll looking at
9 iron, so we see lots of iron here on the bolt, as you
10 would expect and less iron in the oxide layer, again,
11 as you would expect.

12 This particular iron bolt has a very
13 nicely uniform oxide layer. We don't see any evidence
14 of spalling here and so we use the oxide layer
15 thickness to determine what type of temperature this
16 particular component would have seen and again, based
17 on an assumed four-hour exposure, this particular
18 component would have seen a temperature of a little
19 over 620 degrees Centigrade.

20 This is another portion of the same bolt
21 and this is actually the head of the bolt and the
22 phase that's been mentioned before in previous
23 discussions, actually is right here. This is a very
24 small phase. It's about 50 microns deep, I believe,
25 and the micron scale here in the larger picture is two

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1 millimeters for your reference. This particular area
2 has this phase that's shown here in atomic percent, 66
3 atomic percent aluminum and 30 atomic percent iron.
4 And this particular phase would have a melting
5 temperature that's inconsistent with what we observed
6 for either the oxide layer of thickness or the
7 condition of the aluminum cover on this particular air
8 brake valve.

9 It's important to note that this is a
10 fairly small area and in fact, the melting temperature
11 of this particular phase is actually slightly greater
12 than the melting temperature of the cast iron
13 component. We didn't observe any melting of the cast
14 iron component so we don't believe that this
15 particular phase was formed by a melting process. And
16 now I'm going to --

17 MR. BIRKY: Just one question if I might
18 on that analysis or on the previous one, too, on the
19 oxide; on this particular one, what assumptions did
20 you make when you did the calculations -- get the
21 equations for the calculation for the oxide
22 determination, the thinning of the metal?

23 MR. DUNN: We took rate constants that are
24 well-established from the literature and that's -- I
25 provided a reference to our source there.

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1 MR. BIRKY: But previous stuff done by
2 NIST suggested there was serious oxygen depletion
3 limiting of the fire. Was that taken into account to
4 calculate the temperature and thinning of the metal
5 for the oxide build-up?

6 MR. DUNN: No, we did not assume or take
7 into account any oxygen depletion. It's -- I believe
8 this data shows about 14 or 15 percent oxygen in the
9 tunnel. That's --

10 MR. BIRKY: So what would be the effect of
11 that? Would that increase the temperature or the time
12 duration to get the same oxide build-up?

13 MR. DUNN: Well, most metal oxides form
14 quite spontaneously and it's doubtful that the slight
15 decrease in oxygen concentration would not have
16 effected the oxide kinetics significantly.

17 MR. BIRKY: It would have? Would not have
18 effected?

19 MR. DUNN: It would not have.

20 MR. BIRKY: What about -- how long were
21 these cars -- after the fire did you do these oxide
22 determinations?

23 MR. DUNN: The analysis was done, I
24 believe, approximately a year after the accident.

25 MR. BIRKY: Was that taken into account?

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1 MR. DUNN: Yes, we did take that into
2 account. We, in fact, in our report, show that some
3 of the phases that are formed are a corrosion product
4 rather than a thermal oxide.

5 MR. BIRKY: Then on this measurement, your
6 initial report, could you tell me what assumptions you
7 made in terms of calculating those temperatures, the
8 temperature of the diffusion process here that you
9 had?

10 MR. DUNN: On this particular bolt?

11 MR. BIRKY: Yeah.

12 MR. DUNN: This is a -- again, I think
13 we've pretty well detailed this in the report. This
14 is assuming a simple diffusion in a voluminum in
15 gamma phase iron which would expect temperatures over
16 about 720 degrees centigrade.

17 MR. GARABEDIAN: We could focus on that
18 but I think it's important to understand the --

19 MR. BIRKY: Well, I guess I was -- you're
20 not suggesting it was 1400, 1500 degrees C at all.

21 MR. DUNN: No, no.

22 MR. BIRKY: Are you correcting that?

23 MR. DUNN: No, I think what's written in
24 the report is to show that this particular phase could
25 not have been formed by diffusion because the

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1 temperature is too high. At that temperature you
2 would easily see melting of the cast iron valve
3 components.

4 MR. BIRKY: I was misinformed by that.

5 MR. DUNN: Yeah, in fact, even the melting
6 temperature of the steel bolt here is around 1490
7 Centigrade.

8 MR. BIRKY: Right. Now, I have one other
9 question on what you presented on the blistering of
10 the paint. You're suggesting that was done by the
11 smoldering inside the rail car itself rather than on
12 the outside fire, from the outside fire?

13 MR. DUNN: Yes.

14 MR. BIRKY: How do you determine that?

15 MR. GARABEDIAN: It is difficult to say
16 where the blistering -- what the blistering was
17 occurred from, whether it was an external fire or
18 internal fire. Picture painting a frying pan and
19 putting it on a stove, it could easily blister the
20 paint on the top side of the frying pan because of the
21 heat underneath it. So it is difficult to say where
22 the exposure came from but we do know that it occurs
23 at about 700 degrees C and it occurred in a very small
24 region of that, just a couple of rail cars in that
25 train.

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1 MR. HODGES: Something to keep in mind on
2 those box cars with the paper in them also was they
3 smoldered in the tunnel for some long period of time,
4 several days. When they were pulled out of the tunnel
5 and they got plenty of oxygen, then the fire flamed up
6 and it would have been a much hotter fire.

7 MR. DUNN: Okay, we're done. I'm going to
8 give it back to Andre.

9 MR. GARABEDIAN: Thanks. Yeah, I'm going
10 to step into the empirical and computational analyses
11 that serve to be a reality-check to what we saw in our
12 inspections. And what I want to focus on is the
13 analysis of the air brake valves. Here we see an
14 isometric view of the ABDX air brake valve and you can
15 see -- let me get this pointer, here we go -- these
16 are the aluminum covers, a photograph of it earlier
17 on, if you want to flip back to it you can get an idea
18 of what those covers look like.

19 Air brake valves are used on all the cars.
20 Cast iron valve body, which is the main portion of
21 this unit with these aluminum covers. The aluminum
22 cover that we were most interested in was located
23 about 10 meters from the fire source and this the guy
24 that melted completely. And we know that the aluminum
25 melting temperature is somewhere in the vicinity of

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1 600 degree C. So we can kind of put those two
2 together. To verify or to get us some computational
3 verification, we used a transient heat transfer model,
4 a very simple convective and radiative heat transfer.
5 Assuming that the aluminum acts as a single body, the
6 heat that's absorbed by the unit raises its
7 temperature and the unit melts, so that's what these
8 equations serve to demonstrate.

9 Going into the assumptions, as I
10 mentioned, we assumed a lumped mass, so we're assuming
11 that this aluminum is one clump of aluminum whether it
12 be a sphere or a square. It's not a thin or unusually
13 shaped unit. It's a full volume of aluminum. We also
14 assumed that the radiative exposure from luminous
15 flames, we didn't take that into account and that's
16 usually about 30 percent of the total heat release of
17 a fire. It's a good assumption for those targets that
18 are underneath rail cars. They don't get the benefit
19 of the radiation, heat radiation from the fire onto
20 it.

21 So these assumptions on this slide
22 actually delay the estimated melting time assuming
23 this being a lumped mass and no external rate of
24 exposure. So this would predict longer melting times.
25 On the flip side, we did not take into consideration

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1 conduction into the adjacent steel or other materials.
2 You know, these covers are bolted to cast iron but we
3 did not assume that the cast iron was capable of
4 drawing heat away from the aluminum, no conduction out
5 of the aluminum. So what that would do if there were
6 conduction out of the aluminum, that would -- without
7 assuming conduction away from the unit, that would
8 accelerate or speed up the melting because we're
9 assuming that all the heat that enters that aluminum
10 cover stays there, doesn't go into anything nearby.

11 Some assumptions on the heat transfer
12 coefficients, conducted heat transfer, 50 kilowatts
13 per meter to kelvin. These are applicable convective
14 heat fluxes when you're calculating exposure of
15 structural steel elements, hydrocarbon fires. There's
16 a lot of performance based design that revolves around
17 the fire modeling and its interaction with the
18 structures. And this is a published heat transfer
19 coefficient for that purpose.

20 We also assumed varying fire exposure
21 profiles. Again, not knowing what the fire profile
22 looked like, we assumed some fairly typical profiles.
23 Immediate growth and a plateau, that's common for
24 hydrocarbon fires. They grow very quickly and
25 assuming perfect conditions, they will plateau at a

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1 certain temperature.

2 The second one is the rap-to-plateau.
3 Ramp over a certain amount of time, assuming fairly
4 slower growth but that it does achieve its maximum
5 temperature then stays at that temperature for some
6 duration. And then the ramp-plateau-decay, this is
7 the case where the fire grows over a growth period,
8 plateaus at its maximum temperature and due to some
9 external suppression or oxygen limitation, it begins
10 to plateau or fuel consumption, it begins to plateau.

11 Here are a couple of graphs the simple
12 model output. Here's an example of a ramp-to-plateau,
13 so this simulation had an 800 degree Celsius fire
14 ramping at about two minutes and then sitting there at
15 800 degree C for some duration and what we wanted to
16 look at was the bulk temperature of that aluminum
17 cover. We were most interested when that entire
18 aluminum cover hit 600 degrees C. That was one of our
19 assumptions. And that occurred, you can see, in about
20 less than 10 minutes in that case. Another case here
21 is a model run that assumes a ramp-plateau-decay a
22 little bit more typical of what other investigators
23 have found, Kevin as well.

24 We have a growth to 800 degrees C, some
25 plateau at that temperature and then a rapid decay.

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1 And even with the rapid decay, we can see that melting
2 can occur in about 800 seconds, you know, 15 or so
3 minutes. So these are just simple heat transfer rates
4 that indicate that aluminum when exposed to these
5 types of temperatures can melt fairly readily. So how
6 do we validate that, do a reality check on it? We
7 used ASTM E1354. It's a cone calorimeter test.
8 Irradiation method, I know there's some confusion in
9 that term. This is all heat radiation, heat radiation
10 to a sample. And the way it's done, it's a conical
11 heater that basically looks like a Nichrome wire, a
12 toaster, and that's dialed into a certain heat flux
13 and that irradiates a sample. The irradiation flux
14 that we used was 150 kilowatts for meters squared.
15 That's a souped up toaster and that's consistent with
16 ASTM E1529. That's the heat flux that's expected to
17 impinge structural steel exposed in these hydrocarbon
18 pool fire situations.

19 And the picture on the left is the ABDX
20 valve recovered from car 52. Again this is the rail
21 -- the tripropylene rail car. You can look on your
22 diagrams. This is the spill source, fire source and
23 we see some very interesting things. Most interesting
24 is that we can still almost read some letters up here.
25 A, B, D is what I see and a cylindrical section right

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1 here. This is the factory provided valve cover that
2 we irradiated with the cone calorimeter. This was new
3 to begin with and it melted in about six minutes.
4 Even with that high degree of melting, you can still
5 make out some of the reliefs of the profile of the
6 cover but no lettering.

7 This was interesting, as I mentioned
8 before, because these air brake valve covers were
9 fairly evenly spaced throughout the tunnel. The
10 picture on the left is, again, the air brake -- the
11 remainder of the air brake valve from car number 52,
12 again, about 10 meters from the fire source, and this
13 air brake valve cover was located on car number 51.
14 You can look on your diagram. That's the next car
15 down, located approximately 20 meters or 66 feet away
16 from the fire source.

17 This is in very good shape when you
18 consider how easily these components melt. So a
19 summary of the analyses, temperature estimation from
20 the aluminum air brake components, well, we know it's
21 greater than 600 degrees C, 10 meters from the fire
22 source, we got complete melting of that valve cover.
23 The estimation is approximately equal to 600 degrees
24 C 20 meters from the fire source. Why approximately
25 equal to, because the valve cover that I showed you on

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1 the previous slide was partially melted. We're going
2 to give it the credit that it saw 600 degrees C. And
3 less than 600 degrees C, 40 meters from the fire
4 source, we did look at some other air brake valve
5 covers later on in the train in both directions and
6 saw no damage to those.

7 Incidentally, the hydrochloric acid rail
8 car, one rail car away from the tripropylene spill
9 source, was not effected by the fire. In fact, the
10 pictures that I showed you to demonstrate what one of
11 those valves looked like was actually from the
12 hydrochloric car. Temperature estimation from the
13 steel components, as Darrell had mentioned, 750 to 850
14 for four hours at the roof or rail car number 50,
15 again, this also had the secondary paper fire, we have
16 to discern what the difference between an exposure
17 fire and the fire from the internal contents, what
18 effect those had, so it's a bit difficult there.

19 And then a temperature estimation from the
20 rail car pain, this was the toughest one to nail down.
21 The best we can say is it was greater than 700 degrees
22 C within 15 meters from the fuel spill, but again, it
23 is important to note that there was not widespread
24 blistering of the paint. It was very concentrated
25 into a fairly small area. Interestingly enough, it

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1 was actually concentrated on a rail car that was quite
2 away uphill from the spill source, again, indicating
3 that it might have been caused by the interior paper
4 fire.

5 So again, a summary, model calculations
6 indicate that the assumed hot fire environment in the
7 tunnel would have melted solid cores of aluminum in
8 about five minutes. And the ease of melting was
9 verified during an empirical test, the cone
10 calorimeter test, where melting was observed in about
11 six minutes. Does that tell us that aluminum melts
12 very readily and the summary is that the fact that the
13 aluminum covers remained intact elsewhere in the
14 tunnel indicated lower temperatures were observed only
15 a short distance from the spill.

16 Are there any questions?

17 MR. RESNIKOFF: I just have one question.
18 I notice in your report that this ramp-to-plateau
19 temperature that's recommended by ASTM is 1180 degrees
20 C, in other words, the plateau, but I notice in your
21 calculations you assumed 800 degrees C. Is there any
22 reason?

23 MR. GARABEDIAN: No, 800 degrees C was
24 chosen to be more representative what a pool fire
25 would be. ASTM E1529 is very severe. They chose, I

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1 believe it's 2000 degrees Fahrenheit as how it's
2 specified in the standard. No specific reason why we
3 chose a slightly lower temperature but obviously,
4 choosing a higher temperature would have only
5 accelerated the melting time, so --

6 MR. RESNIKOFF: I had one other question.
7 These oxidation measurements that you've taken, this
8 depends both on the temperature and the duration of
9 the fire, right? You have two variables and you only
10 have one known.

11 MR. GARABEDIAN: Yeah, I'll have Darrell
12 answer that one for you.

13 MR. DUNN: That's correct. That's
14 correct, so you have to either assume a temperature
15 and get a time or assume a time and get a temperature.
16 For our particular case, we looked at a relatively
17 short time, what we thought would be the exposure
18 prior to the water main breaking, and got a
19 temperature from that.

20 MR. GARABEDIAN: And, again, the site
21 visits and the photographs of these valve covers was
22 to serve as a functional check of those analyses, so
23 that was the idea. We were very lucky to find those
24 aluminum covers very systematically spread out among
25 the rail cars. They were very good indicators. Yes.

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1 MR. MOORE: Speaking of aluminum covers,
2 can you tell me where they're physically located on a
3 rail car?

4 MR. GARABEDIAN: Yeah, they were located
5 in different places and excuse me while I flip back
6 through these. This one was located on the brake end,
7 which is the end furthest away from the tripropylene
8 car. This is on the hydrochloric car, the next tanker
9 car down. This is actually on a -- a plateau at the
10 back of the rail car, I'd say a little bit more than
11 waist high. Let's give it three and a half to four
12 feet. This one is exposed in all directions to the
13 walls of the tunnel. There are covers on the top that
14 are exposed to the roof of the tunnel.

15 This is a fairly typical location. Other
16 locations, as you saw in the slide later on in the
17 presentation, had one or two of these units underneath
18 the rail cars at certain locations underneath the car.
19 A convenient place to attach it is probably where they
20 ended up. So they were in different locations to kind
21 of give us an idea of exposures.

22 MR. MOORE: Once you move away from the
23 immediate fuel source for the fire, does the vertical
24 location and also the cover provided by the car itself
25 if it's located underneath the car, effect what

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1 temperatures you might see in the heat profile?

2 MR. GARABEDIAN: Yes, yes, it would, yeah.

3 MR. MOORE: So, I guess my question is,
4 are you -- looking at the location of the covers as
5 you looked at the covers on different cars to try to
6 determine whether there was enough temperature to
7 melt, their physical location on the car itself and
8 any sheltering that might be provided by the car in
9 addition to looking at the physical distance, up rail
10 or down rail?

11 MR. GARABEDIAN: Yes. There was not much
12 to see after car number 51. They were all intact, so
13 there wasn't much to discern from, well, this one was
14 intact when it was at waist level, this one was intact
15 when it was under that car. They were all intact up
16 stream or up tunnel. So tough to tell whether the
17 ones underneath the cars received additional exposures
18 or additional exposures because they were closer to
19 the ground and that's where the spill fire was or
20 additional exposures because they were closer to the
21 roof and that's where the hot gases were, difficult to
22 tell but we know that they didn't melt so I don't --
23 I can't take any data from it.

24 MR. BAJWA: All right, thanks, Andre. I'm
25 going to recommend a short break and I think we all

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1 need that, and we'll come back in five minutes and
2 then have the last presentation and questions on the
3 last presentation. Restrooms are through the door,
4 take a left.

5 (A brief recess was taken.)

6 MR. BAJWA: Can we get back to the table
7 so we can get started again, please? Thank you. All
8 right, let's get started. Our next presentation will
9 be on the Baltimore Tunnel Fire Evaluation of a Spent
10 Fuel Transportation Cask. Mr. Harold Adkins from PNNL
11 will present. Mr. Adkins has an MS in mechanical
12 engineering. He is a member of the Fluid and
13 Computational Engineering Group at Pacific Northwest
14 National Labs. That particular group has been
15 involved in spent fuel storage and transportation
16 thermal analysis for over 20 years. Harold.

17 MR. ADKINS: Good morning. As Chris said,
18 I'm Harold Adkins from PNNL and what I'm going to
19 discuss are the thermal results that we came up with
20 when we subjected a HOLTEC Hi-Star 100 transport
21 system to the particular conditions that were given to
22 us by NIST.

23 The first thing I want to start out with
24 is just kind of a general description and give you an
25 idea of how big and what they're shaped like. This is

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1 an artist's rendition that HOLTEC provided and
2 basically what you see is the cask sitting on a rail
3 car on a cradle that's a boxed in cradle and it's
4 strapped down and pretty much almost the entire
5 cylindrical surface of the cask, the structural
6 portion of the cask is covered with a neutron shield
7 and outer casing, if you will, and then the ends are
8 covered with impact limiters. They're made up of --
9 they're hybrid multiple panel honeycombs with a
10 stainless steel shell.

11 This particular cask is a similar
12 description information. Also you have a handout, by
13 the way, that you can probably read. It's a little
14 more legible. Basically, what you have is a cask
15 that's loaded with a sealed, weld sealed canister,
16 stayed flanges and a fuel compartment for multiple
17 fuel assemblies that slips into the cask and then a
18 bolted closure. Now, of course, the impact limiters
19 go on the ends of this and it's loaded on the
20 transport trailer you saw on the previous image.
21 Some, I guess, general characteristics; more
22 description here is, it's roughly 306 inches long, 128
23 inches in diameter. That's with the limiters
24 themselves.

25 Again, two forged end flanges, the cask's

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1 structural portion is primarily made up of a number of
2 concentric shells that are welded to the end and
3 stayed flanges. This cask is comprised of 2.5 inches
4 thick stainless steel containment shell, five inches
5 of carbon steel for gamma shielding, two forgings, of
6 course, bottom and top closure, two hybrid honeycomb
7 impact limiters, again that are made of different
8 pound honeycombs and then a stainless steel skin.

9 The cavity of this particular cask is 191
10 inches long, 68.75 inches in diameter. This
11 particular design has a five-inch thick composite,
12 neutron shield construction on the outside of the
13 structural portion of the cask that is comprised of
14 channel plate, steel channel, steel plate and epoxy
15 resin that the channel and plate are filled with. Of
16 course, this system passively dissipates the heat from
17 the spent nuclear fuel. Some more details of the
18 canister that fits inside of the cask is it's 191
19 inches long, 68.4 inches in diameter. It's a thin-
20 walled steel vessel that's made out of stainless steel
21 and it's got two stayed end flanges. They're both
22 welded into place.

23 The internal is a basket. It's roughly
24 and egg crate construction that allows for 24 spent
25 nuclear fuel assemblies to fit inside with appropriate

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1 envelopes. It also is comprised of flux traps, helium
2 gaps, boron sheet with their associated storage
3 pockets. This particular canister is backfilled with
4 five atmospheres of helium, five atmospheres of
5 pressure helium, and this, you know, unit also
6 dissipates the heat passively to the cask to be
7 passively dissipated to the atmosphere.

8 This particular system is licensed for 20
9 kilowatts decay heat load. Going to the objective
10 here, the main objective that we set out to do is to
11 perform a detailed analysis of the HOLTEC transport
12 system when subjected to, of course, the BTF
13 conditions and the data that NIST provided. And you
14 know, obviously, all conductive, convective and
15 radiative heat transfer regimes need to be
16 incorporated to accomplish this. Some of the
17 assumptions associated with this particular analysis;
18 first of all, one of the things that we immediately
19 looked at is, you know, you've got this entire body
20 sitting in the tunnel fire environment. However, the
21 impact limiters themselves are comprised of aluminum
22 honeycomb which is mainly pressed ribbon that's bound
23 by epoxy that's covered with stainless steel skins and
24 essentially what happens to the aluminum honeycomb is
25 it will melt back from the skin a little bit and

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1 provide an insulated barrier to the top and bottom
2 ends of the cask and is actually a fairly poor heat
3 transfer path out of the particular system. Use of
4 nominal dimensions were acceptable. That was another
5 assumption. The fuel assemblies were centered within
6 the basket cells themselves, where there was no
7 readily available conduction path out of the basket.

8 The canister was radially centered within
9 the cask. Spent nuclear fuel, decay heat profile for
10 this particular model, we chose to go with an absolute
11 hottest possible cross-section of the cask. Again,
12 it's a 2D model, so what we did is we imposed a 1.1
13 peaking factor on the decay heat within the basket.
14 Another thing that we did is we assumed that this
15 particular cask before even going into, I think, the
16 ambient inside of the tunnel is 70 degrees of the
17 ignition of the fire. We assumed that this cask
18 reached normal hot steady state which was 100 ambient
19 and was sitting and baking out in the sun in reached
20 steady state before it went into the tunnel. And then
21 we ignored the transport trailer and we considered
22 this to be conservative considering the fact that it's
23 in the vicinity of the colder air temperatures that
24 are sweeping through the tunnel to feed the fire.

25 The method of solution was to apply a

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1 general finite element solution code. ANSYS was the
2 particular code we used to solve this and we used
3 well-ventilated or well-validated convection
4 correlations, buoyant and forced convection for the
5 two different regimes. Obviously, buoyant convection
6 for the normal conditions of transport, when it's
7 sitting and reaching steady state and then forced
8 convection during the fire situation.

9 Let's see, accurate thermal physical
10 properties were imposed. These were properties that
11 were taken from the HOLTEC TSAR that had been verified
12 and those were even cross compared before we performed
13 the analysis. We used ANSYS Parametric Design
14 Language to go through and evaluate the convection
15 coefficients on the fly throughout this transient so
16 everything was being continuously updated as far as
17 the heat transfer coefficients on the surface of the
18 cask as we went through the calculations, so it wasn't
19 just a matter of assigning a particular value.

20 We incorporated all the conductive,
21 convective and radiative components that we could
22 possibly justify and also rolled in explicit
23 representations of all the sub-componentry including
24 Boral plate. The pocket itself contains the Boral
25 sheets inside of the basket. The basket structure,

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1 the basket stays, the canister shell and then of
2 course, we used in this tunnel fire, the air
3 temperatures, tunnel wall temperatures and the
4 velocities to form out boundary conditions for this
5 particular problem.

6 Model construction, I guess the first
7 thing I can speak to here is the canister body. We
8 incorporated roughly 18,500 elements to represent the
9 conduction through the basket and canister itself and
10 through the fuel assemblies. Convection was
11 incorporated inside of the basket and the magnitudes
12 were -- I guess, the magnitude of available convection
13 were values that were taken directly from information
14 that was used in the development of COBRA SFS and
15 then, of course, all the radiation interaction within
16 the basket was counted for by 72 -- a small -- the
17 modeling of 72 small enclosures inside of the
18 canister.

19 The cask body, the model construction
20 details on that, we went ahead and rolled in over
21 8,000 elements to represent the cask body.
22 Convection, of course, was accounted for on the
23 outside of the cask, not the inside. The gap between
24 the canister and the cask is so narrow that you do not
25 have a -- you don't establish a convection regime.

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1 Radiation was accounted for on the inside and the
2 outside of the cask and this is in two phases.
3 Obviously before we do into the tunnel, the cask is
4 radiating to the environment, you know, like the
5 standard ambient it would be if it was to sit in a
6 rail yard or what have you. And then, of course,
7 during the fire, there was a radiation interaction
8 accounted for between the tunnel and the cask and then
9 in the case where we actually -- we ran two cases. I
10 need to mention this early on so some of this will
11 make sense.

12 We ran two cases where the cask was
13 situated at five meters center from the fire source
14 and then the cask was also evaluated 20 meters down
15 from the fire source. In the case where we evaluated
16 the five meter fire source, the radiation from the
17 actual fire face or sheet of the fire was accounted
18 for and its associated view was calculated.

19 The cask cradle, also, there was some
20 considerations that went into it. It had roughly 1100
21 conduction elements that were used to represent it.
22 We modeled convection within the inside of the cradle
23 and the outside and how it interacted with its
24 environment and radiation was also accounted for
25 between the cradle, the cask and the tunnel.

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1 MR. RESNIKOFF: For the neutron-absorbing
2 part of the cask, you know, how did you model that?
3 Did that stay intact throughout the fire or did that
4 melt?

5 MR. ADKINS: I'm going to go into more
6 detail on that further on here, but I can tell you
7 what I did. That's not a problem. Mainly what we did
8 is we said the conduction path would be enhanced if
9 the material was to stay intact during the fire and
10 then for some other details that I'll give you on some
11 other evaluations that we performed that Kevin had
12 briefly mentioned, we actually right at cessation of
13 the fire said that that material magically turned to
14 air and became an extremely insulative material.

15 Let's see, we're done with that.
16 Basically, to give you an idea of the modeling venture
17 here, here's the cask with the canister inside, a
18 cross-section of it, sitting on the cradle and this
19 mainly just outlines that materials and the fact that
20 each sub-component and everything else was accounted
21 for. Basically, you'll see different colors for each
22 particular material in this but as you can see, the
23 fins, through the neutron shield, the capping, the
24 plating, the gamma shield, everything is explicitly
25 accounted for. Here's a close-up basically of right

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1 at the top of the cannister and what you're seeing is
2 where the fuel -- you're seeing one fuel compartment
3 with the Boral sheet. Maybe the next slide is a
4 little clearer, yeah, here we go. The difference
5 between these two slides is merely the helium
6 environment inside of the canister, but basically,
7 what you'll see is, you'll see narrow sheets on the
8 outside of the fuel compartment that represent the
9 Boral sheet and also its pockets. You'll see the fuel
10 inside of there where there's a radiative enclosure
11 between the fuel and the compartment and then, of
12 course, you can see the stand-offs of the canister
13 that you can also see are put in direct contact. That
14 was another assumption.

15 MR. BAJWA: Harold, can you use a pointer
16 to point those out?

17 MR. ADKINS: Yeah, that would be great.
18 In fact, what I'll do --

19 PARTICIPANT: Go back over that.

20 MR. ADKINS: You mean, you guys don't know
21 this stuff? I will actually. Basically right in the
22 center here, this big blue chunk is the fuel. Right
23 between the purple and the blue is the gap between the
24 fuel radiative enclosure. Right over here, this black
25 portion, this is a flux trap and you can see the Boral

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1 sheets with their wrappers on the outside and the
2 pockets. The red is the basket stand-off. The green
3 is the canister shell and this kind of, I guess, lime
4 green -- this lime green is the gamma shield. Okay,
5 the next slide here is basically a backed up version
6 of -- or backing up from the particular section that
7 we were looking at and what you can see is the neutron
8 shield plates, the capping, the channeling and this is
9 on the outside of the cask here. Where is my pointer?
10 Right here on the periphery of the cask.

11 You can see these fins. The purple is the
12 neutron shield material which is a Holtite-A specified
13 by the manufacturer of the cask and then this wants to
14 rush me, I guess. The next slide here is basically
15 the boundary conditions associated with the analysis
16 and how we used NIST's temperature data, temperature
17 and velocity data to establish the effected zones per
18 the temperature regimes and the flow regimes that
19 Kevin calculated. We'll go into more detail here,
20 I've got some bullets, but basically what you can see
21 is right where these red stand-offs are, the little
22 tick marks on the sides of the tunnel, those are
23 basically panels.

24 If you look at the top of the tunnel,
25 Kevin's data where he specified the absolute hottest

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1 tunnel temperature, we went ahead and conservatively
2 lined that whole cylindrical portion with his peak
3 tunnel temperature reporting and then the side portion
4 where it's over to the sides of the tunnel here, just
5 down from the cylindrical portion, that was his wall
6 temperature we assigned the lower portion of the wall,
7 obviously, the wall temperature. The bottom was the
8 bottom of the tunnel, of course. And then the air --
9 or I guess the air environment as the air was sweeping
10 through, we assumed the roughly around from the very
11 top of the cask to about halfway around to the cradle,
12 which is a huge effected zone considering the fact
13 that like you saw in Kevin's slide, a lot of the hot
14 air was basically entrained and stuck to the tunnel
15 surface very effectively. But what we assumed is that
16 this huge portion of the top of the cask was exposed
17 to the convective environment.

18 Now, the one thing that is critical to
19 mention here is this whole thing was modeled as a huge
20 radiation enclosure in the interacting radiation
21 enclosure, thermal radiation. Okay, the loading and
22 boundary conditions associated with this analysis are
23 as follows. A 20-kilowatt heat load was just as what
24 it's certified for and what we did is we applied a 1.1
25 peaking factor on top of that to represent the

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1 absolute hottest possible cross-section. Now, one
2 thing that needs to be realized here is that in the
3 whole cask body, the steel shelves are so thick that
4 typically, you know, even if you're modeling your
5 hottest cross-section of the cask, it's not going to
6 be as substantial and as conservative as applying this
7 1.1 heating factor and then you know, isolating it
8 where it has no way of migrating heat down the axis of
9 the cask.

10 Some of the pre-fire conditions associated
11 with this, as I referred to before, one of the things
12 that we did is we assumed it came to steady state with
13 its normal hot conditions which was 100 Fahrenheit
14 ambient. We applied 12-hour solar over this 24-hour
15 period which is, you know, per the regulations, 10 CFR
16 71.71. Emmisivity on the outside surface of the cask
17 pre-fire was .85. The ambient was one. Buoyant
18 convection correlations were used for this and
19 basically the same APDL logic that was incorporated to
20 determine the convection coefficients through the
21 transient were applied to determine the heat transfer
22 coefficients for this particular case as well and
23 then, as I said, we allowed it to come to steady state
24 prior to going into the fire.

25 MR. MOORE: Harold, before you leave that

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1 slide, real quickly, what age fuel correlates with
2 your 20 kilowatt decay heat load?

3 MR. ADKINS: I'm not a fuel guy, but I
4 don't believe that matters, especially from a thermal
5 standpoint. I can't comment on that. Mainly what we
6 did is we took the geometric configuration of a W 17
7 by 17 fuel and put the specified heat load that
8 they're certified for that does envelope that fuel.
9 That's all I can comment on.

10 MR. MOORE: Thank you.

11 MR. ADKINS: Okay, fire conditions were
12 such. The boundary conditions, of course, came from
13 the NIST data. We ran two cases, a five-meter and a
14 20-meter case from the fire source, the ignition, the
15 fire ignition. The cask outer surface was assumed to
16 be -- the emmissivity went from .85 to .9 and the
17 tunnel surface was .9, the external environment to the
18 cask. These are per 10 CFR 71 again.

19 Forced convection correlations were used
20 with the APDL logic. We used laminar convection
21 correlations, well-validated correlations, I might
22 add, and the reason laminar ones were considered is
23 there are some other cases that I'll discuss here
24 where we did some post-fire considerations and, of
25 course, as this thing sits and the tunnel cools down,

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1 you're obviously, going to be walking away from the
2 turbulent regimes.

3 Convection interaction was obviously
4 modeled, a radiative interaction inside the tunnel and
5 to the tunnel itself was modeled. The gamma shield
6 gaps, this cask is built by welding a number of
7 concentric shelves that have air gaps in them, and
8 what we did is, when it goes into the fire, we
9 automatically assume all these gaps disappear. So
10 there's a stronger heat path into the cask the minute
11 the fire initiates. Let's see here.

12 Okay, one thing that's critical about the
13 results that I'm going to present here shortly, are
14 the fact that, you know, as Kevin was saying, after 30
15 minutes we have our peak temperatures on the fire and
16 then basically you know, the temperatures start to
17 witness down trending, but what we did at that point
18 is we said, okay, 30 minutes is where we establish our
19 peak temperatures and for the analyses results that
20 I'm going to discuss shortly here, we assumed that
21 right after 30 minutes, basically the temperatures
22 were held constant. They reached steady state and
23 held that continuously further on into time. Go
24 ahead, Bob.

25 MR. HALSTEAD: You got ahead of me,

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1 Harold. If you'd go back to your last slide or this
2 is still the one you've got where you have the NIST
3 data, BC's assumed. What actually are you -- for the
4 -- if you actually overlay this with the illustration
5 of the cask, in terms of the heat input that's coming
6 into the top half of the cask, where your two little
7 ears indicate correlation with the --

8 MR. ADKINS: Sure.

9 MR. HALSTEAD: -- what's the external --
10 what's the external temperature on the surface of the
11 cask that you're assuming there?

12 MR. ADKINS: When?

13 MR. HALSTEAD: Well, I mean, once you
14 reach this steady state for three hours, the first
15 three hours of the fire that we -- what's the hottest
16 temperature during the three hours where we know the
17 water main hasn't effected the fire?

18 MR. ADKINS: Okay. Boy, Chris.

19 MR. BAJWA: I think you're asking -- you
20 want to know what the heat input to the cask is?

21 MR. HALSTEAD: Right. I want to directly
22 relate this to the NIST characterization.

23 MR. BAJWA: Okay, Harold if you go back to
24 the --

25 MR. HALSTEAD: The temperature in the

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1 upper half of the tunnel.

2 MR. ADKINS: I think what's important here
3 is the NIST characterization didn't involve accounting
4 for the water line bursting or anything like that. I
5 mean, none of that was weighed in. So basically what
6 we did is, NIST provided time, temperature curves to
7 us for the upper region of the tunnel, the mid region
8 of the tunnel and the lower region of the tunnel, the
9 air. Then they provided surface temperatures for the
10 top of the tunnel, the side of the tunnel and the
11 bottom of the tunnel and then they also provided
12 velocities, I guess, gas velocities, if you will,
13 because it's not pure air, gas velocities traveling
14 through the upper portion of the tunnel, the side
15 portion and the bottom portion and the velocities were
16 selected in regions where they would give us
17 conservative values over the course of the fire.

18 MR. HALSTEAD: Well, I understand that.
19 What I'm trying to ascertain is -- okay.

20 MR. MOORE: While Bob's looking for that,
21 is that data that you just mentioned, the
22 time/temperature curves for the various regions
23 available?

24 MR. BAJWA: It's not specifically in the
25 NIST report. However, I believe we could provide you

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1 whatever data you'd be interested in. So if you'd
2 just let me know what you want, we'll provide that for
3 you.

4 MR. HALSTEAD: Okay, looking at this
5 region of the cask --

6 MR. ADKINS: I'm sorry, yes.

7 MR. HALSTEAD: All right, I'll do it on
8 this one. Looking at this region of the cask, the
9 top, the top half, what's the -- what assumption are
10 you making about the average surface temperature due
11 to all of the -- all of the heat processes in the
12 tunnel over the 30 minutes, 3 hours and 150 hours? Is
13 that constant and what is that temperature that you
14 assumed -- that you ran, not necessarily what happened
15 in the tunnel? What did you run?

16 MR. ADKINS: Yeah, I think the important
17 thing here is first of all, I didn't assume a cask
18 surface temperature because that is calculated. When
19 you come out of the NCT, I believe we're up at, if I
20 recall -- I mean, one of the things we did is we have
21 a macro that goes out and pulls the absolute peak
22 temperature of a particular component and reports it
23 as a function of time.

24 MR. HALSTEAD: No, I understand that. I
25 want to relate this to the NIST characterization of

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1 the fire. So is the top half of the cask in an 800-
2 degree C fire, 450 hours in your analysis, 1,000-
3 degree C fire for 100 -- I want to know what it is
4 that you're modeling for 150 hours, okay?

5 MR. BAJWA: I can speak to that.
6 Basically, we took the NIST data, okay, so for the
7 first half hour we are polling the NIST data. We are
8 following that time/temperature curve that the NIST
9 data provided. Then in half an hour, taking the
10 maximum temperatures that existed at the end of that
11 simulation, at 30 minutes and we're holding that
12 constant for the remainder of the time, so for the
13 next 120 hours.

14 MR. HALSTEAD: Okay, that's what --

15 MR. ADKINS: And that top portion
16 interacts with the peak temperature and velocity of
17 the fluid that was reported out of Kevin's model for
18 the location of the tunnel, because realize we did a
19 five-meter and a 20-meter case.

20 MR. BIRKY: Clarification; you're not
21 holding that at a temperature, are you? You're
22 holding it at some heat flux, right, from the fire?
23 Isn't that what the input is in your model?

24 MR. ADKINS: No, no, no, it is not. The
25 heat fluxes are calculated, okay, and the heat

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1 transfer coefficients are calculated. The
2 temperatures are not held but inputted the way Kevin
3 reported out of his model directly. What's that?

4 PARTICIPANT: (Inaudible)

5 MR. ADKINS: Yes.

6 MR. BIRKY: And that gas temperature is
7 what the cask is seeing up there between those red
8 ears; is that the thing?

9 MR. ADKINS: That's right, that's right.

10 MR. BIRKY: Oh, okay.

11 MR. ADKINS: And I guess the one thing to
12 remember here, too, is, you know, you look at how high
13 this cask sits in reference to the geometry of the
14 tunnel and it doesn't stick up very high. And, you
15 know, you look at Kevin's plots, here's another
16 measure of conservatism, you look at Kevin's plots and
17 the majority of the hot air volume is sticking to the
18 top of the tunnel.

19 MR. HALSTEAD: Well, I would just add,
20 that involves an assumption on your part that that
21 cask sits on the rail car in the cradle and that's a
22 very questionable assumption.

23 MR. BAJWA: What he's saying is that the
24 maximum temperature at the ceiling of the tunnel is
25 applied to the top of the cask for this analysis.

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1 That's what he's saying.

2 MR. HALSTEAD: I understand that, but what
3 I'm talking about in terms of subjecting portions of
4 the cask to that, it would be interesting to see the
5 lid end of the cask tilted up into that temperature
6 and that's, of course, the issue that we're looking at
7 here, taking the data from the Baltimore Fire and
8 trying to see what would be the maximum type of test
9 we would subject the cask to based on the worst thing
10 that could have happened in this type of fire. I
11 understand that's different from the assumption that
12 you made here.

13 MR. RESNIKOFF: I'm still unclear. Just
14 maybe you could clarify it. You have this cask
15 sitting in a tunnel at 800 degrees Fahrenheit for 150
16 hours, yes, no?

17 MR. BAJWA: No, 800 degrees C.

18 MR. RESNIKOFF: C. Is that wrong?

19 MR. BAJWA: That's not correct.

20 MR. RESNIKOFF: What's right?

21 MR. BAJWA: What's right is we are taking
22 a time/temperature curve. The temperature varies with
23 time in the NIST data. We're taking that and applying
24 it to the cask. Okay, so for the fire that -- for the
25 fire simulation that lasted 30 minutes, we took the

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1 time and the temperature data and applied it to the --

2 MR. HODGES: And also if I'm remembering
3 right, you didn't take the peak temperature and apply
4 it to the full circumference of the cask. You used a
5 temperature gradient from the top of the tunnel to the
6 bottom of the tunnel and applied those gas
7 temperatures to the cask.

8 MR. BAJWA: That is correct.

9 MR. RESNIKOFF: So that temperature
10 gradient that you found at 30 minutes, you then
11 applied that for 150 hours.

12 MR. BAJWA: Exactly.

13 MR. ADKINS: I'll continue here, I guess
14 on the fire boundary conditions. Well, I'll finish up
15 actually. The model -- I need to provide some
16 clarification to you. I see where the confusion
17 starts. The 150 hours is just how long the model was
18 run. You know, the times at which we say that peak
19 temperatures exceed a particular limit that we have
20 chosen, that is shorter than that duration, so --
21 additional fire radiation again, one of the things
22 that I told you, at five meters, the five meter case
23 -- is there a question, Bob?

24 MR. RESNIKOFF: Yeah, I'm lost. I thought
25 we had established that at 30 minutes whatever that

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1 temperature gradient was, you're going to apply that
2 for 150 hours.

3 MR. ADKINS: That's correct. And the
4 model was run for 150 hours, but I'm saying
5 temperatures where we say that this is the maximum
6 that we can take, are not just automatically reported
7 at 150 hours. It's shorter than that. Yes, peak clad
8 temperatures is what we ran this particular evaluation
9 to and made that the judgment point. So the one
10 thing, too, here is for the 5 meter case is we went
11 ahead and established how much heat would be coming
12 from the fire itself via radiation to the surface of
13 the cask because it did have a minor view when it's
14 that close. So that was also captures for the 5 meter
15 case.

16 The 20 meter, it attenuates so much that
17 it really wasn't necessary to roll it in and it was
18 neglected. One thing that I'd like to mention here is
19 some of the conservatisms associated with the modeling
20 that we just discussed. One is, we allowed the system
21 to reach steady state. It wasn't moving down the
22 tracks and convecting and cooling down more than --
23 you know, it would have cooled as it was being
24 transported. The 100 ambient where it's just sitting
25 out in the sun baking and not moving is somewhat

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1 conservative.

2 The 2D modeling with 1.5 peaking factor,
3 that could actually take the -- this spent nuclear
4 fuel decay heat load up to an order of magnitude of
5 like 22 to 24 kilowatts depending on, you know, the
6 rest of the geometric configuration. So that is
7 another conservative approach. Full conduction of the
8 Holtite-A was considered throughout the fire. Now, if
9 we did any evaluations where we didn't have -- where
10 we had a post-fire cool-down, what we did is we turned
11 that into air and made it extremely resistive to any
12 kind of heat transfer so the only mechanism was
13 through the fins.

14 The fire BC's were considered steady state
15 after the 30 minutes NIST data, so once they reached
16 peak temperature, they were just assumed to continue
17 on to infinity. Max tunnel ceiling temperatures were
18 applied over the whole portion of the cylindrical
19 surface of the tunnel. And I guess now it's time to
20 discuss some of the results here.

21 The model was run until -- basically, it
22 was run 150 hours but the judgment criteria that we
23 used to say that there was a problem was the primary
24 containment boundary and that was a fuel cladding and
25 we assessed the temperature at which we said the

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1 response time should be limited to, to the short-term
2 regulatory limit of the cladding reaching 1058
3 Fahrenheit. For the 20-meter source case, it reached
4 that in 116 hours. To give you an idea of how long
5 that is, it's five days. And that's after the
6 ignition of the fire. For the five-meter source, it
7 was obviously shorter. It was 37 hours, 1.5 days,
8 approximately and just to give you an idea of the
9 trends, the particular figures.

10 Here's the 20-meter case, and as you can
11 see the surface temperatures of the casks comes up
12 rather quickly. Now, one of the things that needs to
13 be mentioned here, too, is, some of this lags with the
14 tunnel surface temperature and things of that nature,
15 because obviously, when you're in the 20-meter case,
16 you're down from the fire so it's going to lag a
17 little bit. The tunnel temperatures come up in that
18 portion or region, let's see here, but that was only
19 for the 30 minutes. I'm getting confused with some
20 other cases I'm going to present to you here.

21 But one of the things, I guess, the key
22 feature is this; the surface comes up relatively
23 quickly. The thermal inertia of this cask is
24 substantial, including just to give you an idea of how
25 much the fuel weighs, we're talking about 1100 pounds,

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1 times 24 of those and then all of the structural
2 bodies around this are all steel, you know, with
3 comparable rates. And then basically what you can see
4 is that the fuel has a very long response time after
5 the surface of the cask has come up appreciably and
6 roughly, again, 116 hours. And then for the five-
7 meter case, obviously, we have some things happen
8 quite a bit faster. The surface of the cask comes up
9 relatively quickly in comparison to even the 20-meter
10 case, but, again, we still have some lagging but as
11 you can see, the approach to 1058 happens obviously,
12 rather quickly in comparison to the previous case and
13 that was at 37 hours.

14 Now, one of the things that I was going to
15 mention before we go to questions is, you know, Kevin
16 was discussing a case where he had run a fire that
17 basically lasted seven hours and he can give you the
18 details of that, but my understanding was, that was
19 roughly how long it took to fully consume the contents
20 of that tanker car under ideal conditions and then
21 what he did is ran the model out for 23 additional
22 hours to capture the trends of the whole tunnel
23 cooling, the wall surfaces, basically you know, the
24 fluid velocities coming through the tunnel and the air
25 temperatures and we went ahead and modeled that as

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1 well.

2 Now, one of the things that I need to
3 mention is that some of the assumptions are a little
4 bit different. This -- we'll call it the 30 hours, so
5 it was a 7-hour fire, 24-hour -- or 23-hour post-fire.
6 The pre-conditions were the same as all the modeling.
7 Fire conditions, the gamma shield immediately went
8 away at ignition of the fire. The neutron shield
9 material, again, was held to represent conductivity of
10 pristine material until the end of the 7-hour fire and
11 then on the post-fire condition basically, that
12 material to lock some of the heat in to the cask, that
13 material went away and was automatically assumed to
14 have the conductivity of air.

15 The tunnel BC's, since we ran out of
16 temperature data, roughly at the 30-hour mark, we
17 assumed that even though the tunnel was going to cool
18 down further, after 30 hours, and that's, of course,
19 including the 7-hour fire, that things were held
20 constant from that point. It didn't continue to cool,
21 because that's all the data we had. The temperatures
22 for that particular case maximum reported. For the
23 fuel, it came up to 764 which is obviously, below the
24 1050A. The canister shell is 809. Cask inner shell
25 was 859. Gamma shield, you're getting out to the

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1 outer periphery of the cask, was 934. Now, the outer
2 surface of the skin came up to 1873 and the peak on
3 that, I think, was after the fuel really started to --
4 or the fire, and Kevin can comment on this, but the
5 fire was obviously well-established, but also that the
6 surroundings, the tunnel and everything else was
7 pretty much up to temperature and so the surface of
8 the cask, you know, obviously responds accordingly,
9 but it peaked out at about 4.8 hours and carried to 7
10 hours.

11 Now, another case that we ran was a
12 ventilated tunnel where Kevin actually opened up the
13 ventilation to the fire so it burned hotter. However,
14 one of the things that was mentioned and this was per
15 Chris' recommendations, we went through and did a
16 search of the peak temperatures within the tunnel
17 environment and the average, where the highest average
18 temperatures were and it ended up coming out with this
19 ventilated tunnel since it had kind of a cant to it
20 and ventilated out, you know, in the direction of the
21 tunnel tipping up. Basically, the peak temperatures
22 were reported out around 30 meters from the fire
23 ignition source.

24 Some of the assumptions associated with
25 that are the conditions, the same as the previous for

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1 the pre-fire fire conditions were the same as the
2 previous actually, but it was 30 meters up from the
3 fire source. And then post-fire conditions, the
4 neutron shield material again, was pristine until
5 after the fire was out and tunnel BC's were held 19
6 hours past the fire, but basically, we ran out of data
7 again at 26 hours, so we just held those temperatures
8 and velocities at that point.

9 The temperatures are somewhat similar
10 here. For this particular case, maximum reported, 776
11 for the fuel, but you know, out to the surface of the
12 cask it was at 1821 or further away from the fire.
13 6.3 hours is where it peaked out and carried to seven.
14 It took a little longer to heat up the portion,
15 obviously, of the tunnel, I think, is where we're
16 seeing response from the 4.8 to 7 versus the 6.3 to 7.

17 I guess at this point, I'd like to open
18 the floor to questions. Sure.

19 MR. RESNIKOFF: I realize that you've
20 taken a cross-section with -- the hottest cross-
21 section of the cask --

22 MR. ADKINS: Sure.

23 MR. RESNIKOFF: -- to magnify some of the
24 results that you might see. But I have a few
25 questions about that. Since it's a 2D analysis, there

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1 are parts of the cask that you have not been able to
2 model.

3 MR. ADKINS: Yes.

4 MR. RESNIKOFF: Like the drain port, the
5 bolts that head into the cask.

6 MR. ADKINS: Sure.

7 MR. RESNIKOFF: Do you intend to do that?

8 MR. ADKINS: Yes. I will comment on this
9 particular model, though. You know, one of the things
10 that we're seeing and we have one that we're coming to
11 completion on which is another cask that we're
12 evaluating and one of the things that we're seeing
13 currently is again, you know, one of the things that
14 I told you about, the impact limiters, is you're going
15 to have the material melt back from the skins and
16 you're going to have a huge insulated barrier and then
17 basically you look at the surface of this cask and
18 it's covered with neutron shield except for the impact
19 limiters for the most part and maybe the top pivot
20 trunnions (ph), but all your drain ports and
21 everything else are covered by an impact limiter.

22 Now, another thing that --

23 MR. RESNIKOFF: That may or may not be
24 true. If there's an impact then the whole impact
25 limiter could smash down.

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1 MR. ADKINS: That's true, that's true, but
2 one thing to keep in mind, too, and I agree and,
3 obviously, that will need to be further discussed.
4 One thing to keep in mind, though is these casks are
5 drop tested to 30 feet and, you know, they're designed
6 to maintain their impact limiters because they are the
7 protective devices of the upper and lower portion of
8 the cask. They're also a thermal shield. One of the
9 things that also needs to be considered is you have
10 these drain ports that are underneath the impact
11 limiter and we're -- typically -- I won't say
12 typically. This particular cask design has metallic
13 seals that have a service temperature up to 1200.
14 Okay, the peak temperatures that we saw in the gamma
15 shield of this particular cask at the hottest cross-
16 section is 980.

17 MR. RESNIKOFF: That's degrees Fahrenheit.

18 MR. ADKINS: Yes, good point.

19 MR. RESNIKOFF: Now, I notice that you've
20 done the simulation that you showed us is for a 20-
21 meter distance and I assumed you have another one for
22 a 10-meter distance or not?

23 MR. ADKINS: A five-meter and a 20-meter
24 distance.

25 MR. RESNIKOFF: A five-meter distance

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1 then. Is there another one here for five meters?

2 MR. ADKINS: It should be in your hand-
3 out, I hope.

4 MR. BIRKY: Yeah, it is, right here.

5 MR. ADKINS: The one after it.

6 MR. RESNIKOFF: I'm sorry.

7 MR. ADKINS: The 20-meter first and then
8 the five-meter.

9 MR. RESNIKOFF: Okay, well, let me just
10 say that there's an accident limit for the canister
11 shell in the HOLTEC TSAR of 775 degrees Centigrade and
12 that seems -- is that reached within how many time --
13 what time, 775 degrees Fahrenheit, excuse me. And
14 that's reached within what, five hours, three hours?

15 MR. ADKINS: Is that correct, Chris?

16 MR. BAJWA: I'd have to check the TSAR, I
17 don't know that.

18 MR. ADKINS: 775 is low to me.

19 MR. BAJWA: That sounds low for stainless
20 steel.

21 MR. RESNIKOFF: I have that. I'm glad you
22 asked that. I brought the handout, I brought the
23 page. I copied it out of the TSAR. Let's see, it's
24 page 3.5-11.

25 MR. BAJWA: That's -- it does say here 775

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1 degrees Fahrenheit. I'd have to look at the TSAR to
2 see why they picked that number.

3 MR. ADKINS: Yeah, because my
4 understanding is that particular design, they don't
5 even count on the canister being the containment
6 boundary.

7 MR. BAJWA: Right, so in HOLTEC's opinion,
8 whether the MPC shell failed or not, it wouldn't
9 matter. That's how they designed the test.

10 MR. RESNIKOFF: This is the TSAR that you
11 approved?

12 MR. BAJWA: Yeah, right.

13 MR. RESNIKOFF: Yeah, okay.

14 MR. ADKINS: The canister isn't the
15 primary containment boundary on this system.

16 MR. RESNIKOFF: Well, but if you're
17 counting on the fuel assemblies, you're counting on
18 the cladding being the primary containment, you're
19 looking at the 778 degrees Fahrenheit, but if you also
20 looked at the bolts for the cask, you would probably
21 find that they would fail, too. This is my
22 conjecture. That is, and if the canister itself
23 failed, and if some of the fuel elements were damaged,
24 and there are a small percentage that are damaged, you
25 know, that had degraded cladding even before you, you

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1 know, start this simulation, then some of the material
2 will get out of the cask. I mean, all those ifs.

3 MR. HODGES: That's a lot of ifs. And I
4 believe what we actually considered here when we did
5 the analysis, if you looked at the canister, looked at
6 the temperature as it was observed and we used the
7 limit from, I think it was an ASME code as far as when
8 you start getting creep failure of the materials, and
9 considering the internal pressure of this canister and
10 looking at potential for creep failure and so what we
11 concluded is it would not fail. We didn't just use
12 the HOLTEC temperature limit. We looked at the
13 material and creep failure.

14 MR. RESNIKOFF: You're looking at whether
15 the wall of the canister actually fails? Is that what
16 you think is going to fail or do you think the bolt --
17 do you think the bolts are going to elongate, the
18 seals on the --

19 MR. HODGES: Well, first off, the canister
20 --

21 MR. RESNIKOFF: -- imports might fail?

22 MR. HODGES: The inner canister is a
23 welded inner canister. It does not have bolts. We
24 looked at that inner canister and whether or not under
25 the conditions it would fail and based upon creep

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1 limits from the ASME code, the answer is no.

2 MR. RESNIKOFF: Well, there's an
3 inconsistency between what you say and what the TSAR
4 says.

5 MR. BAJWA: You'd have to look and see
6 what --

7 MR. HODGES: What you have in the TSAR is
8 probably a conservative limit for other reasons. What
9 we're saying is, in the fire, would this fail and
10 based upon creep limits and ASME code.

11 MR. HALSTEAD: Well, I have three general
12 comments to make on this and I won't make these long
13 ones because I'm hoping at some future date, Wayne and
14 Chris, that we'll have another meeting. As I've said,
15 for the next three weeks, our primary concern is
16 analyzing this information relative to a rather small
17 issue, that is how to specify a fire test for PPS.
18 And we're not satisfied that the larger issue of the
19 sufficiency of the cask performance requirements in
20 Part 71, but frankly, we're going to spend time
21 between June and December of this year working on
22 that.

23 But first of all, it seems to me that
24 there are some specific differences of opinion here
25 about the performance of the specific cask that you

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1 evaluated. Secondly, I have a general concern that I
2 can't explain as to why your findings are so different
3 than some of the other analyses that we rely upon. In
4 particular, I'm looking at the performance envelope
5 analysis that Professor Miles Greiner prepared under
6 contract from DOE. So it's certainly not that I'm
7 throwing research at you that was necessarily funded
8 by the State of Nevada.

9 And thirdly, we think the most important
10 issue regarding the adequacy of the regulations is
11 given the uncertainties about what happened in the
12 Baltimore fire, making a conservative assessment of
13 what the worst fire could have occurred there based on
14 the NIST findings, what happens if the most vulnerable
15 cask currently certified by the NRC that could be used
16 in rail shipments, and remember that includes the
17 truck casks, because they have been used in rail
18 shipments and there are proposals to use them large
19 scale.

20 And we also have the issue of currently
21 licensed rail casks the IF300 and the NLI1024, in
22 which there are major differences both in terms of the
23 thermal mass, we're talking about 24 to 27 ton
24 packages compared to 130 to 140 ton packages. We're
25 talking about major materials differences, steel, lead

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1 steel for example, as opposed to the composite steel
2 construction. So my third concern here and the
3 biggest concern I have with the way that this whole
4 body of research has been put forward publicly by the
5 NRC is to say we took this analysis of what happened
6 in the Baltimore fire and we took a cask that in my
7 opinion has extremely good inherent thermal
8 performance characteristics, and includes an extra
9 regulatory barrier which the State of Nevada has
10 advocated for many years, i.e., a welded canister
11 which, in my opinion, provides most of the protection
12 both in terms of creation of direct pathways for
13 escape of cesium 137, but also has thermal
14 significance as well. So that's the issue that I'm
15 hoping we will come back to after we've had time,
16 first of all, to deal with our immediate burden of
17 dealing with the PPS implications of all this.

18 And I know we're going to get into, you
19 know, some -- you've done all the presentation work,
20 right, you're going to put forward?

21 MR. BAJWA: That's correct.

22 MR. HALSTEAD: I want to just take a
23 couple of minutes to say how much we appreciate having
24 this meeting. Those of you who are close to this
25 particular issue know that there has been -- there

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1 have been some extremely hard feelings between Nevada
2 and NRC, on Nevada's part for feeling that we were
3 excluded from meetings and I'm sure on the Commission
4 staff's part, a feeling that someone who's not even a
5 licensee has asserted the right to interfere in
6 management prerogatives. I really try to see both
7 sides of this. And having been a project manager, I
8 know how difficult it is to have meetings with
9 contractors when preliminary reports and data have to
10 be evaluated.

11 All that said, I'm sorry that we didn't
12 have a meeting like this back in July of last year,
13 before you started your work. I'm sorry that you
14 didn't invite us to the table to explain our initial
15 analysis of the fire and our plans, which have always
16 been pending the completion of the NTSB studies to
17 come back and take a look at the Baltimore fire with
18 that information in hand. And my goodness, that may
19 be years from now as the NTSB schedule goes. I think
20 it would be useful if we could work out a better
21 protocol for the way that you provide information.

22 We feel that we were unwisely, if not
23 unethically and possibly illegally excluded from early
24 meetings that you had with your contractors, but we're
25 still researching whether you have a legal right to

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1 exclude us and realistically in a post-9/11 world,
2 getting in and out of these buildings, you know, makes
3 it very difficult for people to show up at a meeting
4 and say, "Gee, we'd like to speak". So that's an
5 area.

6 There's the area of the availability of
7 written documents. You know, we had to file a Freedom
8 of Information Act request in order -- and we burned
9 a lot of resources and frankly, it wasn't very helpful
10 to us and I understand, Chris, that you had some
11 concerns from NTSB as to why you felt you had to
12 withhold an essentially completed document, the NIST
13 report, from August to February but I would argue in
14 return that you could have eliminated the figure that
15 the NTSB was concerned about and then we could have
16 had that data earlier on.

17 So the long and the short of it is, I
18 would hope in the aftermath of this meeting that we
19 can work out at least as far as the State of Nevada
20 and the NRC are concerned, a better protocol for
21 interaction between your staff and contractors and our
22 staff and contractors on these issues so that we don't
23 have to continually rip each other to shreds in
24 public.

25 Now, we're going to have an adversarial

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1 relationship because that's how licensing dockets
2 work, but I think that this could have been conducted
3 better. I wish from my initial contacts with Wayne
4 Hodges that I had thought this through and decided
5 what do we really want, what do we really need, how
6 can I clearly state that to the NRC in a way that
7 would make it easier for them to comply with that and
8 I think you have to look at the model of stakeholder
9 interaction that has been established in the package
10 performance study. Now, we're not going to parking
11 lot it here, because for many things that I think
12 haven't been done in a mutually advantageous way, I
13 think that there's a good model for the NRC to
14 consider patterning its future stakeholder
15 interactions on, and Chris, you've been part of that.
16 And so you've seen that it can be messy at times when
17 it gets to the issues.

18 So before anything else, I guess I want to
19 just reiterate again how appreciative we are that you
20 scheduled this meeting and brought your people in. I
21 find that while there are a lot of unresolved issues,
22 the issues that we needed to deal with most for the
23 May 30th deadline, I think this meeting has been
24 extremely helpful. I think on the larger issue of
25 looking at what happened in the Baltimore Tunnel as a

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1 potential insult to an NRC certified cask, I believe
2 that's still largely open and we would hope to
3 interact with you again on that. Thank you.

4 MR. RESNIKOFF: I know you had some more
5 specific --

6 MR. BAJWA: What I'd like to do, Marvin,
7 if you could hold you question just we want to try to
8 get to it but we have run over time and I did promise
9 that we would give anyone in the public who would want
10 to comment or question. I'd like to do that. Before
11 I do that, I'd just like to make a comment on your
12 third point about looking at other cask designs. We
13 are currently doing that for the Baltimore Tunnel Fire
14 exposure and when we get to a point when we have some
15 results on that, we will put those out and share those
16 with you.

17 We are also concerned about other cask
18 designs. We will not deny that the HOLTEC Hi-Star is
19 a robust design and has performed very well,
20 obviously, in the analysis that we've done. So we are
21 looking at other cask designs. So I'd like to go to
22 anyone in the public if you have a comment or a
23 question to step to the podium and state your name and
24 affiliation if you would, and we'll go from there,
25 unless we've scared the public away. Okay, Marvin,

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1 why don't you go ahead?

2 MR. RESNIKOFF: Has this been written up
3 yet? Do you have a report or is just all in
4 overheads?

5 MR. ADKINS: You've got some information
6 in the FOIA, basically on the approach for the five-
7 meter and 30-meter primary evaluations.

8 MR. RESNIKOFF: I just got a few overheads
9 is what I got from the FOIA. Is something else in the
10 mail?

11 MR. ADKINS: Something else is being
12 worked on. At this point I don't know what the status
13 of it is. There will eventually be a more formal
14 document that explains the approach for this. We just
15 haven't had time to gin it up basically.

16 MR. RESNIKOFF: Is there any -- do you
17 have any estimate as to when that's going to be done?

18 MR. ADKINS: I'd only be speculating. I
19 really can't tell you at this point.

20 MR. RESNIKOFF: Because it's fairly hard
21 to digest all of this without also looking at the
22 nitty-gritty of it all.

23 MR. ADKINS: The one thing I should have
24 mentioned right at the beginning of my presentation,
25 but there's only so much you can pack into -- keep in

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1 your head, but there's a lot of detail in the slides
2 that typically isn't mentioned in a situation like
3 this, just because slides are meant to be brief.
4 There's a lot of information in those slides that you
5 pare it down and that was included for your benefit in
6 case you had questions associated with that particular
7 analysis.

8 And you know, Chris is obviously more than
9 equipped to answer a lot of the questions, too,
10 because he was in on the ground floor as well.

11 MR. RESNIKOFF: Well, let me just ask one
12 more specific question. Just looking at the neutron
13 absorber on the outside, it's your judgment that if
14 the neutron absorber melts away, that that actually
15 provides less conduction, well, definitely less
16 conduction, but there's less heat removal or heat
17 going into the cask when you have no neutron absorber
18 than when you do. I mean, the design of the HOLTEC
19 cask with these half-inch radial connectors, it's
20 designed because the neutron absorber is an insulator.

21 MR. ADKINS: Yeah.

22 MR. RESNIKOFF: And you need to get rid of
23 that heat some way and so they've -- those elements,
24 those radial elements also serve as a heat conduction
25 pathway.

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1 MR. ADKINS: Sure.

2 MR. RESNIKOFF: So, I'm sort of -- I'd
3 like to see more detail about it, but it doesn't look
4 like the presence or absence of the neutron absorber
5 makes much difference in the scheme of things.

6 MR. ADKINS: I wouldn't necessarily go to
7 that because I can tell you hands down the difference
8 between the neutron absorber and pure air. There's a
9 substantial difference on conductivity and I don't
10 recall those values offhand. It's been awhile since
11 I've looked at those. But, you know, another thing to
12 consider, too, is you know, as far as the heat path
13 in, typically what this -- it's a polymeric material.
14 It's like an epoxy and what it does is, it's -- if I
15 remember right, it's a thermoset. It may not be a
16 thermoset but the stuff chars so bad that it leaves no
17 gap for radiation interaction. I mean, it just
18 basically degrades the conduction path.

19 So the fins really are the key to the
20 design of those casks. And -- well, I guess that's
21 all I should say.

22 MR. BAJWA: Merritt?

23 MR. BIRKY: Well, I sort of have a
24 question on follow-up on that in terms of the fins.
25 When you do the calculations, does that take into

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1 account when that happens, what happens in terms of
2 the temperature rise and that sort of thing and once
3 you lose that path?

4 MR. HODGES: Where you get the pyroboric
5 reaction and all of a sudden there's no path through
6 that. Well, we have assumed it's there through the
7 course of the fire to maintain conservatism. Do you
8 see what I'm saying? I mean, within the seven-hour
9 period as you can see, we're up, I think the service
10 temperature of the stuff is up in the -- if it's
11 anything like the Bisco, it's like 300 Fahrenheit, 400
12 max, maybe 250.

13 And then if we take a situation where
14 we're saying that it's fully intact at, you know, 900
15 to 1400 through the course of the fire, you're saying
16 that, you know, it's drawing in more heat than if you
17 were to let it degrade. And then, you know, when it
18 chars --

19 MR. BIRKY: But then you have more heat
20 load to get it to dissipate, though, too, do you not,
21 from the fuel? I mean, how does that get out then?

22 MR. ADKINS: Well, that's the point, it
23 can only get out through the fins after we degrade it
24 to the level of oxygen and say that there's no
25 radiation interaction in there. So basically, if you

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1 were to look at -- and I understand what you're saying
2 there. If you were to look at pre-fire, fire, post-
3 fire, and if you were to expose the cask well into the
4 post-fire and let it come to steady state, after the
5 stuff was charred, the inner components of the cask
6 would be above temperature, but by the same token, to
7 find out that evaluation where that would reside is
8 those values are in the TSAR. The reason is, is
9 because they have to evaluate that cask after the
10 neutron shield material gets charred and they do a
11 similar approach.

12 They say that it's in full tact through
13 the fire. After the fire it's gone, so they have
14 nothing to air in that void and obviously, the inner
15 components are going to come up to temperature, but by
16 the same token, typically after the cask comes out of
17 the fire, another reverse weighing component is the
18 fact that being sooty, you're typically higher on the
19 outside just because of the sooting and --

20 MR. BIRKY: Now, you refer to air, but the
21 thing is charged with helium, is it not, part of it?

22 MR. ADKINS: No, not in the neutron
23 shield.

24 MR. BIRKY: No, further in.

25 MR. ADKINS: Yeah, but I wasn't talking

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1 about anything to do with that. I mean, mainly what
2 you're doing is taking the conductivity through that
3 thin layer on the outside and reducing its
4 conductivity slightly because the neutron shields
5 material is gone.

6 MR. RESNIKOFF: The concern I have is the
7 cask outer surface, I mean, your 30-hour NIST fire
8 has a cask outer surface of 1873 degrees Fahrenheit.
9 These conductors -- the outer surface is at 1875 and
10 that's directly connected then to the shell. But the
11 shell then is down at 934, about half the temperature
12 of the outer shell even though they're connected.

13 MR. ADKINS: Yes. And part of it is, is
14 because if you look at the way those are attached,
15 it's a tiny little weld that's attaching it. I think
16 it's roughly a quarter inch and there was some
17 weighing that we did at that particular juncture and
18 I need to go back and revisit that but one of the
19 things is, too, is the cask has a huge thermal
20 inertia. It's only on fire for seven hours. You
21 called it a 30-hour fire. It's not a 30-hour fire.
22 It's a 7-hour fire. Over the beginning portion of the
23 fire, when it starts up, especially at the 20-meter --
24 I'm going to get all these numbers mixed up -- the 20-
25 meter portion, basically what's happening is you know,

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1 it's coming up to temperature a little slower because
2 all the environment around it is coming up to
3 temperature slower and then another thing that you
4 have to keep in mind, too, is, is at the same time,
5 when it's coming through this hot portion of the top
6 cask, there's huge conduction paths all the way around
7 the cask, so it's redistributing the heat readily.

8 MR. RESNIKOFF: So you don't assume then
9 that this half-inch radial connector is connected to
10 the cask body at a half inch. You assume a much
11 smaller connection so there's not a big connection
12 path?

13 MR. ADKINS: I'd have to go back and check
14 but if I remember right, full credit is given to that
15 till after fire.

16 MR. RESNIKOFF: Okay, well, I guess that
17 will come out in your paper.

18 MR. ADKINS: Yes. The main driver though,
19 is the conduction path that's circumventially around,
20 you know, because you're talking seven inches
21 thickness steel, seven inches thick.

22 MR. RESNIKOFF: Right.

23 MR. ADKINS: And it's only the top portion
24 that's exposed to this hot gas, whereas, the side --
25 and you know, this is relative, obviously relative,

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1 because these are extremely high temperatures, but the
2 side portion, the air is substantially cooler than the
3 top portion and the bottom is substantially cooler
4 than, you know, the top portion and also the side
5 portion.

6 MR. RESNIKOFF: Well, as I remember, the
7 slides that were shown at the ACNW you had it actually
8 a time -- you showed over time what was happening to
9 the various temperatures and you showed the under-
10 carriage heating up slowly, much more slowly than the
11 top. I remember that, but then in your model I assume
12 this was taken into account, you assume that the
13 under-carriage was then reradiating the heat as the
14 fire declines.

15 MR. ADKINS: Yes. I'm not familiar with
16 the term "reradiation". I think what you're saying is
17 radiation interaction within the tunnel, so you have
18 the cask, the tunnel and the cradle all interacting
19 with each other. Yes.

20 MR. GARABEDIAN: I have a quick comment to
21 add to the fin --

22 MR. RESNIKOFF: Just as long as it's not
23 a question. We're asking all the questions here.

24 MR. GARABEDIAN: No. My experience in
25 actual fire testing would demonstrate that the

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1 temperature on the inside of a steel plate, let's take
2 a bulkhead of a ship that's connected to another
3 bulkhead with a fin stiffener, you have to take into
4 consideration the percent area that you're talking
5 about. It took the cumulative area of steel and
6 contact with steel and took it over the entire
7 circumference of all of the other area that's not in
8 contact with steel. That's a better indicator of how
9 that temperature is going to get distributed. If you
10 have a certain percentage of steel in contact, it will
11 be governed by the rest of it that's not in contact by
12 a function of the area. It's an easier way to look at
13 it.

14 MR. BAJWA: All right, I'd like to give
15 another opportunity to any members of the public who
16 would like to make a comment and then we need to start
17 wrapping things up. So last chance.

18 (No response)

19 MR. BAJWA: Okay, seeing no interest,
20 Wayne, I'd like to give you a chance to make some
21 closing comments and then I have a few more kind of
22 paperwork stuff to clean up before we close out for
23 today.

24 MR. HODGES: I don't have a lot to say in
25 closing other than we've tried to present in as much

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1 detail as we thought you'd be interested in what we
2 did in analyzing the fire. We still think given the
3 limited data, it was the best analysis we could do.
4 We've tried to make things bounding and we think it
5 shows the robustness of that cask. We agree that
6 other work on other casks is needed. We're going to
7 look at them. We'll look at the other conditions and
8 all these analyses take time.

9 MR. BAJWA: Okay, I've been told that
10 there are additional copies of the handouts and so if
11 you didn't get a copy of the handouts when you came
12 in, please come to the front here.

13 The slide that's up now is just some
14 additional information. There was a recently released
15 Commission paper which summarizes, basically, what
16 you've heard today. And it is available on the web
17 and the address is there in case you want to look it
18 up.

19 The transcripts for this meeting will be
20 available. We will make them available via the web
21 as soon as we can. That usually takes, in my
22 experience, two to three weeks to get back but we'll
23 try to do that as quickly as we can.

24 Finally, there are the public meeting
25 evaluation forms. Some of you picked them up, some of

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1 you may not have. If you have not, please pick those
2 up and fill them out, if you can. And basically, I'd
3 like to thank everyone for coming. I think this has
4 been a very useful meeting. I think there's been a
5 lot of good information exchanged. Obviously, this
6 issue is ongoing and will continue. There is work to
7 be done on both ends from what I gather and we
8 appreciate any input that you have in what we've done.
9 As you take these slides back and digest them and
10 maybe think about it more, you may have some
11 suggestions or additional comments. Please feel free
12 to send those directly to me.

13 And Bob, you mentioned that we might want
14 to have a meeting in the future. If we feel that we
15 need to do that, we're open to doing that. So, thank
16 you for coming.

17 (Whereupon, at 11:51 a.m. the above
18 entitled matter concluded.)
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